PwC Economics and Policy

Modelling Airline Sector Linkages

A Computable General Equilibrium Analysis

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Our approach

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Our approach

We have combined econometric and Computable General Equilibrium (CGE) approaches to gauge the scope of linkages between the key indicators of air industry activity and the wider economy.

We take a three step approach.

Step 1: We take quarterly data for growth rates in airline sector output (as measured by seat capacity) and GDP and test to see if there is a statistically significant connection (cointegration) and establish whether there is a causal relationship from airline sector output to GDP.

Step 2: If a causal link can be established, we then shock the CGE model with a proportional increase in airline sector output.

Step 3: We introduce capacity constraints to see whether the potential gains from an increase in seat capacity could be fully realised.

This approach is designed to provide some insight as to the possible size of multipliers relating to aviation sector output. The model is calibrated to econometric results and should be treated with caution.

What is a CGE model?

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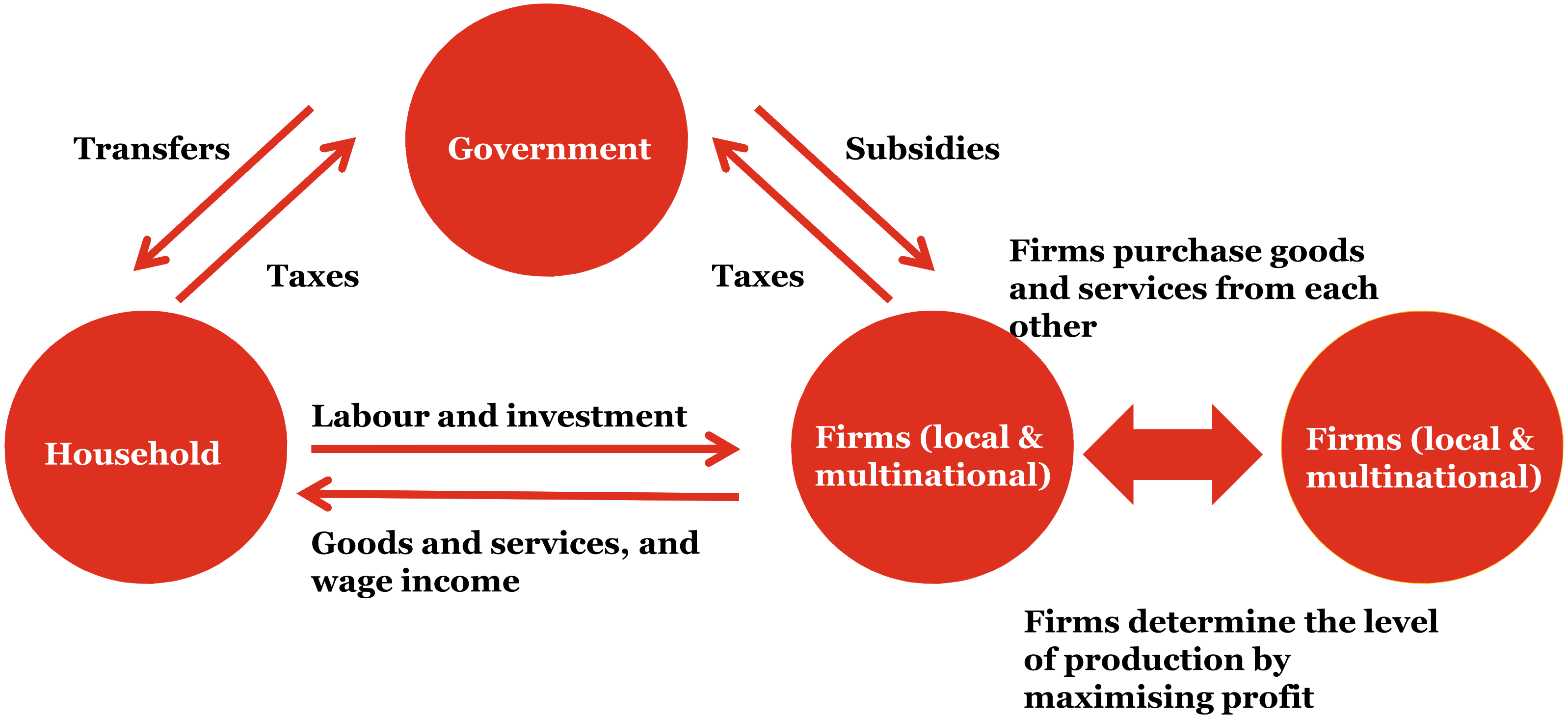
A CGE model captures the following economic relationships:



What is a CGE Model?

A more technical definition: a CGE model is a set of equations that numerically simulates the interactions of differing agents in the economy

- **Partial equilibrium analysis:** ‘standard supply-demand analysis’ where price and quantity adjustments to reach equilibrium in an isolated market. **Ignoring connections with other markets.**
- **General equilibrium analysis:** adjustments in related markets to reach a equilibrium across all markets in the model. **Interdependencies of markets are taken into account.**

CGE Models are built on the Walrasian General Equilibrium Structure which was developed and refined by *inter alia*, Arrow (1954), Debreu (1959) and Hahn (1971). The essential characteristic of a general equilibrium system is that market demand equals supply for all prices at a set of relative prices that can be identified.

Some key CGE model features

Perfect foresight and rational expectations

- Can operate a recursive structure (update capital stock manually between periods) but then dynamics are down to modeller's judgement. The model can also be calibrated to specific forecasts of the economy e.g. the OBR's
- Rational expectations is not always the best assumption, so can proxy the effect of myopia and compare with rational expectations – real world is somewhere inbetween.

Imperfect Competition

- Cournot (quantity competition) in each market. Degree of imperfect competition in part calibrated to the number of firms and market concentration indices.

Separate treatment of Human and Physical Capital

- There are significant frictions that affect productivity in the model e.g. a worker can't suddenly become an airline pilot if they are a chef without retraining.

PwC's UK CGE model

Features

- Based on 2010 UK data, covering 11 industries, 11 product markets, 1 household type and 3 types of labour (professional, skilled and unskilled), and differentiates between debt and equity capital
- Accounts for 95% of the UK tax system
- Detailed modelling of CO2 emissions and their interactions with the economy
- It incorporates the UK Tourism Satellite Account, and includes inbound and outbound tourism

Limitations

- Does not distinguish between value of different types of seat capacity
- No distinction between relative productivity of leisure and business flights
- They are calibrated models so can be sensitive to parameter choice
- Uses a fixed set of functional forms (CES, Cobb Douglas)

CGE Modelling

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We have modelled two separate scenarios…

Scenario 1: Multiplier effect of a £1 increase in seat capacity. No airport capacity constraints. No econometric results are invoked on the model.

Scenario 2: Effect of a 1% increase in seat capacity (in line with PwC econometric analysis of international business impacts of aviation interventions) and airport capacity constraints.

Scenario 1 is a straightforward estimate from the CGE model. Scenario 2 uses econometrically estimated relationships to augment the results from the CGE model.

Modelling approach: Scenario 1

Scenario 1: Transmission Mechanism

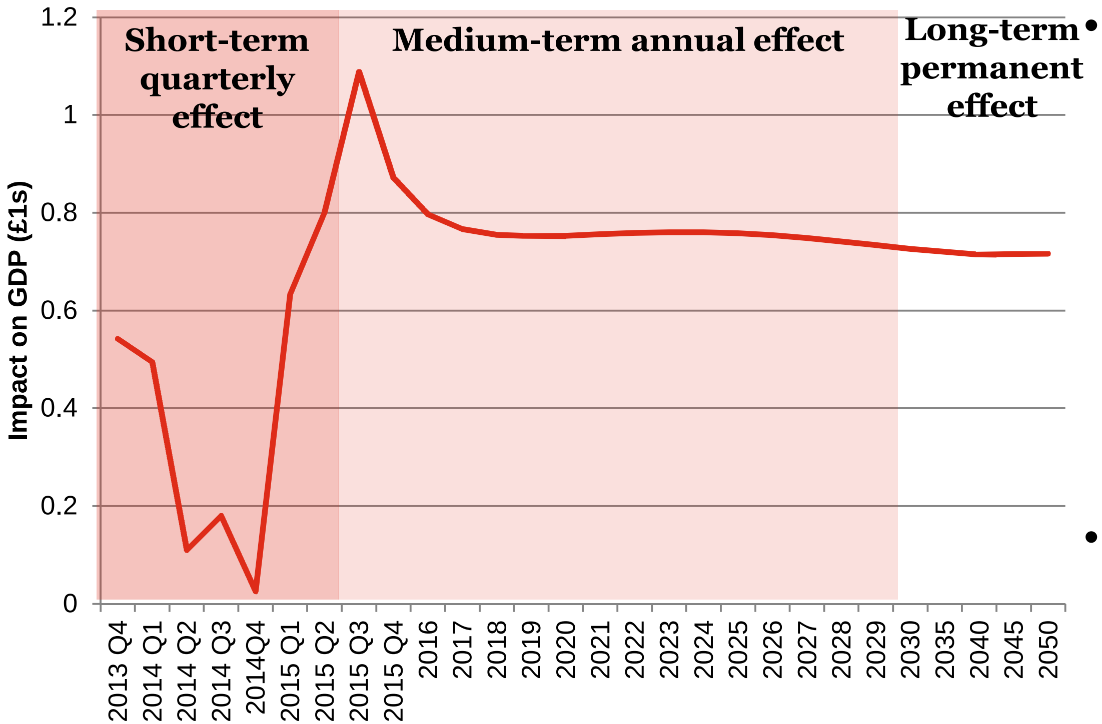
We test the initial calibration of the CGE model. In this scenario we shock the model with a 1% increase in seat capacity and examine the effects on key economic indicators such as GDP, consumption, imports etc.

This is designed to give a feel for the potential transmission mechanism associated with an expansion in aviation sector output. The transmission mechanism refers to the channels through which aviation sector output affects the economy.

We treat an increase in seat capacity as an increase in airline sector supply. This becomes our model input. The model then determines the effect of this increase in airline sector supply on demand, airline sector profitability and the wider economic effects.

Model Results: Scenario 1 GDP multiplier

Figure 1: Impact of a £1 increase in airline sector output on the level of real GDP.



- Figure 1 shows that the GDP multiplier effect of a £1 increase in airline sector capacity results in an approximately 80p gain to GDP.
- There is a significant dip in GDP in the short-term. This is a transition effect. Our econometric estimates from the "international business impacts and aviation interventions report" suggests that the appropriate lag structure regarding the feed through from seat capacity into GDP is about 1-2 years.
- During this transition period the economy loses the GDP impact associated with the money tied up in any investment

Model Results: Scenario 1: breaking down the GDP result

The multiplier can be broken down into components

Long–run effects: a £1 increase in airline capacity leads to a:

- 40p increase in UK consumption
- 30p increase in UK investment (of which FDI is a sub component)
- 45p increase in UK exports
- 35p increase in UK imports

The overall effect is a 80p gain to GDP as shown in Figure 1.

These figures include direct, indirect and induced effects and are net multiplier effects.

However, this analysis is partial. It does not include any feedback that the airline sector has on wider economic productivity etc. It suggests that a £1 increase in aviation sector output, does not translate fully into £1 of GDP.

This result is not specific to the aviation sector and is observed in our modelling of other sectors of the economy. The multiplier is “net”, so factors the impact of increased aviation sector output displacing from other parts of the economy.

Modelling approach: Scenario 2, step 1

Scenario 2: Shock model with cointegrating relationship between seat capacity and GDP.

The results from our cointegration analysis suggest that a 1% increase in the one-quarter lagged growth rate of seat capacity leads to a 0.1% increase in the growth rate of GDP. This is statistically significant at the 1% confidence level.

This approach is more robust than that taken in Scenario 1 which did not fully account for the statistical connection between the aviation sector and the wider economy.

The CGE model can demonstrate the way in which a change in aviation capacity can transmit itself through the economy. It needs to be acknowledged, however, that the results from any CGE model are not fully reliable given the complexity and uncertainty associated with the relationships modelled.

This statistically connecting relationship is then coupled with a capacity constraint that is detailed on the next slide.

Modelling approach: Scenario 2, step 2

Scenario 2: Shock model with capacity constraint

UK airport capacity is constrained. Estimates provided by the DfT aviation model are presented in the table opposite. Constrained passenger forecasts are 8% lower than unconstrained forecasts by 2050.

We model capacity constraints through a reduction in airport productivity. Without a capacity constraint the aviation industry would operate more productively.

The capacity constraints reduce airport industry output by 3% in 2020, 8% in 2050 etc.

Year	Capacity constraint
2010	1%
2020	3%
2030	5%
2040	6%
2050	8%

Modelling approach: Scenario 2, step 2

Scenario 2: Shock model with capacity constraint (continued).

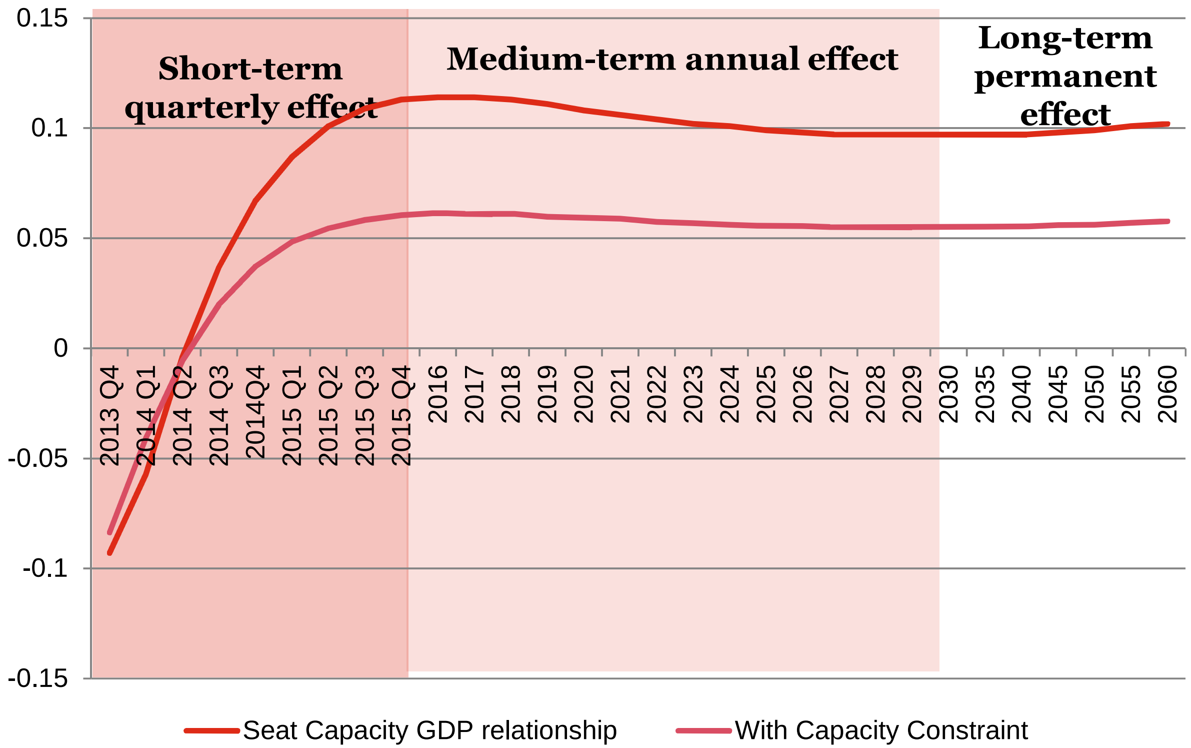
The DfT air transport model suggests that in its unconstrained capacity scenario, passenger volumes will increase by 1-3% per annum between 2013 and 2050. We calibrate our model to assume an average of this growth rate.

When we factor in the capacity constraint, the quantity of passengers declines, compared to the unrestricted case. Output in the aviation sector falls. The scale of this effect is shown in Figure 3.

There is a potential rebound effect from within the model in response to capacity constraints. The model is shocked with an 8% reduction in 2050, but this does not necessarily fully materialise. Airline companies or airports could implement mitigating measures not necessarily accounted for in DfT forecasts or a price response to maintain profitability levels.

Model Results: Scenario 2: GDP Results

Figure 2: Impact of a 1% increase in airline sector output on the level of real GDP.



- The model is shocked with a 1% increase in airline sector output so that the level of GDP increases by 0.1% in line with the results of our cointegration analysis.
- The capacity constraint is then imposed on the model, and the positive impact of an increase in seat capacity falls by around 40%.

Model Results: Scenario 2: CGE results – further interpretation

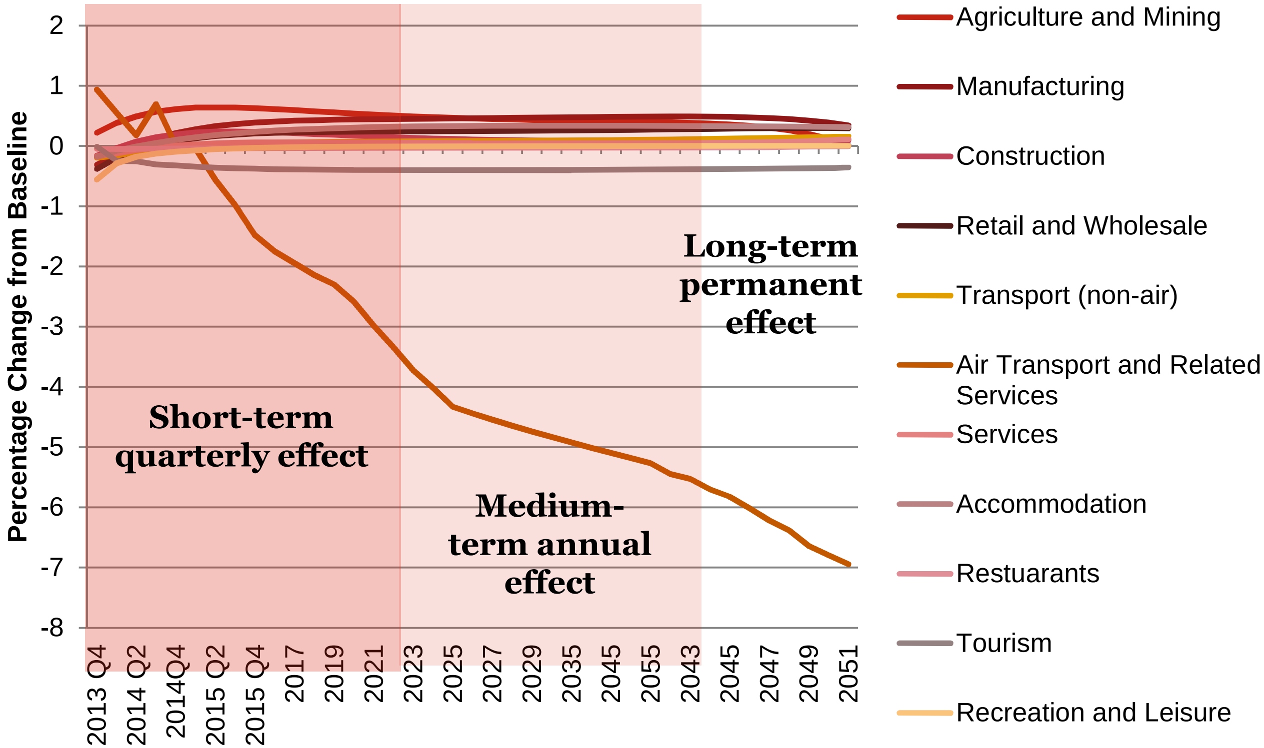
- The capacity constraint is calculated such that the airports market is regulated and that the price is fixed. This means that the airports sector will be able to capture some of the producer surplus associated with the removal of the capacity constraint.
- In terms of the GDP impact in Figure 2, the effects of the increase in seat capacity stabilise over time in both the constrained and unconstrained model and only translate into a small levels effect on GDP – it does not cause a permanent growth effect. The economic implication of this is that small changes in seat capacity do not have endogenous growth effects.
- Although the airport is capacity constrained there is scope for the airline sector to increase seat capacity and realise its benefits. This could be achieved through the introduction of larger aircraft, the restructuring of existing aircraft cabins, more effective marketing of current capacity to achieve higher load factors.

Model Results: Scenario 2: CGE results – further interpretation

- The structure of the dynamic result also provides insight as to the nature of the adjustment mechanism. Initially the GDP adjustment process starts off as being negative and then becomes positive in later years. This is because of the investment profile in the model.
- Businesses are aware that seat capacity has increased and that they are able to generate more overseas business opportunities. The price of aviation products falls in the model allowing businesses to consume an increased quantity of flights. This effect is marginal – a business might only take a small number of extra flights per annum, the effect would not be transformational and would be very much dependent on how the increased seat capacity is allocated across new or existing routes.
- Because businesses know they will be able to generate increased trade from additional tourists and their greater ability to reach foreign markets they will withhold consumption and store up savings for investment purposes. The same pattern of behaviour is exhibited in consumer markets. This leads to the temporary short-term reduction in GDP.

Model Results: Scenario 2: Output by Sector

Figure 3: Impact of a 1% increase in airline sector output on the level of real output by sector



- Figure 3 shows the impact of the capacity constraint on the 'air transport and related services' sector. It is this sector that we use to proxy aviation output through seat capacity.
- Other sectors of the economy grow in response to an increase in seat capacity, but growth would be higher if not for the constraint.
- The output of the aviation sector does not fall by as much as the actual specified capacity constraint, which reflects the mitigating actions of to the airline sector in response to the constraint.