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PEER REVIEW: S-CGE MODELLING OF HEATHROW AIRPORT EXPANSION

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Peak Economics

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Final report to Department for Transport

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Contents

1 INTRODUCTION

1.1 Background

The Department for Transport (DfT) has commissioned the development of a Spatial Computable General Equilibrium (S-CGE) model to understand the GDP impact and its regional distribution of an expansion in capacity at Heathrow. This peer review provides commentary on that model and application, identifying strengths and limitations.

1.2 Method and context to the peer review

This peer review is based almost entirely on the Frontier report *Spatial Computable General Equilibrium Modelling Of Capacity Expansion At Heathrow Airport* dated 4th June 2026. This report represents an amalgamation of notes developed by Frontier during the project. These notes have been lightly edited together. During the course of the project, I have had sight of these working notes and have informally provided feedback on them to DfT officials. I also tabled questions via DfT officials, where details on the modelling are not included in the notes, or where the details are opaque or ambiguous. Only some of these queries have been responded to. The peer review is therefore based primarily on the above report.

Whilst having sight of some earlier working notes, modelling results including the sensitivity tests were only made available to me on 4th June. This peer review has therefore been completed over a short timeframe of a week. As such it aims to provide assurance regarding the overall direction of the modelling, what is and is not included in the model, whether the model's sensitivity seems in line with the evidence base, as well as provide some commentary on the key drivers to growth. The actual structure of the model has not been reviewed, beyond a limited review of the model closures and the data sources used to develop the model.

A revised set of headline results were issued on June 10th. Where numbers are cited in this report they relate to the June 4th numbers. The points being illustrated with the numbers remain the same.

1.3 Report structure

Following this introductory chapter, Chapter 2 gives a brief summary of the economic impacts of air services and the channels by which they change the economy. Chapter 3 describes the modelling framework and offers commentary on it, whilst Chapter 4 gets into the specifics of the model closures and assumptions used in the modelling, offering a similar commentary. Finally, Chapter 5 offers a summary.

2 ECONOMIC IMPACTS OF AIR SERVICES

2.1 Air operations

Figure 2-1 illustrates conceptual economic linkages regarding how a change in airport capacity may lead to changes in the economy.

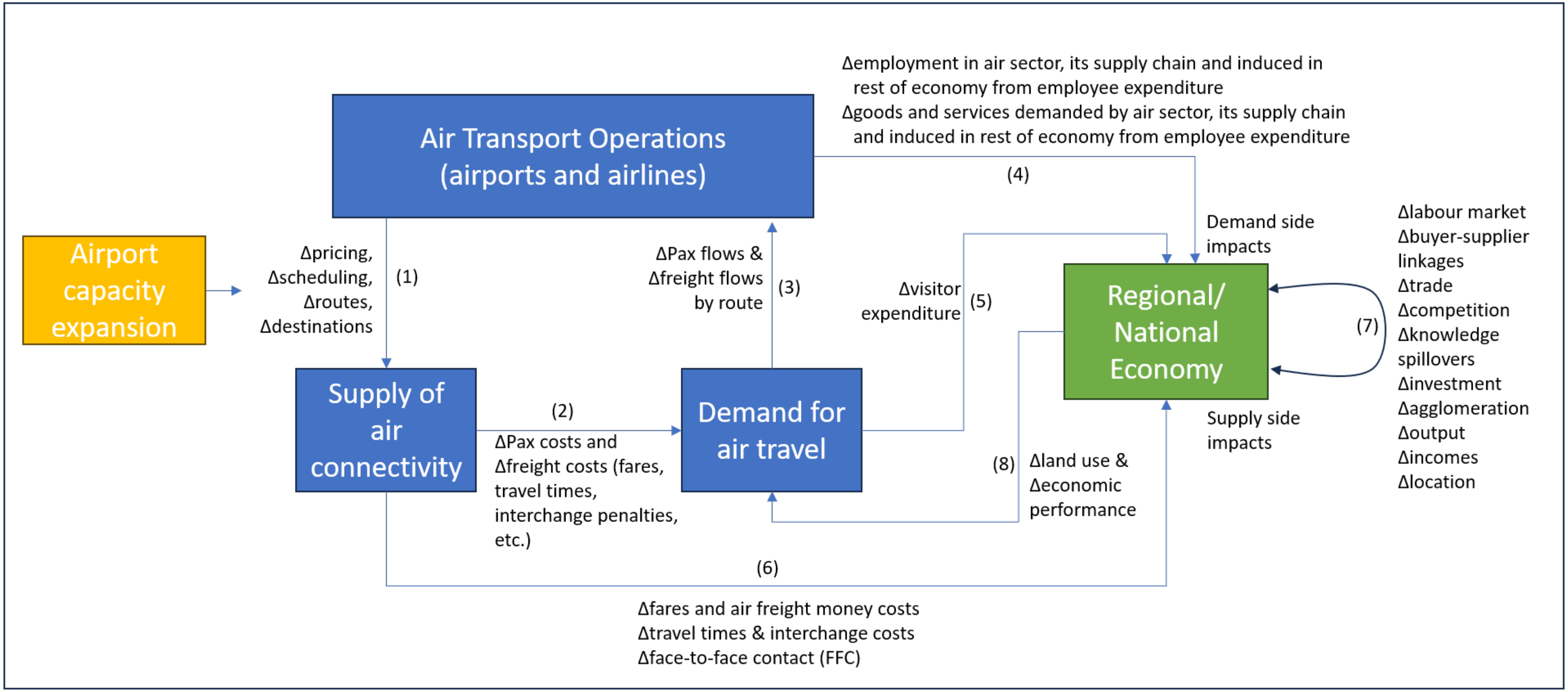
Looking first at the air sector, coloured blue in Figure 2-1. The change in airport capacity permits a change in pricing and scheduling as well as routes and destinations available – labelled (1). This gives a change in the supply of air connectivity and leads to changes passenger and freight costs including fares and travel times – labelled (2). The demand for air travel will then alter (3). The increased patronage etc. creates a demand for goods and services associated with airport operations.[1] These first-round effects may in themselves lead to second-order effects within the air sector as changes in demand (3) may then lead to further changes in prices and schedules etc. (1).

These changes in the air sector then interact with the regional and national economy through both demand-side and supply-side linkages. Changes in air transport operations demand more employment and goods and services from the economy – labelled (4) in Figure 2-1. For an international hub airport such as Heathrow this is a significant economic impact. For example, at Heathrow 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). So, a significant expansion in airport operations will have a significant impact on the local labour market. If the local labour market is tight, then crowding out of these employment gains will occur at the local and regional level.

The change in passengers, broadly categorised as either business visitors or tourists, also changes demands in the visitor economy. This is labelled (5). There is both an outflow of UK residents travelling overseas and an inflow of foreign visitors to the UK. The outflow of UK residents will reduce demand in the UK economy, some of this may be displaced from the domestic visitor economy and some from general household consumption, whilst the inflow of foreign visitors will increase demands within the UK visitor economy. It is an empirical matter as to whether the changes only partially or fully offset each other. Again, demand-side impacts in a tight labour market will lead to some crowding out of the expected changes in the visitor economy.

[1] There is a simultaneity here in that the specification of the change in the air network, following the airport expansion, in itself creates a change in air operations, without the change in the demand for passengers.

FIGURE 2-1: MAJOR CHANNELS THAT AIR TRANSPORT AND THE ECONOMY INTERACT



On the supply side of the economy, labelled (6) in Figure 2-1, 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). There are also cost reductions as passenger fares and air freight charges may reduce. In addition, there will be changes in face-to-face contact (FFC). These affect the supply side of the economy, as industries that utilise air services will benefit from improved productivity, lowering costs and increasing output. The economy would be expected to re-structure towards these sectors.

FFC contact is seen as particularly important aspect of air services as it facilitates joint ventures between businesses, collaborations between scientists, the management of subsidiary businesses or business operations in locations far removed from headquarters and improved buyer-supplier linkages. Consequently, 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)).

Households will also experience a cost reduction and will be able to alter consumption patterns, which will have allocative impacts in the economy.

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 gaining more, and displacing activity towards it. Agglomeration impacts may reinforce these changes. 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] These channels are labelled (7) in Figure 2-1.

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[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

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) means 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).

Finally, these changes in economic performance give rise to different land uses and different demands on the air network. This feedback effect is labelled (8) in Figure 2-1.

2.2 Construction, investment and financing of airport infrastructure

In the Heathrow context the airport investment is a private sector initiative funded through the capital markets. In that sense investment is funded by domestic savings, and/or foreign investment. Different scenarios are then possible:

- At one extreme, investment in Heathrow displaces investment elsewhere in the UK. There is no change in the total level of savings and investment in the UK, and therefore no change in capital stock. This is a resource re-allocation between industries.
- At another extreme either the savings rate increases or foreign investment leads to the total investment in the UK being additional. The increase in capital stock associated with Heathrow is all additional.
- In-between positions are possible with investment in Heathrow being part financed by displaced investment within the UK, and part financed by an increase in the savings rate in the UK and/or part-financed by foreign investment.

Any additional investment in the UK's capital stock (bullets 2 or 3) will result in resources being directed into construction, crowding out some activities in other sectors. Depending on the scenario either the increase in the savings rate, or the inflow of foreign capital will lead to an appreciation in the exchange rate, crowding out some exports and leading to more imports. This reduces domestic output.

Investors also require a return on capital, thus there will be interest payments and repayment of capital. If they are overseas investors, then there will be outflows of capital from the UK during the operating period of the airport.

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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.

Construction impacts are typically excluded from most cost-benefit analysis infrastructure appraisals. Implicitly, therefore, it is presumed that the infrastructure investment is displacing investment elsewhere in the UK (the first bullet point above). Construction impacts are also viewed as temporary. If, however, the investment induces a sustained increase in the savings rate, construction and financing impacts can move from being purely temporary reallocations to generating a permanent increase in the capital stock and output, effectively shifting the economy's long-run equilibrium.

2.3 Economic Impacts of Air Connectivity

In a preceding study for DfT I undertook a literature review of evidence on the economic impacts of air connectivity (see Laird (2026)). I briefly summarise this in relation to impacts on regional economies, industrial sectors and channels of growth.

2.3.1 Channels of growth

International Trade: A robust finding across numerous studies is that improved air connectivity significantly boosts international trade. Several observations arise from these empirical studies. Firstly, the benefits of reduced flight times seem to affect trade at the extensive margin (the number of products traded), and not at the intensive margin (the quantity of products traded). Secondly, the mechanism linking connectivity to trade is primarily via business travel and personal interaction rather than freight. Thirdly, direct routes seem to be of most relevance. Fourthly, both exports and imports change, and finally there is significant heterogeneity in impact across products. Connectivity-driven trade gains are concentrated in industries with high needs for face-to-face communication and contracting complexity, such as advanced manufacturing, machinery, or technology-intensive sectors. These industries benefit disproportionately from reduced travel times and greater ability to engage in personal business meetings. In contrast, sectors less reliant on interpersonal exchange, or where substitutes (like digital communication) are effective, see smaller trade responses to connectivity improvements. Indeed, emerging evidence suggests that digital connectivity can partially substitute for physical connectivity: for instance, country pairs with strong online social networks exhibit a somewhat weaker trade response to new flights, though this substitution is only partial.

Investment and Foreign Direct Investment (FDI): Air connectivity has a profound impact on capital flows and firm location decisions, working through similar mechanisms of reduced communication and coordination costs. There are limited studies but those that do exist show a significant impact on FDI flows. The flow of FDI typically goes from high-income to middle-income countries, raising incomes in the host country. As with trade, benefits may not extend to the very poorest regions that lack the complementary human and physical capital needed to attract investment even if flights exist.

Knowledge Creation and Diffusion: A growing area of research has illuminated how air connectivity fosters innovation and knowledge spillovers by enabling collaboration and the transfer of ideas across distances. Again, direct connections are important, as are travel time and costs. Once again, it is new/complex technologies and where FFC is most relevant that benefit the most. Emphasising the direction of FDI flows, the evidence also points towards air connectivity benefiting the weaker region or country (e.g. knowledge transfer from the US to a host country, or convergence in innovation across Metropolitan Statistical Areas (MSAs) in the USA). There is further evidence that the impact of air services is more muted where there is competition with land transport and are strongest near the airport city.

2.3.2 Regional growth and sectoral outcomes

Employment and Population. The US-focused literature generally finds small but positive effects on city-wide employment and population growth from enhanced air traffic, with disproportionate gains in service industries, confirming the importance of air travel for knowledge-oriented and producer service sectors. A consistent finding is that gains in employment outpace population increases, implying that improved connectivity causes a rise in the local employment rate (people moving to take jobs or higher labour force participation). In the US context all recent data shows employment gains are service-sector driven. Studies using early US data (1950-1980) and in China show manufacturing employment is related to air connectivity.

The European evidence is far less abundant and largely focused on smaller, regional airports. It suggests more heterogeneous impacts, sometimes negligible. This contrast between US and European findings can be partly attributed to differences in geography, existing transport alternatives, and maturity of networks. The US studies often consider large, city airports in a period of rapid network growth, whereas some European studies focus on saturated networks or regional airports where diminishing returns may have set in. However, Europe's evidence base remains very limited; only four recent European studies with credible causal designs were identified (three on Norway/Germany regional airports and one on Italy).

Puzzles. 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 into increased employment in these sectors in the US. 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 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.

3 THE MODELLING FRAMEWORK

3.1 Suitability of Heathrow expansion to S-CGE modelling

The conventional framework of economic analysis used by the DfT is the welfare economics/ cost-benefit analysis approach codified in Transport Analysis Guidance (TAG). This permits the 'extraction' of estimates of GDP gain. However, it is primarily a narrow approach where a proportionate simplification is that general equilibrium affects – reallocation between sectors, land use change – are small and immaterial.

For most projects considered by DfT this would be appropriate. However, such an approach is highly questionable for a project as large as Heathrow Airport expansion, where one may expect an analysis of how resources move around the economy from lower-value to higher-value activities in response to an improvement in air connectivity to be significant in both welfare and GDP terms. Furthermore, a project such as Heathrow Airport expansion is likely to have significant demand side impacts via increased air operations and changes in visitor expenditure. In a resource-constrained economy, this can lead to wage and price inflation, which crowds out economic activity. Additionally, the manner that international flows in trade and visitors will be affected, with knock-on impacts on balance of trade, exchange rates, etc. again points to the inadequacy of the standard approach to project assessment.

A suitably specified S-CGE model, with its general equilibrium focus and 'closure rules' for the capital, labour and foreign exchange markets, offers a significant conceptual advantage over the conventional framework. I am therefore supportive of S-CGE modelling being used to assess Heathrow Airport expansion. A number of remarks are necessary, however, with regard the application of standard S-CGE models to assessing the impact of Heathrow expansion.

Financial shocks. S-CGE models are well suited to capture changes in financial impacts from the policy shocks. This includes changes in demand for (and expenditure on) air operations, visitor expenditure and changes in air fares and freight charges.

Travel time shocks. They are less well suited to the analysis of productivity gains from travel time improvements to business passengers or air freight, though there are a class of S-CGE models that endogenise travel time for business and freight (Stroombergen and Laird, 2023). An approach to address this in the modelling is to use values of travel time savings to business (and freight if relevant) as a productivity shock to the (air) transport-using sectors of the economy.

Trade effects. A core strength of an S-CGE model is in the capturing of the real income gains of more extensive trade partnerships. This leads to re-allocation between sectors towards higher value-added sectors. This increased level of specialisation will lead to productivity gains in the economy, which will be amplified through increased economies of scale in production and increased variety of goods (the extensive margin). For the latter to be realised, economies of scale would need to be included in the model, as would product variety.

Transaction costs, spillovers and innovation. The external effects on the likelihood of forming contracts between buyers and suppliers, the benefits of new collaboration on innovation and knowledge diffusion are not classically endogenous to an S-CGE model. Some form of external modelling would be necessary for this.

3.2 Aviation modelling and the policy test

3.2.1 The Aviation Modelling suite

The S-CGE model takes its output from DfT's Aviation Modelling suite. This modelling suite aims to reflect how passengers choose between airports and how flights are allocated to airports. The internal structure of the model and its operation does not form part of this peer review. However, it is worth outlining the model as it forms an input to the S-CGE analysis.

Demand forecasts from the National Air Passenger Demand Model (NAPDM) are primarily elasticity based and driven by income and price. These demands are then distributed around UK airports using the National Air Passenger Allocation Model (NAPAM). This is a logit model, as used in destination choice models, and considers surface access costs (travel times and costs) in the UK. Price differences between airports would also be reflected in the choice. Within this model there is a model of the aircraft fleet – the fleet mix model (FMM) - and a model of Aircraft Traffic Movements (ATMs). The latter model simulates whether new routes will open (subject to sufficient demand) or potentially close.

There is also a feedback procedure that raises the prices of fares at an airport when demand exceeds capacity. When airports are at capacity, fares can then exceed operating costs with surpluses occurring. In the modelling these surpluses are assumed to accrue to the airlines.

A noted limitation of the model is that it is focused on passenger demands and does not include any modelling of air freight. Informally, DfT officials have advised that the model has difficulty converging when the air travel demand outstrips capacity. This has limited the modelling horizon. In this situation the model is relying on an iterative process that uses prices that vary by airport to create an equilibrium demand.

The model produces forecasts for passenger travel demands by route, operating costs by airport and revenue. A final point worth noting is that passenger demands are split by one-way trip, but the demand model and airport allocation model separate the market by residency (UK or foreign) and business and leisure. Thus, while return trips are not specified individually, the true origin (UK or overseas) is known.

3.2.2 The policy test and the Aviation Model outputs

In relation to Figure 2-1 the DfT's Aviation Modelling suite covers mechanisms (1), (2) and (3) coloured in blue, and the capacity expansion at Heathrow Airport coloured in orange.

The model takes the capacity expansion, adjusts fares to reflect that Heathrow is no longer at capacity, which then abstracts demand from other airports as well as potentially inducing demand. It identifies new ATMs to meet the demand, subject to the new capacity of Heathrow. Air operating costs adjust in line with the change in ATMs.

The results from the DfT Aviation Modelling suite identify that the primary effect of expanding capacity at Heathrow Airport from opening in 2035 to the late 2040s is to reallocate passenger between the London Airports.[4] In the 2050s, in the baseline, London airport capacity is reached and

[4] Primarily this is between Gatwick and Heathrow.

it is only at that point that there is a significant increase in air passenger demand from the Heathrow capacity expansion.

It is also worth noting that the policy test assumes that, whilst a second runway at Heathrow is provided in 2035, terminal capacity only increases incrementally in 2038, 2049 and 2054. Terminal capacity is also a limiting factor for passenger demand and ATMs.

There has been no modelling of costs and benefits to users of the London transport network of any enhanced surface access requirements required by a larger Heathrow, or the impact on the Exchequer of these. Nor has there been any modelling of delays during construction (e.g. to other air passengers) or to road users if e.g. the M25 is diverted into a tunnel under the new runway. The impact of these costs is not therefore included in the analysis.

3.3 TERM-UK

The S-CGE model developed is based on the TERM modelling suite and is called TERM-UK. TERM is a well-known and established genre of S-CGE models. It draws on an established database of parameters, and the practitioners of the model have experience in setting it up using data for new regions/countries. This is helpful as it gives confidence in the modelling.

The particular interest is in any strengths or limitations in its suitability to model Heathrow Airport expansion. With reference to section 2 of this report, one would expect there to be population (migration) impacts, employment impacts, and impacts on economic performance related to investment, innovation and agglomeration.

TERM-UK is set up to partially model these economic mechanisms. It assumes competitive markets and constant returns. It also models the impact of changes in import/export flows on exchange rates. Products from different regions are differentiated so do not fully substitute for one another, so there are some gains from variety. The model therefore captures productivity/GDP gains from improved allocation, specialisation, terms of trade, access to cheaper imports and substitution across regions associated with cost reductions in goods and services. In the modelling, this cost reduction is estimated as an ad valorem transaction cost reduction. This is a key shock to the model.

TERM-UK also includes a migration model, and the Frontier report refers to this. However, the documentation provided does not identify how that model has been operationalised in TERM-UK. Furthermore, none of the outputs reported indicate changes in regional employment and labour supply, so it is unclear whether the migration model is active, and if it is whether it has any or much influence on the results.

TERM-UK differs from some of the newer S-CGE model genres, such as the RAEM family of models, in that it is not set up to capture mechanisms one would associate with the New Economic Geography (NEG) literature. Such models typically include monopolistic competition, economies of scale,[5] firm/entry exit (so productivity gains via increased competition), Dixit-Stiglitz love of variety and related to that the extensive margin of trade in products (so new products and gains in productivity from new products), as well as agglomeration (further gains in productivity). Such

[5] TERM can model economies of scale, but the reporting suggests this option has not been utilised in TERM-UK with constant returns being assumed instead.

productivity gains would need to be included via an external mechanism in TERM-UK: in this application via a 'productivity' elasticity.

NEG type models also have a strong focus on location decisions (core-periphery type arguments), which lead to a re-enforcement of any productivity affects arising through increased trade, competition and agglomeration. In our context, the observed increase of services in cities in US with good air connectivity, and manufacturing in cities in China with good air connectivity, resonates strongly with the core-periphery NEG arguments – suggesting they are relevant in this context. This aspect of international location decisions will be absent from a model such as TERM-UK even with the add-on approach to transaction costs and a productivity elasticity.

The data used to set TERM-UK up is primarily production related data. It includes the Office for National Statistics (ONS) 2023 input-output tables, ONS data on regional employment by sector and ONS data on regional GVA by sector. Some effort has been spent to ensure export-import data on goods traded has been included in the model at a regional level, with 'port level' data being used to help determine regional shares of export-import activity. No data has been used on services exported/imported by region. Regional shares of services exports/imports are set equal to industry activity shares (presumably by region) for exports, and household consumption shares for imports.

Data on household consumption patterns (e.g. the goods and services households in Region A buy, and the regions they buy them from) is not utilised.[6] Similarly data on government fiscal flows is not utilised. Only indirect taxes are included in the model. Regional household consumption shares of tradeable goods and services are therefore set equal to each region's share of national aggregate income. Non-tradeable goods and services are consumed within the region (e.g. electricity, residential care, etc.). Government consumption shares are set equal to household shares. TERM-UK therefore does not include a full Social Accounting Matrix in the manner that most commentators might expect.

In summary, TERM-UK is therefore best seen as an S-CGE model in the classical school, as the model does not endogenise all the productivity gains and location decisions associated with channel (7) in Figure 2-1, particularly those gains that are emphasised by NEG. Such impacts need to be included via an external mechanism, which in this case is based around elasticities and transaction costs, with likely some of the nuances being lost. TERM-UK also has a focus on the production side of the economy (e.g. changes in GDP), as it has a limited representation of households and government behaviour. The simplified household and government representation mean that any welfare measures output from the model would be best viewed as partial.

[6] In the UK the "Living Cost and Food Survey" would provide this data. It is suitable for use at the ITL1 level, the regional structure adopted within TERM-UK.

3.4 Economic channels modelled in DfT's Aviation Modelling Suite and TERM-UK

3.4.1 Channels fully included

The DfT Aviation Model has been used as an input to the S-CGE model in terms of the demands from changes in air operations and changes in visitor expenditure. These cover channels (4) and (5) in Figure 2-1. DfT's Aviation Modelling suite itself covered channels (1), (2) and (3). These are five critical channels, and it is important for the study that they have been fully represented.

3.4.2 Channels not included

There are no feedback effects between the S-CGE model and the Aviation Modelling suite. Channel (8) is not therefore included. Very likely these will be second-order impacts and, given the size of the zones (with populations varying between three million and nine million), their exclusion is likely not material in the context of the robustness of the modelling outputs for their proposed use.

3.4.3 Channels partially included

The channels that have been partially included in the model are channels (6), how transport facilitates economic change, and channel (7), how the economy changes in response to the transport infrastructure shock.

As mentioned earlier, the model does not endogenise all the productivity gains that might be associated with an improvement in air connectivity. To capture these gains, the modelling approach has utilised changes in passenger demand from the DfT Aviation Modelling suite to predict both changes in trade between the UK and the rest of the world, and a productivity uplift to the UK economy. There are a couple of steps in this. Firstly an elasticity of passenger flows to trade from Wang et al. (Forthcoming) was used to create an effective change in ad valorem trade costs, that will lead to an in increase in trade that one would expect from the change in passenger flows. Then an elasticity of trade to real income has then been applied sourced from Feyrer (2019).

There are some important comments to make on this approach:

i. **Direct benefits on travel time and fare reductions on industries have been omitted from the modelling.** The data on both travel times (including surface access times, flight times, flight frequency benefits) and fares are available within the DfT Aviation Modelling suite. Informally, I have been told by DfT officials that the fare reductions themselves constitute approximately £2.5 billion in 2055. In aggregate terms, this is of a similar magnitude to the predicted GDP impact in some scenarios. Whilst these fare reductions represent a transfer between the air sector and businesses/households, there could potentially be significant re-structuring in the regional economies towards higher value, air transport using, activities and changes in household consumption that are not being captured in the modelling. That is before one considers the impact on travel time reductions on businesses. This is a significant limitation of the modelling. However, the use of the transaction cost shock (see point (iii) below) would be expected to capture the uplift in trade from these direct cost reductions.

ii. **The direct benefits on air freight have been excluded.** The DfT Aviation Modelling suite does not attempt to model changes in air freight. However, the benefits of reduced air freight charges, and potential improvements in flight times, for existing air freight has not been addressed in the model. This is another significant limitation of the modelling approach, particularly when one considers that approximately a third of UK international trade in goods by value is via air. However, and as above, the use of the transaction cost shock (see point (iii) below) would be expected to capture the uplift in trade from these direct cost reductions.

iii. **The indirect benefits of increased trade are partially included.** Increased trade is modelled via an elasticity approach linked to passenger demands, and an ad valorem reduction in international transaction costs by sector. This reduction in transaction costs then permits the model to capture the benefits of cheaper imports, re-allocation of the economy to lower-cost, higher value-added activities and benefits from increased variety of goods (goods from overseas are not perfect substitutes for domestically produced goods). However, the additional productivity gains from increased competition, knowledge spillovers, agglomeration, etc. are not captured via this method. A productivity elasticity linked to the change in trade by sectors is therefore applied to each sector of the economy. The approach adopted here is reviewed in more detail below in section 4.6.

4 MODEL CLOSURES, SENSITIVITIES AND ASSUMPTIONS

4.1 Capital market closure, construction impacts and operational impacts

The capital market closure rule is that Investment equals Savings plus Foreign Investment. Incomplete government accounts of course mean that the post-tax savings rate and post-tax Return-On-Investment (ROI) cannot be captured within the model. This limitation would be most relevant if the focus were on welfare analysis and wider economic impacts within a cost benefit analysis. That is not the case here, so with a focus on GDP the lack of full government accounts is less of an issue.

Within this capital market, the closure rule implies that investment can only be funded by savings or foreign capital. If the total quantum of investment is to alter between the Do Minimum and Do Something then the ROI has to increase.[7] In equilibrium, this means the savings rate needs to increase. With a higher savings rate, households consume less and save more. Thus, increased investment displaces consumption. My reading of the Frontier report and my understanding of the model is that, in the Do Something, the savings rate has been increased so that households provide 50% of the capital funding required for Heathrow expansion. The remaining 50% is funded by foreign investors.

Appendix A to the Frontier report contains the results of a 'dummy' scenario that excludes the impact of capital investment associated with expansion. In my view this is a very useful scenario and reference point, as it illustrates in part the sensitivity of the results to the capital market assumptions/closure and the resulting influence of investment on the predicted economic impact.

The headline result is that total net present value (NPV) increase in GDP from expansion over the 32 year modelled period falls from £22.3 billion to £2.7 billion.[8] That is, £19.6 billion (approx. 88%) of the GDP gain from expansion is due to expenditure on construction of the airport, and only £2.7 billion is due to the enhanced air connectivity the expanded airport offers.

The difference between the two results arises as a consequence of the actual capital investment in the airport, and the higher level of capital stock in the economy that results. The latter 'apparently' is responsible for the uplift in GDP in 2056 during the operational phase from approx. £1.4 billion or a 0.018% increase in GDP (in 2056 in the dummy scenario – Annex A in Frontier report) to £3.6 billion or a 0.046% increase (2056 core scenario with EUR trade effects and productivity uplifts – see Table 6 of Frontier report).[8] This is an uplift factor of just over 2.5. It is noteworthy as it occurs <u>after</u>

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[7] If the total quantum of investment does not increase, then investment in Heathrow would displace investment elsewhere in the UK.

[8] A revised set of results were issued on June 10th. This discussion relates to the June 4th numbers. The revised results are lower in nominal GDP terms, but the percentage increase in GDP is higher. For example, the core scenario is projected to increase GDP by 0.052% or £2.6 billion in 2056.

the capital investments have been completed, and one would presume would be sustained throughout the remainder of the operational period – which has not been modelled.

My view is that this difference arises through assumptions, or modelling artefacts, regarding how the investment in the airport is financed. The report itself is rather opaque on this matter, suggesting that 50% of the capital investment displaces household consumption and 50% is funded from overseas. As mentioned above, classically, household consumption is assumed to be displaced if households save more. For households to save more, the savings rate needs to increase. An increase in the savings rate in the Do Something means that for the entire investment period, the rate of investment in capital stock will be higher than in the Do Minimum– through no reason that is related to the project.

Alternative scenarios should be explored:

- Investment in Heathrow displaces investment elsewhere in the economy;
- Investment in Heathrow is entirely funded from overseas; and
- Investment in Heathrow is funded by a mix of displaced investment and overseas investment.

The primary concern here is whether it is justifiable to <u>impose</u> a savings and investment rate in the Do Something compared to the Do Minimum counterfactual. In doing so the policy test is not just about the benefits of enhanced air connectivity but about raising the savings and investment rate. Of course, the increased productivity of the economy following air connectivity increases the rate of return on investments, which will endogenously lead to an increase in the savings rate. This latter growth mechanism is not being challenged, but it is the imposition of a higher savings and investment rate to generate the funding for the project that is being queried, as this has a material impact on the project benefits of the airport during its operational phase.

I do need to caveat the above by saying that the report is opaque in exactly how the model has been adjusted to facilitate the funding in the Do Something, and it is possible I have misinterpreted what has been undertaken. However, the differences in the operational phase of Heathrow between the core scenario and 'dummy' scenario are so large (a factor of 2.5) that, in my view, this aspect of the model and the reasons for the difference need exploring further, before any weight can be placed on the GDP impact of expenditure on construction activities.

4.2 Modelling period and appraisal period

What is very striking is that the benefits from the improved air connectivity only occur very late in the modelled period. This is an unusual way to define the end point of a modelling period, as it relies on extrapolation to understand the majority of the benefits over the appraisal period (typically 60 years).

This is because the uplift in passenger demands, at a national level, drives the trade benefits in the model, which only occurs towards the end of the modelled period. The model period starts in 2024 and finishes in 2056. Construction expenditure on the airport begins immediately, with the first impact on passenger volumes through Heathrow occurring in 2038. 18 further years of operation are then modelled, before the end of the model period.[9] However, passenger volumes only begin to increase in 2049 with a significant step up in 2055 – just two years before the model period ends.

The reason for this is that there is sufficient capacity in the London Airport system until approximately 2050. Up until then the passenger demand is distributed to other airports (e.g. Gatwick). When Heathrow opens in 2038, passenger demand re-distributes back to Heathrow with losses at Gatwick, etc. against the Do Minimum counterfactual.

Several comments are relevant here:

(1) It is highly unusual to terminate a modelling and appraisal analysis after only several years (2053 to 2056) after the model is showing operational benefits.
(2) A standard appraisal period for UK transport infrastructure is 60 years, and runways and terminal buildings would be expected to have sufficiently long asset lives to be appraised over that time period.
(3) There has been no attempt to extrapolate the benefits over the appraisal period, even holding demand fixed at 2056 levels (as is often done in road and rail appraisals).

The issue is exacerbated by the fact that no direct benefits to business travellers and air freight users (travel time, frequency, and fare savings) that re-distribute back to Heathrow against the Do Minimum counterfactual have been included in the modelling (see section 3.4.3). This is clear when looking at the profile of GDP impacts associate with the dummy scenario, where there are minimal benefits during the first ten years of operation, and only benefits of note from 2053 onwards. In reality, even if there is no net passenger uplift, the fact that business travellers prefer Heathrow over other UK airports would indicate business efficiency benefits which will have an impact on the economy. This productivity gain, as discussed in section 3.4.3, has not been included in the modelling.

For reference my attempt to back out a 60-year NPV for GDP adds £45 billion to the core scenario NPV (on top of the existing £22.3 billion). In nominal (undiscounted) terms this adds over £270 billion.[10]

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[9] The third runway is available in 2035 alleviating the ATM capacity limit, but the terminal capacity does not alter until 2038, which is when the terminal passenger capacity limit is alleviated.

[10] The starting point is £3.5 billion of benefit in 2056. The revised headline GDP numbers (£2.6 billion benefit) issued on June 10th reduce this figure to £27 billion NPV, and £150 billion in nominal (undiscounted) terms.

4.3 Labour Market Closure

The report is ambiguous on the labour market closure rule adopted in the model. On one hand, the text of the report is very clear, the labour market has a fixed level of supply at a national level. There can be temporary adjustments in employment (e.g. through increases in demand), but in the long run these will be crowded out and employment will return to the Do Minimum (base) level at a national level. Migration may influence regional employment levels (between the Do Minimum and Do Something), but for every region that gains, there will be a loss elsewhere in the economy.

Contradicting this, the graphics indicate that there are changes in employment at a national level. For example, Figure 25 in the Frontier report shows real wages increase by between approximately 0.10% and 0.12% and employment increases by approximately 0.02% to 0.025% in 2056.

For reference, a back of the envelope calculation would suggest that a 0.02% increase in employment would create approximately 7,000 extra jobs (0.02% of 33.4 million jobs in the UK). This would have a GDP impact of £0.9 billion in 2056 (at 2023 prices).[11] That is, about a quarter of the GDP uplift in 2056 in the core scenario is related to an expansion in labour supply. The other three quarters might be attributed to productivity gains. In the 'dummy' scenario, where the focus is solely on operational impacts, about two-thirds of the GDP impacts arise through changes in labour supply, implying only one-third arise through productivity gains. Thus, what labour market closure rule has been adopted in the core scenario is very relevant to ensure a full understanding of the model results.

Two further comments are necessary here:

(1) If Figure 25 of the Frontier report is correct, and the text is incorrect, it would seem that a labour supply elasticity to real wages of approximately 0.2 has been used. This is double the value in TAG, but is similar to the value found in review work undertaken for DfT (Ercolani et al., 2024). Though later econometric work by Ercolani et al. (2025) found much higher elasticities (approximately 0.6) estimated to individual level data. Thus, an elasticity of 0.2 seems quite justifiable, based on the existing evidence base.[12]
(2) If a labour supply elasticity to real wages has been assumed (as per the graphics), it would be worth running a scenario test, with fixed labour supply. And conversely if fixed labour supply has been assumed (as per the text) it would be worth running a test with flexible labour supply to real wages.

[11] TAG wider impacts dataset has average GDP/worker at £131,729 in 2056 (2023 prices).

[12] It's also worth noting that the US evidence consistently finds that labour supply exceeds population growth. The implication is that more people are drawn into the labour who were previously inactive. These are city level evaluations, and it is possible that the jobs occur due to a migration of firms (or economic activity) to the cities, rather than a pure labour supply response. But this does give some indirect evidence that labour supply at a regional level is responsive to real wage changes following air connectivity improvements.

As mentioned elsewhere in this peer review there is a lack of discussion in the report on the migration model and the employment impact at a regional level. This lack of detail and discussion further clouds the readers understanding of the predictions of the S-CGE model with respect to employment.

4.4 Government Fiscal Closure

As discussed earlier, the government accounts are not fully represented in the model. The government closure rule is that the government cannot change the surplus or deficit in the Do Something from that which it incurs in the Do Minimum. The Government is not expending money itself on this project, but through a growing economy may receive more tax revenue. In other S-CGE applications, with full government accounts this rule might be met with a reduction in taxes or a fixed sum disbursement from government to households. In this application, the balance is made by adjusting government expenditure. This is noted as being different from a lot of applications, but in this context is not viewed as being material to the policy question being asked.

4.5 Tourism Impacts

International visitor impacts are a clear and obvious economic impact from a change in international air connectivity at a major international airport like Heathrow. It is therefore re-assuring that some significant efforts have been spent on modelling these.

In summary, these efforts entailed creating three tourism ‘industries’ for domestic tourism, foreign holidays (for UK residents) and foreign tourists coming to the UK. These industries are created by separating out the visitor/tourist impacts from industries associated with them (e.g. hotels, restaurants, etc.). For UK citizens domestic and foreign tourism are perfect substitutes.

Taking average visitor spend per trip and extrapolating this to new visitor/holiday trips suggests that spending on foreign trips by UK residents exceeds incoming spending by foreign visitors to the UK by approximately £3 billion in 2056.

The strength of the CGE framework really comes into play in how this expenditure shock filters through into the wider economy.[13] A simple growth accounting approach might suggest that GDP would reduce by £3billion per year. However, in a fully employed economy, freed up resources would be re-employed in other activities, and the model therefore re-allocates capital and labour to these new activities. Furthermore, not all of the prior expenditure would occur on UK produced

[13] The report is not clear how the model is shocked for changes in tourism demands. Potentially final demands by households could be separated into tourism demands and other demands, with the shock occurring on the tourism vector.

goods and services, as some leakage would occur on imports. Additionally, the outflow in expenditure will change the balance of trade and the exchange rate will adjust making imports more expensive and exports from the UK cheaper – this is an opposite effect to the Dutch disease referred to earlier.[3]

The net impact of these general equilibrium effects is that the reduction in £3 billion in expenditure in the UK economy only reduces GDP by about a tenth of that (approx. £250 million). This is an important output from the model.

It is of course dependent on the model's structure. In this case, the labour market closure of full employment is very relevant. The implication of this closure is that workers in the domestic tourism sector will not become 'unemployed' in the long run but instead will re-allocate to other sectors, with wages adjusting downwards if there is an excess labour supply. Furthermore, export orientated industries in the model have the capacity to expand output to take advantage of a depreciation in the exchange rate. If any of these model aspects could not be justified – e.g. tourism in a particularly vulnerable regional economy was to be negatively affected (e.g. the impact of a loss of tourism in Cornwall, where there are limited alternative sources of employment, versus a loss of tourism in London), these model assumptions may need looking at. In that sense, an understanding of the regional impacts of changes in tourism would be beneficial, and in principle an S-CGE model is useful in that regard. However, as I discuss below, the manner that this model has been set up means that the predicted regional impacts do not capture many of the expected nuances that one may expect to occur from a change in air connectivity.

Given the likely policy relevance, and potentially political sensitivity, of these tourism/visitor expenditure changes then it might be worth isolating their effects in separate model tests (e.g. by excluding the ad valorem tariff adjustments and external productivity shock to trade). That way, a better understanding of how the model is handling tourism impacts can be obtained.

4.6 Gains from face-to-face contact and exporting

4.6.1 Overall approach

As previously mentioned, the gains from increased FFC and exporting are captured via an external adjustment to international transaction costs, and a productivity adjustment. The elasticities utilised are drawn from Wang et al. (Forthcoming) and Feyrer (2019).

In a working note, some of which has been edited into Annex C of their report, Frontier set out why they preferred to draw elasticities from the literature rather than undertake econometric analysis. They concluded a literature review was the preferred approach. In the context of this study, I would agree with them. This is not because the existing literature on this topic is extensive and there is little to gain from further analysis, as this is far from the truth and the literature on this topic is quite thin. I support this approach because very likely it would be impossible to undertake robust econometric work within the time constraints, and likely budget, of this study unless a dataset was already set up.[14]

As I discussed in my literature review, which is a precursor to this study, the majority of the literature on the economic impacts of air connectivity concerns final impacts on population, employment, etc. at a city level or a national level. That literature addresses final outcomes and is therefore inappropriate for inclusion as an input in an S-CGE modelling framework. Instead, Frontier were looking to utilise the model to identify the productivity and efficiency gains from increases in trade (channel 7 in Figure 2-1). This requires an approach to generate trade volumes that might be expected from an increase in air connectivity. As the S-CGE model does not cover all the potential responses an increase in trade can generate (see sections 3.3 and 3.4) a further elasticity to was used to create a productivity shock. My view on this approach is that within the constraints of the project this is a reasonable approach. The issues then come down to the choice of elasticities, and how these are implemented within the modelling framework.

4.6.2 Trade effects

Firstly, looking at the literature on the relationship between air connectivity and trade, my literature review identified nine high quality papers.[15] Of these, four identify the air connectivity elasticity using the existence of a direct flight, two using over-flight bans and two using a discontinuity in air regulations at the 6,000 mile flight length. Thus the Wang et al. (Forthcoming) study is the most suitable study, as it utilises a novel approach based on connectivity to hubs as an identifying approach and is therefore suitable to more situations.

There are, however, a number of important aspects to this study:

- The underlying hypothesis is that business travellers from an importing country fly to the exporting country and create a working partnership (via FFC) which stimulates an import to the business travellers home country.
- Total passenger demand is used as a proxy for business trips due to a lack of data on business trips available to Wang et al.
- One-way passenger data was used, instead of 'true origin' data as the international dataset utilised by Wang et al. did not hold 'true origin' data.
- The trade data is global and at a national level, though the Schengen area (effectively the EU) is treated as a single country. Other studies demonstrate the impacts on final outcomes (e.g. employment) are at a city level or proximate to it, as discussed in Section 2.3.
- Wang et al. is limited to trade in goods/commodities. Services are not included.

[14] Previous attempts at econometrics in this area by PwC in 2016 during the Airports Commission failed - see Mackie et al. (2013) for a review of that attempt.

[15] In my literature review 41 high quality studies were identified across all economic impacts. Frontier's review has less papers in it.

- A single global elasticity is identified covering all country pairs. This is found to vary with the Nunn contract intensity measure.[16] The elasticity relates changes in trade to changes in passenger demands.
- Some sensitivity was found in the elasticity for country pairs which have 'social links.' Countries with social links rely on FFC much less, and the elasticity is lower.

Frontier has estimated the Nunn contract intensity measures used by Wang et al for each industry in the S-CGE model and then derived an elasticity for each industry. This is a good approach and is in spirit of the role of FFC in facilitating trade in the most contract-intensive commodities. They have assumed that all services have a high contract intensity. They have then converted this elasticity to an equivalent ad valorem trade cost reduction based on a demand elasticity to price of -4. They estimate with and without European trade included in this ad valorem cost reduction.

The final elasticity has then been applied as it has been estimated by Wang et al, rather than as the underlying economic theory hypothesises. That is, it has been applied to changes to all passenger flows, not changes in business flows, and it has been applied to changes in one-way trips thereby not distinguishing between who the true buyer is and who the true supplier is.

My view on this approach and elasticity is broadly as follows:

- This is a single elasticity from a single study. There are no other comparable studies to compare it to, as one might for example with estimates for the value of travel time savings or even agglomeration elasticities. Furthermore. that study is global and is not UK focused. It is a good study, but one must recognise it is a broad estimate.
- It is good that the elasticity utilised in the modelling has been adjusted to reflect contract intensity by industry.
- It is unclear to me that all services are of high contract intensity. Low-skilled services that might be imported/exported into the UK would include travel, hospitality, logistics, and basic business support categories (e.g. the Polish logistics company carrying export goods from the UK to Austria)
- It concerns me that nuances in trade are not being identified in this approach, as:
    i. All passenger trips have been utilised, rather than business trips. This would not be an issue if business and leisure trips were as responsive as each other to price changes. However, they are not. Thus, this approach may overstate the trade increases to countries where growth in leisure trips (in percentage terms) will outgrow growth in business trips (e.g. Europe). The DfT's Aviation Modelling suite identifies business trips separately from leisure trips, so this information is available; and

[16] Nunn (2007)'s contract intensity measure is a variable that measures, for each good, the proportion of its intermediate inputs that require relationship-specific investments. A relationship-specific intermediate good is one that is not traded on organised exchanges, so is not a homogenous good such as oil, or wheat. It is also a good that does not have a reference price. Reference prices are associated with goods that are not fully standardised but for which some published prices may exist (e.g. certain chemicals).

ii. The true origin of the business trip has not been utilised. This would not be an issue if import and export flows were symmetrical. However, the UK imports more manufactured goods than it exports, and exports more financial services than it imports. The DfT's Aviation Modelling suite identifies market segments by their true origin, so this information is available.

Nevertheless, it is good that the use of two ad valorem trade cost changes has been tested, as this gives a sense as to how sensitive the model is to this approach. It is also good that the report identifies the contribution of the 'trade effects' to the benefits. This seems to be around 20% in the core analysis (approx. £600 million) and shrinking in absolute terms to about a third (approx. £200 million) in the sensitivity test. In the 'dummy' test where capital costs of the airport enhancement have been excluded, unfortunately there has been no breakdown by effect. One would presume though that the trade effects (and productivity effects) will dominate (see earlier discussion on the capital markets closure).

I do, however, feel that the sensitivity test excluding European effects to be rather artificial. In my view ideally an elasticity based on business flows should have been used and different ad valorem cost changes should have been applied to imports and exports. Or this could have been a sensitivity tests. The exclusion of European trade would not therefore have been necessary. Also, sensitivity tests utilising the confidence intervals in Wang et al. would have been more representative of the uncertainty in the empirical 'trade effects' elasticity. This to me is both closer to the theory and the empirics. There has been no discussion in the report as to why such an approach was rejected and the approach utilised preferred.

4.6.3 Productivity effect

An additional productivity elasticity to trade flows of 0.3 has been applied. This has been sourced from Feyrer (2019) and is described as a 'representative of the middle of the range of estimates'. The rationale for including this is that the increased trade would lead to "diffusion of knowledge, innovation, scale effects and agglomeration". As noted earlier these effects are not captured in the S-CGE model and an external shock is needed.

I have a few comments to make on this:

- Firstly, Feyrer (2019) has relevance to the issue at hand. This is a good thing. His paper uses changes in aircraft technology to identify changes in trade that are not due to changes in income. This then allows him to identify how changes in trade lead to income growth, as well as isolating the growth in income from the effects on trade of institutions, historical integration, existing infrastructure, etc.
- Secondly, the Feyrer (2019) elasticity is an elasticity to income from trade. Therefore, a policy or external shock (e.g. aircraft technology change which Feyrer uses to identify off) that leads to increased trade will stimulate a whole series of economic changes that lead to higher incomes and trade. It would include all the income effects captured by the ad valorem transaction cost change estimated from the Wang et al elasticity. Furthermore, if

this change in trade stimulates further increases in capital stock over time then it would also capture the impact of those investments on income too. Feyrer himself says that "*A broad interpretation of the results would be to think of trade as a proxy for a number of bilateral interactions that could be affected by changes in the relative distances between countries. Some possibilities include direct foreign investment, multinational involvement, and simple information exchange facilitated through easier movement of people. In short, trade may be providing a proxy for many different elements of economic integration. In this view, the results should be seen as showing a positive causal effect of increasing integration between countries.*"[17] Thus key elements of the S-CGE modelling framework plus the addition of an external trade effects shock (the Wang et al elasticity) form part of the Feyrer elasticity. The Feyrer elasticity does not therefore just relate to "*diffusion of knowledge, innovation, scale effects and agglomeration"*, and it must therefore be double counting a significant portion of the impacts already modelled in the S-CGE model and via the ad valorem transaction cost reduction.

- Thirdly, Feyrer's elasticity when seen as benefits of closer integration, and when seen as being estimated during a period when global integration increased massively (1960 to 1997), might be thought of as being specific to a situation where large gains in integration are possible. It may therefore not be appropriate (or too large) for dense-intra EU/Europe core regions and highly connected global cities. This is because the gains to be made from closer integration for such locations will not be as large as the gains that were available between 1960 and 1997. London fits the profile of a globally connected city in a dense European core, and there is therefore a question as to whether the Feyrer elasticity is too large to transfer to the London context.
- Finally, I have not been able to identify an income elasticity of 0.3 in Feyrer (2019). He reports a range of between 0.5 and 0.75. Mid-range for that would be approximately 0.6. See Tables 4 and 5 in Feyrer (2019).

I therefore am cautious about how to interpret this productivity impact. Clearly, there are economic impacts missing from the S-CGE modelling, as documented earlier in this peer review. But how well the approach adopted captures these missing effects without double counting effects already included, and what the empirical basis for the elasticity adopted is, is unclear to me. Correspondingly, and on the basis of the information presented in the report and my own reading of the literature, my view is that the magnitude of these additional productivity effects should be treated with caution.

[17] Feyrer has in part interpreted their elasticity as a general elasticity to economic integration, that covers a multitude of aspects. On the basis that their data is from 1960 to 1997 when worldwide economic integration increased significantly, then today some thirty years later diminishing returns may be relevant. So, an equivalent trade response may not lead to the same gain in income.

4.7 Sectoral Impacts

The S-CGE model has 25 industries within it. In addition to the 3 tourism sectors already discussed there is an air transport sector and a construction sector, leaving 20 other industries.

The first thing to note is that the tourism, air transport and construction sectors are separately represented in the model which is positive. Significant demand side impacts will be occurring in these sectors as a result of the policy shock.

With respect to the 20 other sectors there is no discussion in the report as to why the disaggregation adopted has been chosen. My review of the sectoral disaggregation seems to point towards a sectoral disaggregation that is general for an economy, with an angle towards tourism and the visitor economy. This is because:

- The nuances of how an air connectivity effects imports and exports would suggest some separation of key export/import sectors into those that have high, medium and low contract intensity. Key manufacturing and service industries that might be expected to be clear beneficiaries of the air connectivity are bundled into 'other manufacturing' and 'other services.'
- Not all the key passenger users of air services (other than tourism) are separately identified. A 2011 CAA report identifies that 60% of business travellers through Heathrow come from four industry groupings with Banking/Finance/Insurance/Legal; the largest at 20% (Civil Aviation Authority (CAA), 2011).[18]. Only two of these sectors have been separated out, and financial and business services (comprising 32% of Heathrow business travel) have been bundled into 'other services'.
- Not all the key freight users of air services (and Heathrow in particular) are identified. A Heathrow report from 2023 identifies that medicine and pharmaceutical products, scientific instruments and power-generating machinery, as well as transport equipment are key air freight sectors with Heathrow holding a large share of UK imports/exports of these products.[19]
- The main beneficiaries in ex post analysis of air connectivity (tradeable services) are not separately identified.

Clearly the industries identified in the first, second, third and fourth bullets are interrelated. High contract-intensity industries (first bullet) use air services (second, third and fourth bullets).

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[18] The four groups are: Banking/Finance/Insurance/Legal (20%), Health/Education/Public Services (14%), Transport & Communications (14%) and Engineering/IT Consulting/Electrical (12%).

[19] Heathrow (2023) *Exporting Excellence Boosting Uk Trade, Driving Economic Growth*. December 2023.

By not specifically identifying the sectors that will gain from air connectivity, the nuances, and potentially some of the impacts, will be lost. For example, it seems hard to see how the model could predict the observed expansion of services around cities with airports.

This lack of specificity, with a broad generalised effect is borne out in the reporting of the sectoral impacts in the report. Here one can see that all sectors of the economy are bundled together with only construction separated out. The implication is that no one sector (e.g. tradeable services) stands out from other industries (aside from construction) – including during the operational phase. This contrasts with ex post studies most of which emphasise tradeable services as the primary beneficiary, with one study (Sheard, 2019) identifying construction as well.[20] The emphasis on construction in the model results once again points towards a closer examination of the capital market closure rules, regarding the financing of Heathrow Airport expansion.

4.8 Regional and International Impacts

The DfT Aviation Modelling suite, the source of the passenger demand data, splits Great Britain (GB) into 455 zones, and Northern Ireland (NI) into 37. Passengers in each of these zones choose one of 29 airports to fly from/to. The rest of the world (RoW) is split up into 67 international zones (in NAPAM), though for demand growth factors these are further aggregated into four areas: Southern Europe, Rest of Europe, Other OECD countries (effectively the US, Canada, Australia, New Zealand, Japan and Chile), and the rest (effectively the rest of South America, Africa the Gulf States, and South East Asia).

The S-CGE model has 12 internal zones at the International Territorial Level 1 (ITL1) level including London, South East, North West, etc., covering all of GB & NI. It has one other zone representing the RoW. Each of the 12 regions of GB & NI trade with each other and the RoW. Population, employment and income data, etc. is included for the 12 GB & NI regions, but not the RoW region. The RoW region covers all international trade to/from GB & NI.

Considerable effort has been expended to identify commodity imports and exports to GB & NI by industry and value by port of entry/exit. These have then been distributed across regions using a gravity model. Exports/imports by service sector industries are allocated by their regional share. Inter-regional trade between regions within GB & NI has been created using a gravity model.

Some comments on this approach:

- Having a low number of internal zones in the UK in the S-CGE model vis a vis the Aviation Modelling suite is relatively normal for S-CGE modelling. This is due to limitations in the

[20] Sheard (2019) identifies that the bulk of the employment effects in US cities due to air connectivity is due to services, with construction playing a smaller role. Also, note that manufacturing employment is not found to be sensitive to air connectivity, despite increases in imports and exports of manufactured goods.

data. It is possible to adopt a more disaggregated approach than 12 zones, but likely in this context (impacts of a London airport) having only 12 zones is probably acceptable. Though possibly adopting a more 'airport city' approach would, if the model could pick up spatial impacts well, identify the types of impact observed in the US and Norway ex post analysis.

- It is also normal to use a high degree of synthesisation to develop a model of inter-regional trade. The gravity model is typical of this approach. The report is however silent on the application of the gravity model, and its calibration. Is it based on transport costs, or distance? How have the zone centroids been defined? These can be relevant – think of the proximity of Liverpool, Manchester, Leeds and Sheffield – the economic heart of the north relative to the geographic centres of the North West and Yorkshire and Humberside.
- Whilst it is quite common to use a single RoW zone for an S-CGE model set up to evaluate a 'project' internal to a country (e.g. HS2 in a transport context), airport expansion projects are intra-national projects. For an international facing project where different world regions have very different trading relationships with the UK, a single RoW will lose some of the detail of the impact of the project. The EU is the UK's largest trading partner followed by the US. China is a large trading partner. Tourism flows (both inbound and outbound) are also very international region dependent. There are examples of S-CGE models, including TERM based ones e.g. EuroTERM mentioned in the report, where an alternative approach to modelling the RoW is used.[21] It is not clear why such an approach has not been adopted in this project.
- The model development has made considerable efforts to identify exports and imports by port of entry and then allocate between regions, but information by mode has not been used. This means that whilst the model 'knows' how much each region trades with RoW, the model does not know how much of this import/export regional trade is by air and via Heathrow. This restricts the models ability to predict the direct impacts on businesses in reductions in air freight costs, and air freight costs via London (see earlier comment on the economic channels not included in the model in section 3.4.2).
- There has been no attempt to map export of services by region using the ONS dataset on international trade in services at a sub-national level,[22] albeit this remains an experimental dataset.
- The trade effects calculated via ad valorem tariffs is at a national level. There is no attempt to disaggregate this down to a regional level, reflecting that the trade effects are being driven via businesses that use Heathrow. Therefore, the application of the trade effects means that all regions in the UK feel the same impact in the proportion of their trade shares.

[21] EuroTERM uses the GTAP trade database, which allows trading regions (e.g. the US which is aggregated into a single zone) to be represented using bilateral trading flows with each country in Europe. Port of entry into Europe is also modelled – as it is in TERM-UK.

[22] ONS dataset: *Subnational trade in services*
https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/subnationaltradeinservices

> In reality, one would expect the gains to be within regions whose businesses use Heathrow, and this is certainly borne out in the ex post evidence.

The net impact of these model development choices, combined with the manner that the ad valorem change is applied, means that all regions in GB & NI receive the same trade effects and same productivity uplift. Furthermore, there is a lack of sensitivity of the model in the role of different trade partners in growing trade with the UK. If, for example, passenger demands to a certain trading partner grow more than to others, one would expect trade to grow more with them than with other partners, and this trade may involve a different sectoral mix/commodity mix.

This 'expected' lack of regional differentiation in regional growth effects can be seen when looking at the results of the modelling. Firstly, in the core results one can see that London has the biggest gain, but all regions gain, with the non-London regions gaining a similar amount. However, once the impact of the capital closure rule is controlled for, in the 'dummy' run in Annex A, one can see that the impact by region is very similar. In my view it would be erroneous to claim a broad distribution of the gains from Heathrow to regions on the basis of the modelling, as once the impacts of the capital closure rule are ignored, the gains by region are very likely to be distributed in line with their base share of the national export trade once account has been taken of differences in their share of contract intensive goods/services. That is, the model outputs at a regional level likely do not reflect the benefits that Heathrow has on each region. The reported distribution of 'regional' gain is therefore an artefact of the modelling and should be treated with caution.

5 SUMMARY

The empirical evidence on the economic impacts of air connectivity 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 through facilitating face-to-face contact (FFC), and to an extent direct cost reductions to users. Unsurprisingly the industries that gain the most from it are those in which FFC plays an important role, particularly businesses in tradeable services and contract-intensive manufacturing. Air connectivity increases inflows and outflows of investment (FDI in an international context), facilitates new collaborations that create knowledge and help diffuse knowledge and creates efficiencies and gains in regional economies through increased specialisation, substitution to cheaper imports, re-allocation of labour and capital between industries, competitive effects on firm entry/exit and through agglomeration. The combination of these factors leads to higher productivity, incomes and international trade.

An S-CGE framework is justified for a project of Heathrow's scale, because the likely effects extend well beyond a standard partial-equilibrium or TAG-style appraisal and include economy-wide, spatial and international adjustments. The modelling of the channels just described then becomes relevant.

The combination of the DfT Aviation modelling and the S-CGE modelling has a number of clear strengths, including the inter-linkage of the Aviation Modelling suite with a general equilibrium framework, and the explicit treatment of air operations, tourism and construction effects.

However, my view is that the reported GDP gains appear highly sensitive to closure rules and financing assumptions, particularly the capital market closure. A very large share of the headline GDP uplift appears to be driven by construction and financing assumptions rather than by the operational connectivity benefits of the expanded airport itself. The labour market may also be contributing a significant share of the benefit, and the closure rule here should also be examined.

The modelling horizon is a significant limitation of the current analysis because the principal national passenger uplift and associated connectivity effects only emerge very late in the simulation period. This means the model captures only a small part of the operational period relevant to a long-lived airport asset.

Important benefit channels remain absent or only partially represented, notably direct business-user benefits from changes in fares, frequencies and travel times, and direct benefits to air freight shippers. This has a number of undesirable impacts on the results, including that there appears to be no economic benefit to Heathrow until the early 2050s despite business travellers choosing to use it, and an inability to disaggregate the benefits of Heathrow to regions that use it.

The use of external elasticities to translate passenger changes into trade effects and then into productivity gains is a pragmatic response to TERM-UK model limitations. The trade effects approach of adjusting ad valorem transaction costs is neat way to utilise the S-CGE model to re-allocate capital and labour to higher value sectors. However, the elasticities are applied in a manner that is questionable and do not reflect the uncertainty in the empirical estimates. There is a material risk that some of the additional productivity uplift is overstated (i.e. some double counting is occurring).

This is because the external productivity elasticity may already embody effects that the S-CGE model and the trade-cost adjustment are partly capturing.

The sectoral and regional disaggregation adopted in the model seems more relevant to an infrastructure project internal to the UK, than an international facing one. As a consequence, the sectoral and regional outputs therefore do not appear sufficiently nuanced to reflect the expected industries, places and international partners most likely to gain from improved Heathrow connectivity, particularly tradeable services, high-value freight-related sectors, London and the South East, and key overseas trading partners.

The modelling work also focuses on the construction and operation of an expanded Heathrow, and therefore does not include issues associated with surface access or during construction. These may also cause material impacts on the economy, and would need including in a fuller evaluation.

The modelling exercise represents a key step in understanding the economic impacts of Heathrow expansion. I would recommend further testing, especially around capital market closure, labour market closure, the treatment of trade/productivity effects, tourism effects, and the modelling horizon, so that robust connectivity effects can be distinguished from results driven by modelling assumptions. If it were possible to refine the model, I would recommend consideration of a more explicit representation of major international trading partners (including tourism/origins/destinations) and a more explicit representation of the sectors which will be expected to benefit the most from improved air connectivity.

6 REFERENCES

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.

Ercolani, M. G., Bromfield, J. P. & Selim, S. 2024. *A review of TAG A2.3 employment parameters: labour supply elasticity and labour tax wedges. Report to the Department for Transport. February 2024.*

Ercolani, M. G., Hearne, D. & Liu, Y. 2025. *Estimates of labour supply elasticities for Transport Analysis and other guidance. Report to the Department for Transport. March 2025.*

Feyrer, J. 2019. Trade and income—exploiting time series in geography. *American Economic Journal: Applied Economics,* 11**,** 1-35.

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

Laird, J. 2026. *Aviation Connectivity and Economic Growth: Literature Review. Report to the Department for Transport.* Department for Transport. March 2026

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*.

Nunn, N. 2007. Relationship-specificity, incomplete contracts, and the pattern of trade. *The quarterly journal of economics,* 122**,** 569-600.

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

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

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

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

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.