



# Aviation modelling

Research paper

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# 1. Quantifying the nation-wide impacts of reducing Australian air transport price

The Productivity Commission initiated this research in response to a request from the Treasury's Competition Review in its consideration of competition issues in the aviation sector. The aim of the research is to estimate the industry, sectoral and economy-wide effects of competition policy reforms in the air transport industry.

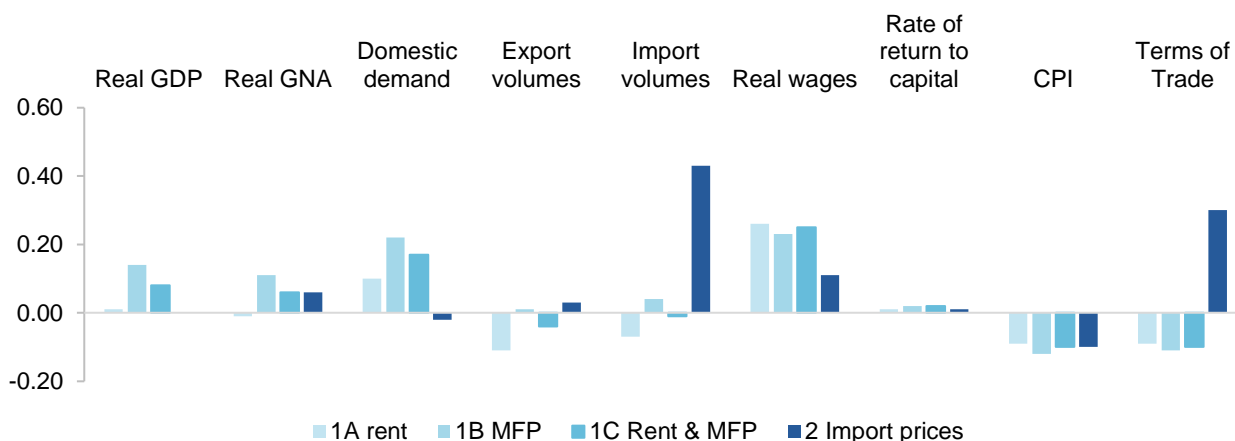
This paper presents the estimates of the industry, sectoral and economy-wide effects of a 10% reduction in prices in the Australian air transport industry. The Commission used its PC National computable general equilibrium (CGE) model (PC 2017, 2022) which is a comparative-static model that allows modelling of an exogenous shock to estimate the long run outcome.

Different policy shocks were modelled to generate a 10% reduction in the domestic price of aviation services: these were the removal of incumbent monopoly power (simulation 1A) or productivity enhancements in aviation through regulatory change (1B), or a combination of the two (1C). A separate exercise to model a 10% reduction in the import price of aviation services (2) was also undertaken.

The picture that emerges across all simulations where the domestic price is lowered is broadly similar (figure 1). A lower domestic price benefits consumers of air transport, leading to an increase in national output, real wages and the rate of return to capital. The story is the same at the industry level.

Although the benefits are of the same sign, they vary in magnitude. Eliminating scarcity rents (1A) where the benefit of reforms remain confined to the industry has limited macroeconomic effects reflecting the small size of the air transport industry (0.5% of GDP). Improvement in multifactor productivity (MFP) has the largest impact on real GDP. The productivity improvements mean that the industry uses fewer resources to expand its output which are now available for use by other industries leading to generally lower their costs of production and increase their exports.

**Figure 1 – Macroeconomic results from CGE model simulations, % change in long run**



Source: PC National results.

## 1.1 Model overview

The focus is on the nation-wide impacts of lowering air transport costs, so a national model is used in this research. The air transport industry has a regional dimension because it operates between major cities in different regions. Modelling regional impacts requires detailed information on regional costs and locations that are not readily available. Moreover, the regional impacts are likely to be small, given the size of the air transport industry.<sup>1</sup>

The research uses the PC National model (PC 2017, PC 2022). It is a CGE model of the Australian economy. Its database corresponds to the Australian economy as represented in the 2018-19 Australian Bureau of Statistics (ABS) *Input-output Tables*, and predates Covid, which caused significant disruption to the Australian and international aviation sectors.

PC National models a complete picture of the 114 sectors in the Australian economy, and is a comparative-static model where factors are fully mobile across industries and the factors of production reach full employment and their rates of return equalised. When an exogenous shock is applied, the impact is distributed across the economy, and factors are allowed to move to find the long run equilibrium. Macroeconomic and air transport sector results are presented in the paper, but results for all 114 sectors of the economy are included in the accompanying Excel file.

In the baseline model, labour and capital are fixed, and in equilibrium these are moved around the economy and fully employed in the long run. We tested an alternative closure, allowing capital to change, which yielded similar results.

PC National has a single air transport industry that sells to domestic industries as intermediate inputs, households and foreign residents (exports) as final products. The imports of foreign air transport services compete with domestically produced services in response to the changes in their relative prices (the attachment at the end of this paper summarises the air transport industry in PC National).

## 1.2 Industry overview

Output of the Australian air transport industry in 2018-19 was \$30 billion. The industry produced \$9.7 billion in gross value added (0.5% of GDP), composed of 58% labour cost and 42% capital cost (ABS 2021, *2018-19 Input Output Tables*). The air transport industry is relatively small compared to the rest of the economy.

### Database and elasticity adjustments

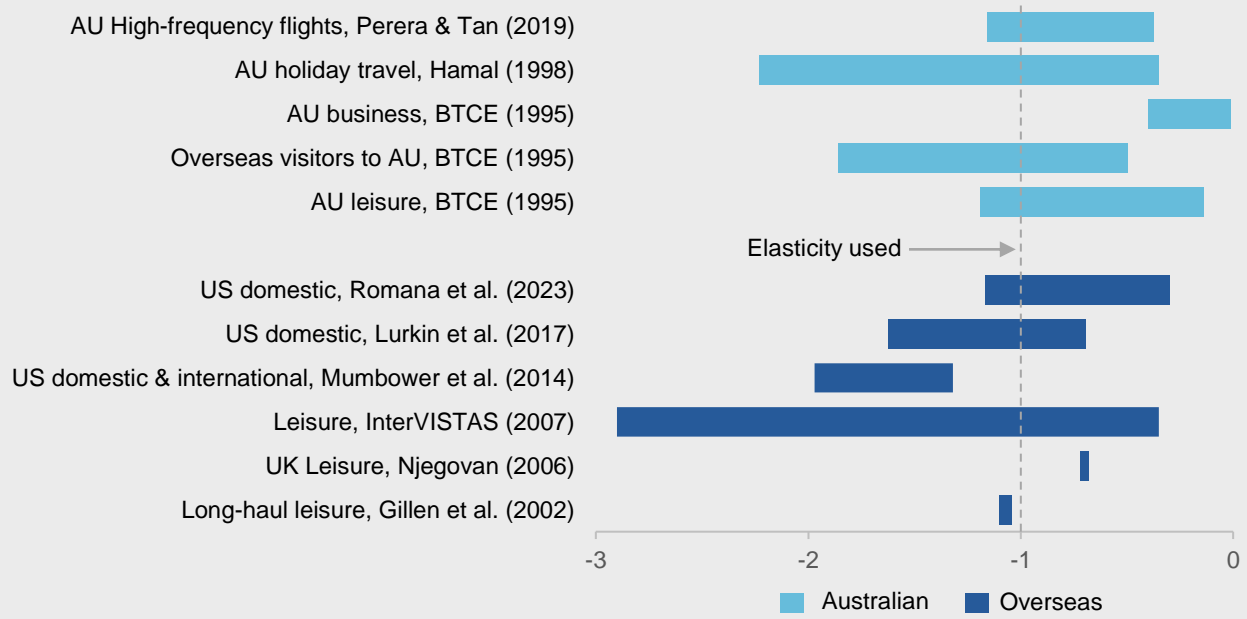
An important assumption in the model is the price elasticity of demand for air transport exports. If prices in the sector fall, the size of the demand response for exports will be a significant driver of any macroeconomic and industry level results. For this modelling exercise the elasticity is set to -1 based on a literature review (see box 1) which is within the range of all Australian estimates (in light blue) except the 1995 business travel estimate, and close to most international evidence (in dark blue).

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<sup>1</sup> Both domestic and international air travel for passengers as well as freight account for 0.5% of GDP in 2018-19 (ABS 2021, *2018-19 Input Output Tables*).

**Box 1 – Price elasticity of demand for air transport<sup>a</sup>**

Estimates for the price elasticity of demand for air transport vary considerably, in part because researchers analyse different geographic markets, flight lengths and types of travel. For travel within and to Australia (light blue bars) the range sits between -0.01 for business travel estimated in 1995, to -2.2 for Australian short-term resident departures for holidays estimated in 1998, with the 2019 estimate within that range. International estimates (dark blue bars) range from -0.3 to -2.9.



<sup>a</sup> The elasticity of demand indicates the percentage change in the demand for air services that occurs in response to a 1% change in the price of those services.

## 2. Causes of price decline

As the Commission was not aware of the policy reforms being contemplated, the analysis in this paper is based on hypothetical causes that could contribute to a 10% price decline in the aviation industry. To implement a price shock in a CGE model we need to understand what creates the price reduction.

Two broader causes that have potential cost or price reduction effects are considered:

1. Removing some oligopoly power that creates entry barriers and
2. Increasing productivity. The former could be triggered by a policy change or reform, while the latter may result from technical or regulatory changes.

These two causes have different impacts on the price.

- An entry barrier tends to restrict the competition and the supply of the industry, which could raise the price above its market level. The barrier benefits incumbents by creating super profits for the capital owners or an above average wage rate for its workers. As a result, consumers pay a higher price for their services.
- A rise in productivity is an increase in output with given inputs or a reduction in the input requirements for a given output. It has the potential to produce the same output at a lower cost. As a result, consumers tend to enjoy a lower price for the same services.

In this paper, it is assumed that an entry barrier in the air transport industry generates a rent above the market determined rental price of capital and the wage rate. The rent is received by the owner of the factors of production. Removing such a rent is expected to lower the cost of production in the air transport industry and the price of air services to its market determined level.

Productivity improvement in an industry is related to two broader categories of production inputs: intermediate products, and primary factors of production. In the model, productivity improvement is defined as input-augmenting technical change. It could be caused by the introduction of new technologies or some policy changes that induce a more efficient use of existing resources. In an industry, policy-induced productivity improvements are more likely to be associated with the use of factors of production, capital or labour, because the use of factors are heavily regulated by government policies. The demands for factors are also sensitive to the policy-induced changes in their prices.

As the focus of this research is on the policy related changes, the following modelling scenarios will use primary factor productivity, referred to as MFP, as a possible cause of price decline in the air transport industry.

In this paper, four simulations are implemented first (1A and 1B) to test how much change is required for each of the two causes to deliver a 10% decline in the price of air transport services. The third simulation (1C) is a test of a combination of the two causes, rent removal and MFP, required to reduce the same price decline. The last simulation (2) is used to remove a 10% rent on imports that brings about a 10% decline in the import price. The sectoral and nation-wide effects of each simulation are discussed and compared in detail.



## 3. Implementation

### 3.1 10% decrease in price of domestically produced air transport services (simulation 1A)

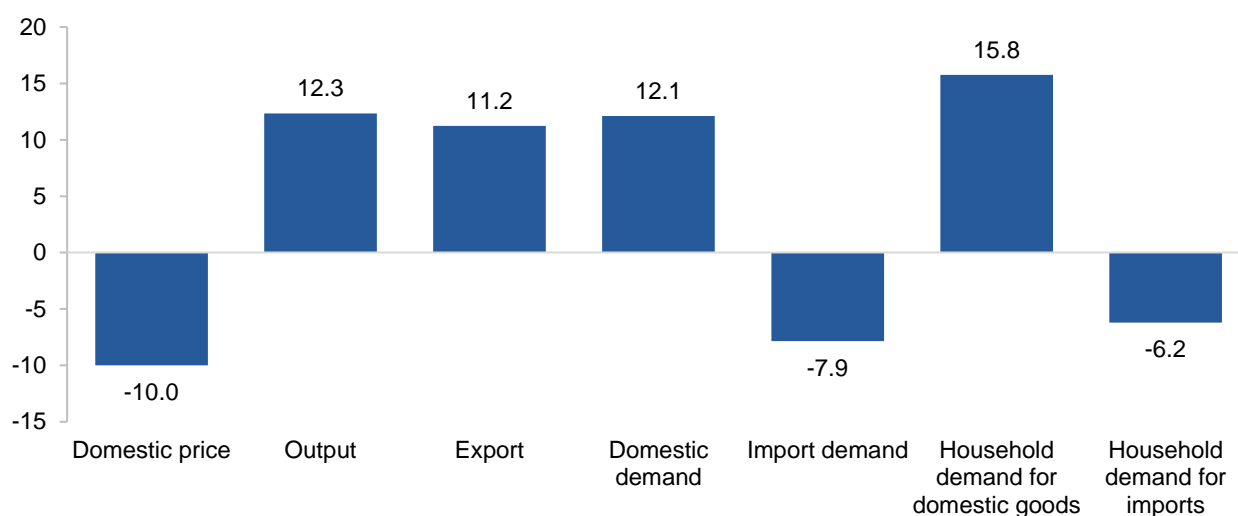
Supply is assumed to be constrained by some unspecified oligopoly power which prevents new entrants and gives rise to a scarcity rent that accrues to the incumbent operators. This rent is assumed to accrue to the owners of capital (that is, profits above the normal rate of return) and parts of labour (for example, management).

It is assumed that the factor costs in the air transport industry, recorded in the input-output data, already contain rents. These rents need to be separated explicitly from the factor costs in the model database to allow them to be removed in the simulation later. If the rent is the only cause of the price being 10% higher than its market level, the rent must be equivalent to ten percent of the cost of production after its removal. The current cost of the air transport industry is \$30.2 billion. To reduce the price by 10%, the rent to be removed needs to be \$2.75 billion,<sup>2</sup> equivalent to 10% of the cost of production, or 39% of the cost of factors in the free market. This simulation involves bringing down the price of domestic air travel by 10% by removing these monopoly rents.

#### Results

Lower air transport prices lead to increased demand for air transport (figure 2). Lower prices benefit consumers of air transport, particularly Australian households (who account for two-thirds of domestic usage), but also exports. This leads to an increase in Australian production (industry output). Lower domestic prices lead Australian consumers to switch away from imported air transport towards domestic output.

Figure 2 – Simulation 1A: Results for the air transport industry (% change)

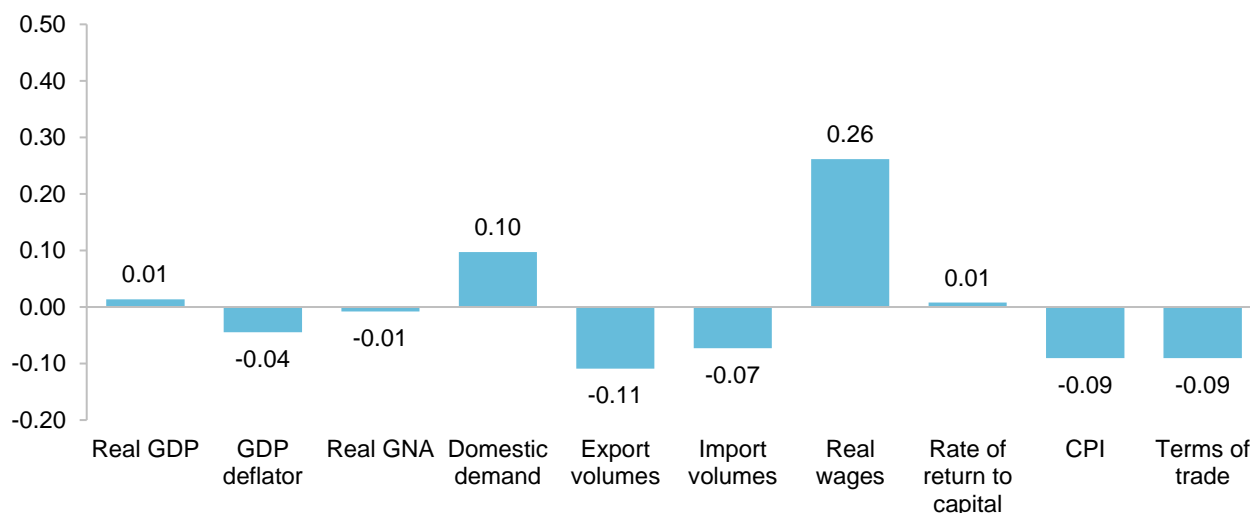


Source: PC National results.

<sup>2</sup>  $\frac{\$30.2 \text{ billion}}{\left(\frac{100}{10} + 1\right)} = \$2.75 \text{ billion}$

Eliminating rents has limited macroeconomic effects (figure 3). Real GDP is projected to increase marginally. This reflects the (relatively) small size of the industry in the broader economy. The air transport industry requires more labour, capital and other inputs to meet the now higher demand. The resulting increase in the demand for labour and capital, respectively, bid up real wages and the return on capital. This attracts labour and capital from other industries. The higher wages and return on capital increase production costs in the rest of the economy, which reduces their international competitiveness. Aggregate export volumes fall accordingly. The fall in the export price of air transport leads to a small fall in the terms of trade. The negative terms of trade effects reduce the purchasing power of national income, resulting in a small fall in real national expenditure (real GNA).

**Figure 3 – Simulation 1A: Macroeconomic results (% change)**



Source: PC National results.

The accompanying Excel file presents detailed results for all 114 industries in PC National. The main industries affected are key inputs into the air transport industry, particularly the aircraft manufacturing (parts and components), and petroleum and coal products (fuel) industries. This reflects the limited use of air freight transport by other industries.

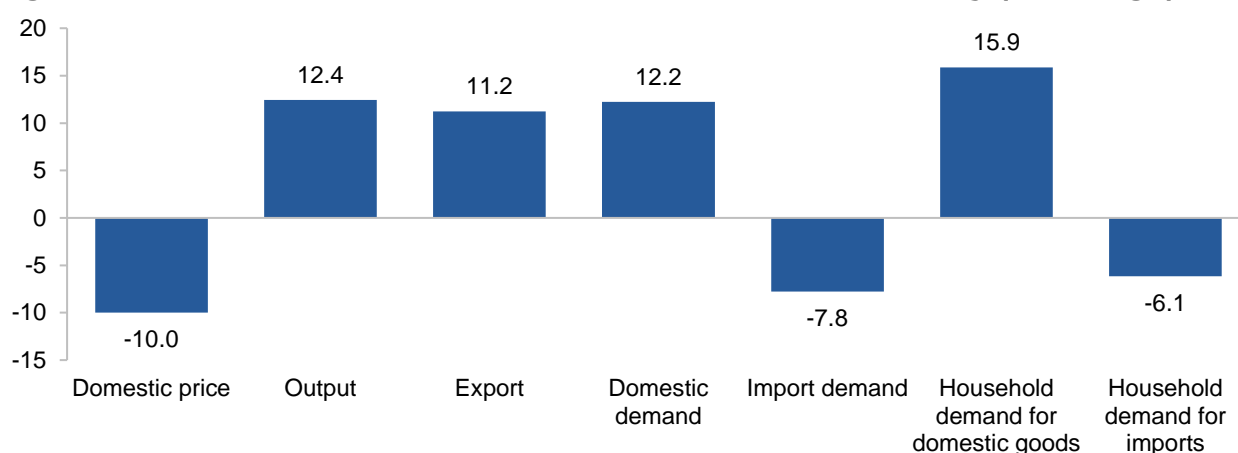
### 3.2 Improvement in MFP (simulation 1B)

Simulation 1B involves bringing down the price of domestic air travel by 10% through an improvement in MFP (applying to capital and labour) in the air transport industry. It is assumed that this improvement arises from some unspecified pro-competition reforms (such as reforming management of take-off and landing slots). The model determines the magnitude of the productivity improvement required to bring the price down by 10%.

#### Results

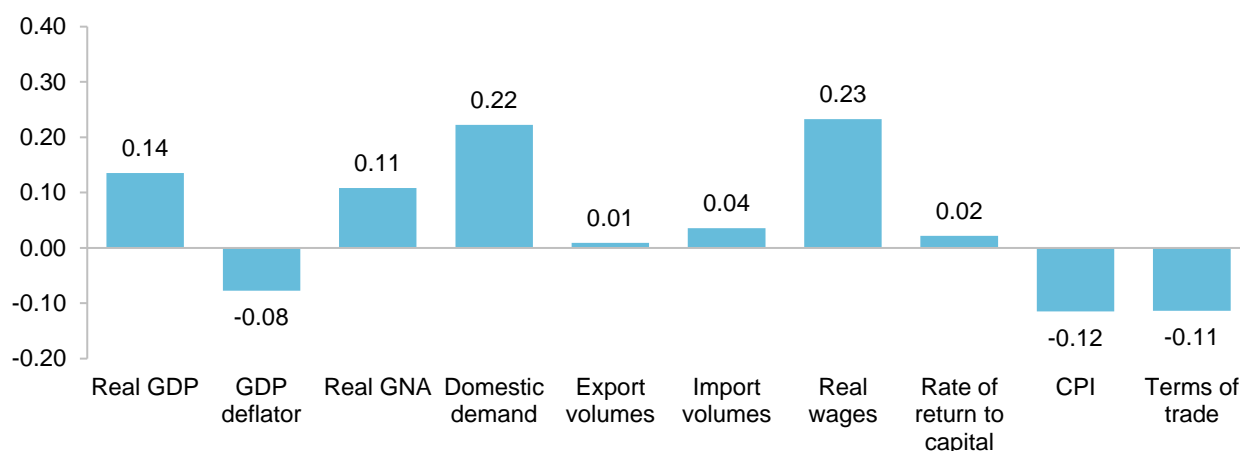
The results are broadly like those for simulation 1A. To bring down the price of air transport services, the factor productivity in the industry must increase by 27%.

At the air transport industry level, the responses to a 10% decline in the price on the demand side are remarkably similar to the previous scenario (figure 4). At the national level, however, the impact of improving the factor productivity is much greater (figure 5).

**Figure 4 – Simulation 1B: Results for the air transport industry (% change)**

Source: PC National results.

One significant difference is that the improvement in MFP increases the effective supply of labour and capital in the Australian economy. The productivity improvements means that the industry uses fewer resources to expand its output than under the rents scenario. These resources are available for use by other industries lowering the costs of their production and increasing their exports. The increased output and income lead to higher import volumes. This results in generally larger impacts compared to those from dissipating rents.

**Figure 5 – Simulation 1B: Macroeconomic results (% change)**

Source: PC National results.

### 3.3 Combining the effects of model rent reduction and productivity improvements (simulation 1C)

This simulation is used to test the combined effects of rent removal and MFP improvement on the economy. It is assumed that these two causes contribute equally to the 10% price decline.<sup>3</sup>

To implement this simulation, the rent in the database is reduced from 10% of the cost to 5% of the cost of production, or 17% of the cost of factors (that is, \$1.4 billion). When this rent is removed, the domestic price

<sup>3</sup> We also tested results with other distributions from 10/90 to 90/10 and the results look like 1A or 1B depending on the proportion of impact from either. The 50/50 scenario presents the balanced case.

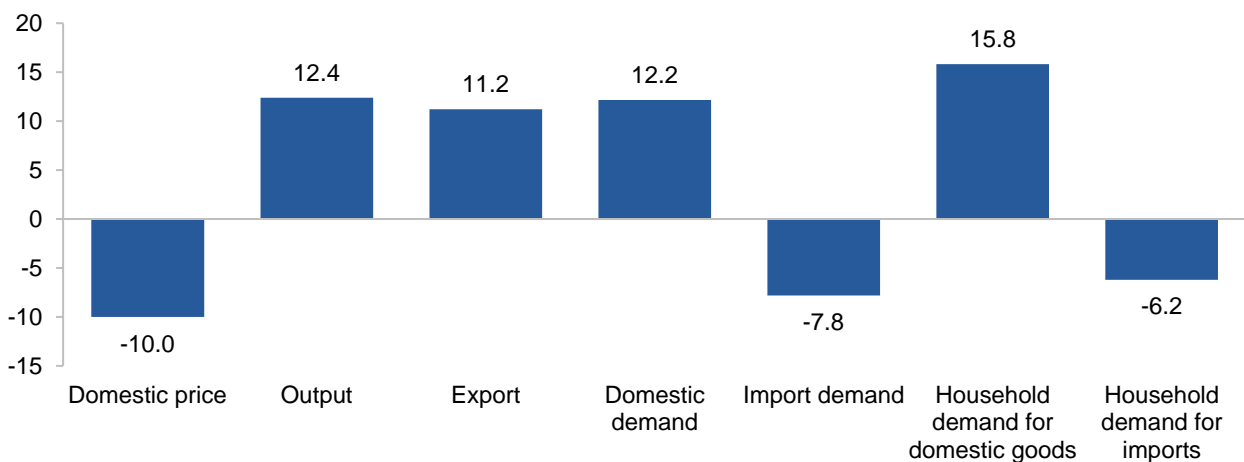
of air services is expected to decrease by 5%. The rest of the price decrease is modelled to come from the MFP improvement.

**Results**

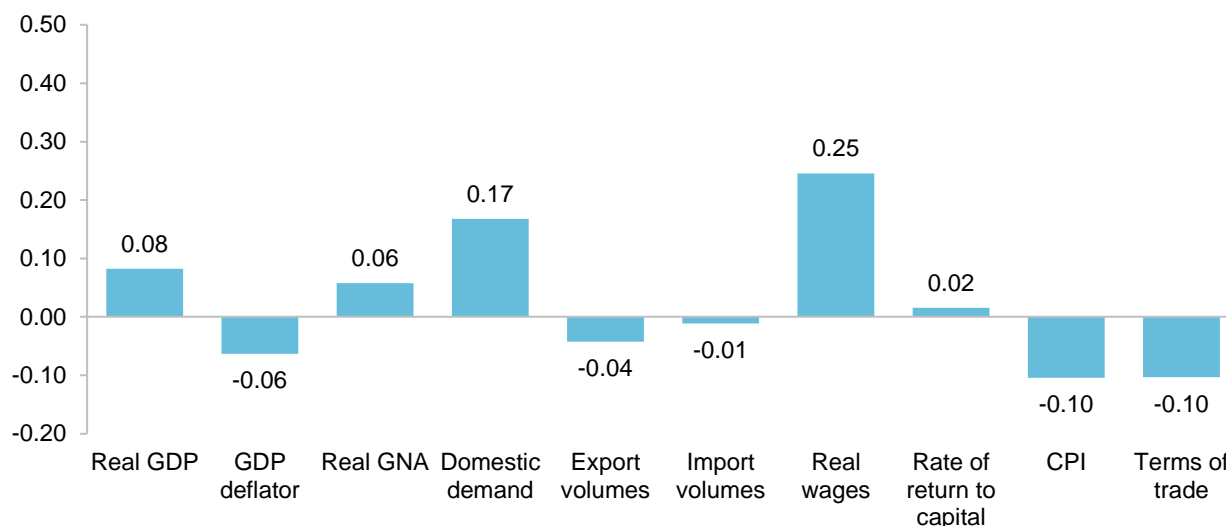
At the air transport industry level, again, this combined simulation (figure 6) gives very similar results on its price, output, domestic demand, exports and imports of air services to that of simulations 1A and 1B in the previous sections. The simulation also shows that lowering the price of air services by 10% requires the removal of a rent of 17% of factor cost plus a 14.7% rise in MFP in the industry.

At the national level, the results also show a similar pattern to that of sim 1B, but on a smaller scale. Although both rent removal and MFP improvement lower the air transport price by the same proportion (5%), the former contributes little to national income (figure 7). It is the MFP improvement that dominates the national results. This is because MFP improvement releases capital and labour from the industry to be used elsewhere. This factor augmenting tech change has a much greater impact on the national economy than a reallocation of existing factors, associated with rent removal. As MFP contributes half of the price decline in air services, its impact on national income (real GDP) is also largely proportionate to its contribution. Real GDP increases by 0.08%, compared with 0.14% from scenario 1B. The impact of these two shocks on real national expenditure (real GNA) is slightly less than that on real GDP. Real GNA increases by 0.06%. This is because the negative terms-of-trade effect reduce the purchasing power of the gain in national income.

**Figure 6 – Simulation 1C: Results for the air transport industry (%)**



Source: PC National results.

**Figure 7 – Simulation 1C: Macroeconomic results (%)**

Source: PC National results.

We also tested different combinations than the 50/50 split between rent reduction and MFP, which effectively provide a linear relationship between outputs in simulations 1A and 1B.

### Results from an alternative closure – letting capital change

The above results are derived from a simulation with national capital supply fixed. Under this condition, when the rates of return changes, capital stock can be reallocated across all industries to maximise its returns. The total capital stock remains unchanged. For a small open economy, however, its domestic rate of return to capital is determined by the international market. This is because free movement of capital across its border ensures its domestic rate of return equate to the international rate of return.

To introduce a free capital market in the above simulation, the rate of return needs to be fixed while capital supply is set as endogenous. When national capital is fixed in simulation 1C, the rate of return increases by 0.02%. When the capital market opens, the higher rate of return induces foreign capital inflow. It spreads across all industries until their rates of return fall back to the given international level. In the end, capital stock increases by 0.02% and real GDP increases by 0.09%, less than 0.01% higher than when capital is fixed. Although all the other indicators are marginally greater than before, the overall pattern of their responses remain unaffected by this alternative model closure with an open capital market.

## 3.4 10% decrease in the price of imported air transport services (simulation 2)

Simulation 2 involves reducing the price of imported air services by 10%. This assumes the lower prices arise from removing an entry barrier to allow for increased foreign airline competition.

International airline flights into and out of Australia, and their actions while in Australia, are highly regulated. These regulations restrict the airlines that can fly into Australia, the cities they can fly into and out of, what they do while in Australia, and the number of flights on offer.

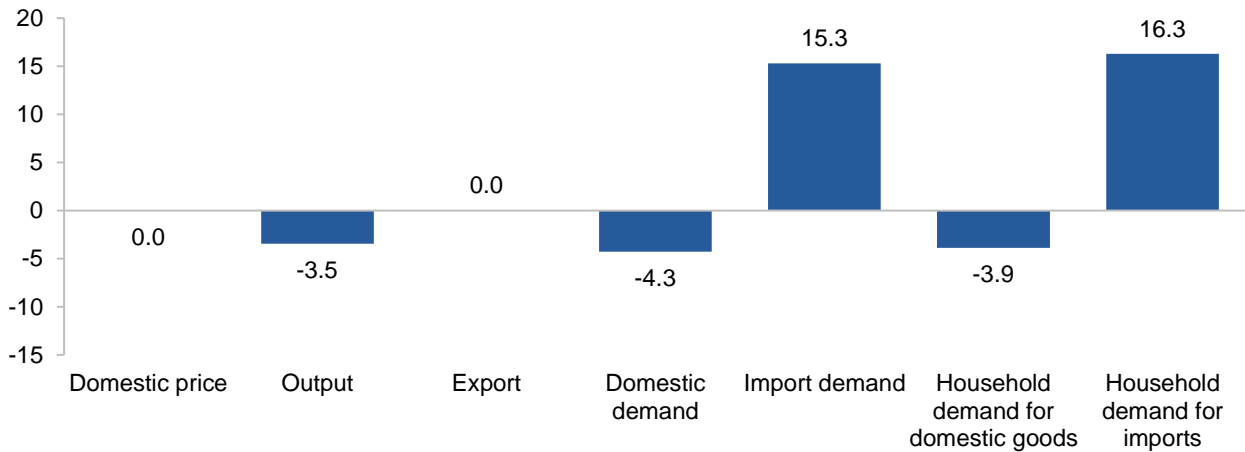
International airlines are unable to transport Australian passengers and freight between Australian cities (known as cabotage). When a foreign airline provides services in the domestic market or sells to households, it represents an import of services.

These restrictions limit competition and keep prices higher than they might otherwise be. The scenario involves removing these restrictions.

**Results**

The lower cost of imported air services leads to a switch away from domestic aviation services towards the now cheaper imports and a reduction in domestic output figure 8). The lower prices benefit domestic consumers of air services, particularly households. As the imports of air transport services are very small, the impact of this simulation is negligible at the national level with almost no change in real GDP (figure 9). Real GNA increases slightly due to an improvement in the terms of trade.

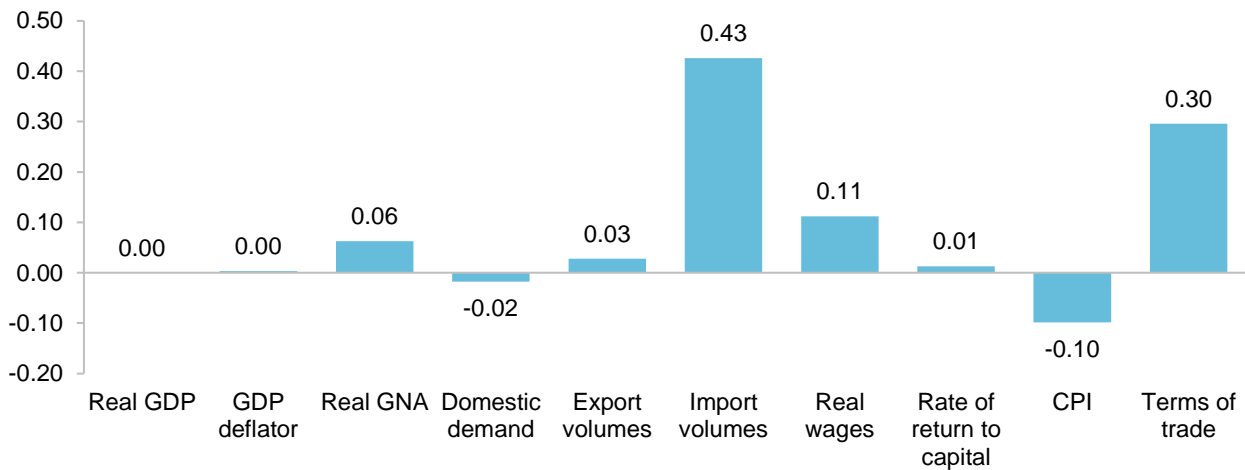
**Figure 8 – Simulation 2: Results for the air transport industry (% change)**



Source: PC National results.

Contraction of the domestic aviation industry frees up resources for use by other industries, but has relatively little impact on the macroeconomy, except on the import side.

**Figure 9 – Simulation 2: Macroeconomic results (% change)**



Source: PC National results.

**Box 2 – An alternative mechanism – more productive intermediate input sectors**

An alternative way to model a price reduction is to assume that intermediate inputs become cheaper as there is a productivity improvement in the use of intermediate inputs in the aviation industry.

Unlike factor inputs, the demands for intermediate inputs in an industry are determined by the underlying technology adopted by the industry to produce its output. For a given production technology, the inputs required to produce one unit of output are largely given. These input-output relationship can only be altered by changing production technology. For example, a new and more advanced airplane may reduce the use of fuel and parts, so that the cost of producing air services may be reduced. This productivity improvement in intermediate inputs is driven by firms' cost-minimising behaviour, not immediate policy change or reform to the sector. As such, a simultaneous improvement in all intermediate inputs did not seem a reasonable assumption for modelling the impact of aviation sector reforms.

Such an assumption would have a much larger economic impact as multiple intermediate products feed into other sectors beyond aviation, and release factors of production and cost-savings that become available for use in other industries. This greater benefit is based on the assumption of a broad technology change, or a wide-sweeping reform that would take in everything from components, through fuel and other intermediaries, many of which have their prices given by the international market, or rely on international technology improvements.

**Impact on factor markets**

Rent removal (1A) and productivity increases (1B) have different impacts on the demands of the air transport industry for labour and capital. When rents are removed, the industry's demands for factors are expected to increase, so that it draws factors of production from other industries. Removing rents encourages a more efficient uses of resources. As total available factors are fixed, the effects of rent removal on the national economy tends to be limited.

When factor productivity improves, on the other hand, capital and labour become more productive in the air transport industry. For a given demand for its output, the industry may no longer require the same amount of capital and labour as before. As a result, its demands for factors are expected to decline. In the above scenario, for example, the demands for capital and labour decline by about 4% and are re-allocated to other sectors. This additional capital and labour are readily available for use in other industries. This is the reason why productivity improvements produce larger benefits to the whole economy, as opposed to the rent removal scenario.

# Attachment



## Stylised representation of the air transport sector in PC National

### Aviation industry cost data from the model, 2018-19 (\$ million)<sup>a</sup>

	\$m	Share
Domestic intermediate inputs	13,855	46%
Imported intermediate inputs	5,381	18%
Margins	877	3%
Duty	3	0%
GST	0	0%
Taxes	142	0%
Subsidies	-10	0%
Labour	5,610	19%
Capital	4,116	14%
Taxes on goods	282	1%
<b>Total</b>	<b>30,255</b>	<b>100%</b>

a. Fuel accounted for 20% of total industry costs.

### Breakdown of primary factor income, 2018-19 (\$ million)

	Income	Rent	Remainder
Labour income	5,610	1,586	4,024
Capital income	4,116	1,164	2,952
<b>Gross primary factor income</b>	<b>9,726</b>	<b>2,750</b>	<b>6,975</b>

### Sales of air transport in the model database, 2018-19 (\$ million)

	Industry use	Household	Government	Investment	Stocks	Exports	Total	Share
Domestic air transport	8,840	14,103	0	171	-123	5,772	28,762	69%
Foreign air transport	3,284	9,405	0	0	0	0	12,689	31%
<b>Air transport</b>	<b>12,124</b>	<b>23,508</b>	<b>0</b>	<b>171</b>	<b>-123</b>	<b>5,772</b>	<b>41,451</b>	<b>100%</b>
<b>Share</b>	<b>29%</b>	<b>57%</b>	<b>0%</b>	<b>0%</b>	<b>0%</b>	<b>14%</b>	<b>100%</b>	

Total costs differ marginally from total sales because the air transport industry in the ABS input-output tables differs slightly from the product air transport. This is because there is some minor production of other products by the air transport industry (such as postal and courier services).

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