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APEC Tourism & Transport Working Groups

Final Report

for TPT 02/2009

Study of International Visitor Flows and Greenhouse
Gas Emissions for a Template to Examine the Impact
on APEC Economies of Future Market-based
Measures Applying to International Transport

November 2009

Executive Summary

This is GHD Meyrick's final report for the APEC Tourism and Transport Working Group joint project: TPT 02/2009 *Study of International Visitor Flows and Greenhouse Gas Emissions for a Template to Examine the Impact on APEC Economies of Future Market-based Measures Applying to International Transport*.

The project is led by Australia[1], with co-sponsoring economies being New Zealand, Thailand and Singapore. The project focuses on selected APEC member economies: Australia, Brunei Darussalam, Indonesia, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand and Viet Nam.

In summary, the objectives of the project are:

- To understand aviation visitor flows and greenhouse gas emissions
- To examine the impact on APEC member economies of future market-based measures applying to international transport;
- To develop a pilot economic model to assist the development of future tourism and transport policies relating to emissions; and
- To inform sustainable policy approaches to international tourist air travel emissions in APEC.

This report explains the pilot model developed for this study, which in turn establishes a framework for a detailed study of this issue. This report first explores intermediate relationships required to answer key questions about the economic impacts of applying market-based measures to international aviation. Some key relationships and findings of this project are:

- *the nature of aviation-related greenhouse gas emissions* – the climate impacts of aviation emissions are found to be several multiples of those suggested by CO_2 emissions alone;
- *the market-based measures that are likely to be put in place for emissions mitigation with respect to international aviation* – a 'cap and trade' system appears more likely to be implemented than competing options, with a price of less than US$50 per tonne likely to prevail in the short term;
- *the nature, magnitude and importance of international aviation tourism movements* – analysis shows a wide variety of aviation flows and different levels dependence on tourism income across sample economies;
- *the relationship between unit passenger costs of aviation, fuel prices and distance flown* – this relationship is found to be complex, with fuel costs per passenger increasing more rapidly than operating costs as distance increases;

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[1] Jointly managed by the Department of Infrastructure, Transport, Regional Development and Local Government and the Department of Resources, Energy and Tourism.

- *the responsiveness of international aviation demand to the application of a market-based measure to mitigate emissions* – estimates of demand responsiveness to price were found to vary depending on distance flown and the destination region; and
- *the importance of international aviation-based tourism for women* – a case study approach suggests gender impacts are not likely to be a significant consideration.

Based upon these relationships, a pilot economic model was developed. This model is not intended to provide definitive estimates of the impacts of market-based measures to reduce aviation emissions. Instead the level of detail and complexity included in the model aims to be commensurate with the quality of the available data. As such, model estimates should be interpreted as broad 'order of magnitude' estimates of likely impacts.

Overall, the modelling results suggest that the proposed market-based emission-reduction measures are likely to reduce international aviation demand reductions by a maximum of 5 percent, while GDP is expected to decline by a maximum 0.5 percent as a result of the measures. These are upper bound estimates: it probable that the impact will be considerably lower, but the lack of defined global emissions reduction target, as well as the numerous limitations of the available data, makes estimating precisely how much lower impossible at this time.

The current study is intended as a pilot modelling exercise, and as such has been limited in resources and geographical coverage. This report (and the supporting model) demonstrates that a more detailed modelling exercise is both feasible – particularly with more extensive data – and potentially useful using the current modelling framework.

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1. Introduction

This is GHD Meyrick’s final report for the APEC Tourism and Transport Working Group joint project: TPT 02/2009 *Study of International Visitor Flows and Greenhouse Gas Emissions for a Template to Examine the Impact on APEC Economies of Future Market-based Measures Applying to International Transport*.

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1.1 Motivation for the study

The growing volumes of international passenger air travel can be viewed as a growing opportunity or problem depending on one’s perspective. Bringing tourism visitors to an economy from distant origins offers large tourism and development opportunities. At the same time, people are increasingly recognising the environmental impacts that aviation can have, both locally with noise and particulate emissions and globally through climate change.

The motivation for this study is to better understand broadly how significant the trade-off might be between reducing environmental impacts from aviation and the potential loss of tourism income. This understanding may assist in the development of tourism, transport and environmental policy in APEC member economies.

The importance of tourism income to APEC economies is clear in an aggregate sense; however, it can also be disproportionately important to particular social and gender segments. Specifically, this study considers the role of women in the tourism sector and the degree to which the economic impacts from climate change policy may disproportionately affect them.

1.2 Approach to the modelling

A key component of the study task is the development of a pilot economic model which seeks to approximately quantify potential impacts that market-based measures to mitigate climate change associated with international aviation would have on the tourism income of member economies.

In the relatively short time available, it has been necessary to create a model that is as robust as possible without being excessively difficult to compile or for end users to operate. As in any modelling exercise, the approach has required a number of simplifying assumptions and perspectives. This section briefly outlines the modelling approach.

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[2] Jointly managed by the Department of Infrastructure, Transport, Regional Development and Local Government and the Department of Resources, Energy and Tourism.

The model is not a forecasting model in that it does not seek to capture all of the determinants of current and future tourism demand in order to make predictions into future years. Instead the focus is on being able to apply “what if” scenarios to “current” tourism demand to see what this demand would look like with and without the market-based measures to mitigate climate change. This perspective will be relevant to changes that occur over the coming few years (though the specific income and aviation demand values will vary), though more complex modelling would be required to understand impacts over ten or more years.

In creating the model, the overall philosophy has been to build in flexibility so that the model can be used to test a range of inputs, rather than spend excessive resources on compiling a “definitive” set of expected parameter values. This approach can ultimately be more powerful for users. Parameter values can also be tested for sensitivity to examine how important it is to get each of the values “right”. Some guidance is provided to model users about more likely values of variables such as the carbon price and demand responsiveness to price changes. In short, the model strives for practical usefulness rather than a purist’s complexity.

1.3 Outline of report

The report’s structure broadly follows the logical development of the modelling and its data requirements. Chapter 2 provides an overview of aviation’s contribution to greenhouse gases and climate change as well as the potential mitigation effort. This chapter also examines the likely pricing of emissions under a mitigation policy. Chapter 3 describes the modelling approach to air distances and current aviation passenger flows between origin economies and destinations within the APEC member sample economies. Chapter 4 explains the approach to estimation of airfares and cost increases associated with the market-based measures. Chapter 5 explains how the information and estimates from preceding chapters are used to estimate the demand for international aviation to APEC sample economies under the market-based measures scenarios. Chapter 6 provides some information about the tourism sector in order to understand the potential income and employment implications of the estimated reduction in aviation demand. Chapter 7 discusses the limitations of and potential improvements to the modelling, while chapter 8 provides concluding remarks.

2. Greenhouse gases and aviation

2.1 Greenhouse gases and climate change

The United Nations International Panel on Climate Change (UN IPCC) defines climate change as "a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2007, p. 30). This definition includes climate impacts from natural sources (such as volcanoes) and human-induced changes (including emissions of carbon dioxide or land use changes) (Garnaut, 2008).

The human-induced component of climate change can be thought of as an enhanced 'greenhouse effect'. Here, additional gases in the atmosphere (such as carbon dioxide) work to trap more heat from sunlight than would be the case without human-induced emissions (Garnaut, 2008). While warming is the most obvious impact of the process, many other aspects of the climate system are ultimately affected, such as rainfall and the frequency of severe weather events.[3]

2.2 Aviation impacts on climate

There are several ways in which flights can contribute to climate change:

- **Carbon dioxide** (CO_2) emissions from burning fuel, which affects the climate in the same way as CO_2 emissions from other sources (IPCC, 1999). In total, CO_2 emissions from aviation accounted for 1.5 to 2% of total emissions for 'Annex 1' economies[4] in 2006 (UNFCCC, 2009).
- **Nitrogen oxides** (NO and NO_2, NO_x collectively) emissions from burning fuel. The effect of these emissions tends to be localised near the point of emission due to their short lives in the atmosphere (IPCC, 1999). NO_x participates in ozone chemistry in the upper troposphere and lower stratosphere: the concentration of ozone (O_3) is expected to increase in response to NO_x increases and methane (CH_4) is expected to decrease (IPCC, 1999). The estimated net climate impact of these forces is additional warming of around 50% of the CO_2 impact (Sausen *et al*., 2005).
- **Water vapour, sulphate and soot** emissions from emissions made in the upper troposphere and lower stratosphere. The warming effect from these emissions largely occurs due to the formation of condensation trails ("contrails", see Figure 1), which are "visible line clouds that form behind

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[3] In addition, Garnaut (2008) notes that it is not simply concentrations of greenhouse gases that drive warming or other climate changes: the amount of cloud cover can also affect the balance of temperatures at the earth's surface and varying altitudes in the atmosphere.

[4] Annex I economies include the industrialised economies that were members of the Organisation for Economic Co-operation and Development in 1992, plus some economies in transition - http://unfccc.int/parties_and_observers/items/2704.php

aircraft flying in sufficiently cold air as a result of water vapour emissions" (IPCC, 1999, Chapter 3). The effect of contrail formation – i.e. the *indirect* impact of water vapour emissions – is estimated at a further warming of around 50% of the CO_2 impact (Sausen *et al*., 2005). The small *direct* effects of emissions of water vapour and soot are mostly offset by the cooling effects of sulphate emissions (Sausen *et al*., 2005).

- **Cirrus cloud formation** – Sausen *et al*.(2005) highlight three ways in which aviation can contribute to additional cirrus cloud formation. An estimate of the warming potential of such cloud formation suggests that the effect may be as large as the CO_2 impact alone. However, there is significant uncertainty around this estimate (from 40 to 315% of the CO_2 impact) and scientific understanding of the issue is nascent (Sausen *et al*., 2005).

Figure 1: Example of condensation trails ("contrails")

Source: http://www.wrh.noaa.gov/fgz/science/contrail.php

Taken together, these aviation contributions represent 2 to 4 times the impacts on climate than are suggested by aviation-related CO_2 emissions alone. However, in this study, only the CO_2 emissions are considered under policy responses to climate change.

2.3 Potential responses to aviation impacts on climate

2.3.1 General framework for mitigation of climate change

Much work has been done to coordinate a global response to attempt to restrict the extent of climate change ('mitigation') as well as the impacts of 'locked-in' climate change ('adaptation'). The United Nations Framework Convention on Climate Change (UNFCCC) has the objective to stabilise "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous … interference with the climate system" (UN, 1992, p. 4).

Stabilisation of atmospheric greenhouse gas concentrations generally requires that global emissions are reduced at some point in the future.[5] In general, the lower the concentration targets, the more rapid and larger the reductions in emissions must be.

2.3.2 Market-based measures

The measures proposed to mitigate the effects and degree of climate change are generally broken down into voluntary measures and policy interventions. Voluntary measures include discretionary 'carbon offsets' and personal choices about consumption, while policy interventions can involve mandating efficiency improvements, taxing emissions or emissions trading.

For the present study, the task is to analyse the potential impacts of policy interventions that use market-based measures to mitigate the impacts of emissions from international aviation. The main market-based measures considered require airlines to hold a carbon permit, buy a carbon offset or pay a tax for each tonne of CO_2 (and other greenhouse gases) emitted in its operations.

By requiring firms to pay additional costs (either through taxation or requiring permits), the policy intervention will raise the costs of supplying aviation services to passengers (and freight). The main aim of doing this is to reduce the quantity of greenhouse gases emitted.[6] However, the impact is to raise airfares which encourage lower use of aviation relative to non-polluting goods and services. It is only because of the negative side effects of aviation (in this instance we focus on the contribution to climate change) that these extra costs (and reduction in demand) would be seen as desirable from the perspective of social well-being.

Among the market-based measures suggested, the most likely policy to be implemented around the world is emissions trading, requiring emitters to hold and then surrender permits for all of their greenhouse gas emissions.

The UNFCCC considers emissions from international aviation (and maritime transport), collectively known as international bunker fuel emissions, to be problematic with respect to attributing to specific countries. In greenhouse gas emission inventories, these bunker fuel emissions are still calculated, but are excluded from national totals and reported separately. These emissions are not part of reduction commitments made by countries under the Convention and the Kyoto Protocol.

The International Civil Aviation Organization (ICAO), a UN aviation agency, is working with the UNFCCC in order to find an adequate mechanism for the inclusion of international aviation in global efforts to reduce greenhouse gas emissions. The current

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[5] Other possibilities include removing gases from the atmosphere either through photosynthesis (i.e. growing plants) or harvesting then burying gases (geo-sequestration).

[6] A secondary aim could be the desire to raise funds to spend on adaptation to, and mitigation of, climate change (see ICAO, 2009b).

proposals supported by ICAO involves both voluntary measures – such as purchasing fuel-efficient new aircraft – and market-based measures.

There are somewhat diverging views from ICAO member states as to the most appropriate policy responses or measures with respect to aviation emission reductions. And, as with the overall climate change mitigation negotiations, “each State would retain the ultimate authority to choose the portfolio of measures appropriate to its circumstances, consistent with the global aspirational goals” (ICAO, 2009a, p. 1).

Airline industry groups have been broadly supportive of ICAO’s approach and have displayed a preference for emissions trading. The largest group, International Air Transport Association (IATA), has made clear its preference for a global-coverage emissions trading scheme combined with technological, operational and infrastructure improvements (IATA, 2008). Separately, an aviation industry and NGO coalition, the Aviation Global Deal group has proposed an open emissions trading mechanism with revenues being shared among climate change adaptation and mitigation activities in developing countries and research into less emissions-intensive aviation technology (AGD group, 2009).

2.4 Expected magnitude of carbon price

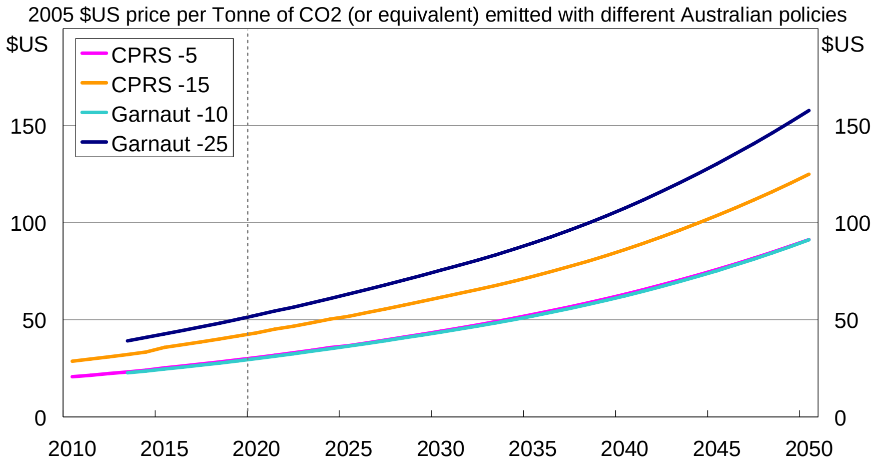
The previous section posited that any implementation of market-based measures for mitigation of climate change is likely to involve a form of emissions trading rather than a direct tax on emissions. Such an approach is typically favoured due to its ability to deliver specific quantity reductions in emissions, which in turn can be guided by scientific recommendations. The particular global price for emissions will reflect the costs of making reductions and demand for emissions-generating goods and services at a point in time. On the other hand, a tax will provide more certainty about this carbon price, but the resulting emissions are less certain, suggesting the tax approach is less able to meet specific emissions targets without regular re-calibration. In other words, the level of tax required to reduce emissions is difficult to establish.

For our purposes, it would be preferable to know a specific price of emissions so that we can establish how large the airfare change will be for a given route. This would allow the application of established estimates for the magnitude of demand response to airfare changes to estimate the tourism reduction that may result from carbon pricing. A tax level that was known in advance would supply this input. With emissions trading, we require two things: (1) an understanding of the likely global emissions target, and (2) an estimate price of emissions permits that would reduce emissions to this level. The first of these requirements is not known since the magnitude of any global agreement beyond 2012 (as well as the likelihood of including aviation emissions) is to be negotiated in Copenhagen in December 2009.

In the meantime, scenarios for both emissions projections and the economic situation have been performed that provide some guidance for the likely price level for emissions trading permits. One such forecasting exercise was performed by the Australian Treasury (2008) for the Garnaut Review (2008). Treasury modelled four emissions scenarios which related Australia's emissions targets to global emissions scenarios that would be consistent with those targets (i.e. higher reduction commitments from Australia would be consistent with lower global emissions).

Under these four scenarios emission prices were estimated between 2010 and 2050. Larger reductions in emissions are associated with higher emissions permit prices, with the largest (Australian) reduction scenario of 25% reduction in emissions from 2000 levels by 2020 associated with a carbon price of around US$40/Tonne in 2013 and a little over US$50/Tonne by 2020 (Figure 2). Less ambitious global emission reduction agreements are associated with prices between US$20 and US$30/Tonne. While these prices are by no means certain, they give a rough order of magnitude for the likely carbon price for our analysis. Sensitivity analysis can test how important the specific level of this price is likely to be in choices about policy with respect to tourism impacts.

Figure 2: Potential Carbon Prices



Source: Australian Treasury modelling (2008)

The following chapters explore the approach and data requirements for the modelling exercise in more detail.

3. Current aviation routes and usage

This chapter explores the nature and extent of international aviation flows. The primary aim of doing so is to generate estimates of distances and current demand associated with international air travel to sample economies in the APEC region, which provides baseline data for the modelling of the impact of carbon pricing on tourism income.

3.1 Approach

International aviation flows do not easily lend themselves to economic modelling. A key source of complexity is the route possibilities *between* two countries; on longer flights, passengers typically have one or more options for a stopover en route. A further source of complexity is route possibilities *within* origin or destination countries. For example the Indonesia-Australia journey may involve a domestic flight on each end, even though the Jakarta-Sydney flight is direct.

3.1.1 Hubs for stopovers

To deal fully with the possibility of stopovers on each route, a detailed examination of current flight schedules would be required. Such a task is not possible within the time available to construct a pilot model in this project.

Instead the approach taken was simply to assume that all flights go direct from one country to another. For some origin-destination pairs, the distance (and CO_2 emission) errors introduced by this approach can be significant. To examine the potential size of these errors, we studied the actual flight routes for services between Auckland and Ho Chi Minh City as shown in Box A.

The evidence presented in this case study suggests that there is potential for significant divergence between the distances and emissions of the direct versus actual flight paths. This means that improved precision could be achieved by analysing flight schedules in order to establish the likely average number of stopovers between each origin and destination pair as well as a suitable ‘distance penalty’ that could be applied in order to ensure relatively accurate estimates of distances and emissions between these pairs. The pilot model has been constructed to allow for both of these factors to be included in any future work or estimation by model users.

3.1.2 Domestic legs of international trips

The secondary complication in international aviation origin and destination distances has also been minimised in our pilot model. While it is technically possible to generate a full matrix of city-to-city origin-destination pairs of distances, CO_2 emissions and aviation travel, in practice such a matrix would be enormous, particularly if a specific route was identified for each city pair (e.g. Queenstown-Hanoi could be Queenstown-Auckland-Singapore-Hanoi or Queenstown-Sydney-Bangkok-Hanoi or many other possibilities). A simpler approach – used here – is to (1) isolate the domestic leg of the travel and exclude it from consideration of the international journey, and (2) assume that all international travel takes place via each country's most trafficked international airport.

3.2 Aviation distances

3.2.1 International distances

Using the simplified approach outlined in section 3.1, a matrix of 'great circle distances', which measure the shortest surface distances between two points (i.e. going 'around' rather than through the earth), has been created using an online calculator. The distances used in the matrix are therefore direct (i.e. exclusive of stopovers) distances between each economy's most trafficked international airport.

3.2.2 Short- versus long-haul

In aviation, it is often useful to draw the distinction between short- and long-haul flights. However, this distinction is not clear-cut in the literature or in practice. A second complication is that a classification of medium-haul flights is often considered. Further, various classifications of these flights can be by hours or distance. A survey of the cut-offs suggests that the following values tend to be used:

- Short-haul: less than about 3,000 km or 3 hours;
- Medium-haul: between 3,000 and 6,500 km or 3 to 6 hours; and
- Long-haul: greater than 6,500 km or 6 hours.

For a single cut-off point between short- and long-haul (given that aircraft tend not to travel at 1,000 km/h), we generally use a compromise value of 4,000 km as the upper bound for a short-haul flight.[7] This translates to 5 – 6 hours flight time.

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[7] As discussed later, this parameter can be adjusted in the final model by users if required.

Box A – Case study: Analysing the ‘no stopover’ assumption

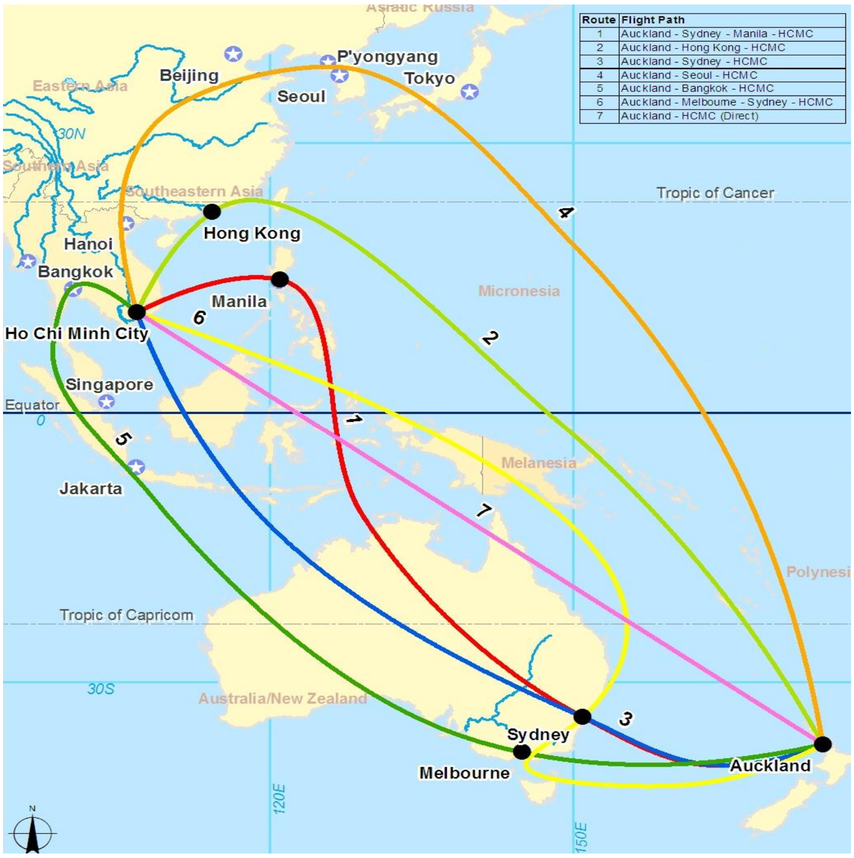
This case study examines the soundness of the assumption that all flights are direct by comparing the distance and emissions of direct flights with those for a number of real flight patterns that incorporate stopovers.

Between many of the major airports in the sample economies, direct flights are possible and are the usual route taken – for example, Jakarta – Sydney, Kuala Lumpur – Bangkok, or Sydney and Auckland. However, the nature of modern ‘hub and spoke’ airline operations is such that the majority of origin-destination pairs are linked with flights involving multiple stages, incorporating stopovers or a change of services at one or more intermediate airports.

This case study examines how significant these stopovers are relative to a hypothetical direct flight between Auckland and Ho Chi Minh City – the airports with highest international traffic volumes in New Zealand and Viet Nam, respectively.

Figure A1 shows the potential routes that are offered on www.expedia.com for a range of airlines. This illustrates the wide range of possibilities for indirect routing that show the degree of variation associated with the strict assumption that all flights operate directly.

Figure A1: Flight routes between Auckland and Ho Chi Minh City



Route	Flight Path
1	Auckland - Sydney - Manila - HCMC
2	Auckland - Hong Kong - HCMC
3	Auckland - Sydney - HCMC
4	Auckland - Seoul - HCMC
5	Auckland - Bangkok - HCMC
6	Auckland - Melbourne - Sydney - HCMC
7	Auckland - HCMC (Direct)

Table A1 examines the distance and per-passenger emissions characteristics of the hypothetical direct flight (derived from the great circle distance and a linear regression of emissions on distance – see Figure 5). This is compared with the combined distances and emissions from the ICAO emissions calculator (see section 4.2).

Table A1: Flight characteristics between Auckland and Ho Chi Minh City

			Distance		CO2/pass.	
Route	**Stop 1**	**Stop 2**	**(km)**	**Difference with direct (%)**	**(est. kg)**	**Difference with direct (%)**
1	Sydney	Manila	10,022	13	791	18
2	Hong Kong	-	10,644	20	912	36
3	Sydney	-	8,994	2	710	6
4	Seoul	-	13,187	49	1,056	57
5	Bangkok	-	10,306	16	914	36
6	Melbourne	Sydney	10,173	15	844	26
7 (direct)	**-**	**-**	**8,854**	**0**	**672**	**0**

Sources: Expedia, ICAO (2008)

This table illustrates that the differences between the distance flown for a direct flight are potentially significant between these two origins and destinations. In the case of the flight via Seoul the difference is nearly 50 percent. Flights via Sydney only are just 2 percent longer than the hypothetical direct flight.

In general, the flights chosen by passengers will tend to have shorter total lengths both to minimise travel time, and because there should be a positive relationship between distance and fares. Indeed, the majority of services between Auckland and Ho Chi Minh City are between 10 and 20 percent longer than the direct route.

A further point to note in Table A1 is that the CO_2 emissions tend to be disproportionately higher than the distances since there is a fixed fuel burn component associated with the landing and takeoff phases of flight. The relationship between distance and CO_2 emissions per passenger is complicated by the different fleet of aircraft used to service each leg. By travelling slightly further to a hub airport that runs ‘trunk’ services, it is possible to lower the per passenger emissions (and costs) by using larger aircraft.

3.3 Aviation flows

3.3.1 Data complications and approach

Data on international aviation flows are available from a range of national and international sources. For this pilot model, the decision has been made to rely on national sources in light of the relatively small sample of destination economies. More detailed and geographically comprehensive (though expensive) data could be obtained from IATA if a more detailed modelling exercise were to be undertaken.

National data on international arrivals is typically gathered from border control arrival cards. These cards typically give information about duration of stay, nationality and mode of arrival. In practice a huge amount of data is collected from these cards but a variable amount is distilled in a form that is appropriate for our model. Specifically, for each sample economy, we require total arrivals split down by mode (separating air from land/sea arrivals) and by country of origin (nationality is used as a proxy for this).

As expected, many sample economies are not able to provide such detailed arrivals data. In some cases the mode split was not available. In other cases only a small selection of total arrivals are allocated to specific countries. In some economies both limitations were present. In any case, in these instances we have gathered sufficient data from numerous sources to provide reasonable estimates of the required flows for available aggregate data.

Where modal splits of total arrivals into air and non-air arrivals were unavailable, judgement was used to estimate this proportion. For example, for neighbouring economies that share a significant land border, the proportion of arrivals by air may be just 30 percent. However, for island economies such as Australia and New Zealand, around 99 percent of arrivals would be expected to be by air.

In a similar fashion, where arrivals were allocated to origins such as ‘other’, ‘other western Europe’ or ‘unallocated’, these arrival values were split according to estimates based on judgement and on similar economies with more detailed arrival data.

3.3.2 Arrivals data and estimates

The full matrix of (estimated) aviation arrivals to each destination in the sample economies is utilised in the pilot model. This matrix contains estimated numbers of aviation passengers that have originated from each economy with outbound tourists recorded (up to 120 for one destination in the most detailed data series). These figures relate to the latest available year for which most economies have records, 2007 or 2008, though some data relates to earlier years. Due to the size of the total matrix, only a summary can be displayed in Table 1.

Table 1: Aviation arrivals by origin region, thousands, 2007/8*

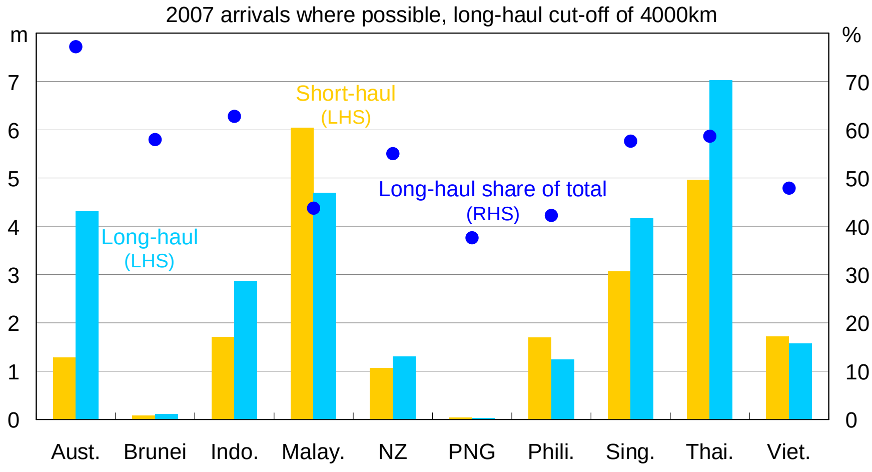
Destination Economy / Origin Region	Aust-ralia	Brunei	Indo-nesia	Malay-sia	NZ	PNG	Philip-pines	Sing-apore	Thai-land	Viet-nam
Asia, *of which:*	2,209	96	3,127	8,012	450	17	1,739	4,799	6,607	2,215
- Sample Asia	*704*	*60*	*1,534*	*5,220*	*87*	*8*	*251*	*1,995*	*1,456*	*536*
- Other Asia	*1,505*	*36*	*1,593*	*2,792*	*363*	*8*	*1,488*	*2,804*	*5,151*	*1,679*
Oceania, *of which:*	1,272	12	398	532	1,084	41	178	845	730	301
- Aust/NZ	*1,113*	*12*	*340*	*483*	*976*	*39*	*135*	*831*	*714*	*301*
- Other Oceania	*159*	*0*	*57*	*49*	*108*	*3*	*43*	*14*	*15*	*0*
Europe	1,358	36	797	1,666	511	4	325	1,097	3,667	233
Americas	644	42	220	301	294	6	698	416	850	534
Africa	101	0	28	222	28	0	4	76	122	0
Total	**5,586**	**185**	**4,570**	**10,734**	**2,366**	**68**	**2,944**	**7,233**	**11,975**	**3,283**

* Some economies did not have 2007 or 2008 data available, so most recent available data were used

Sources: national sources, consultant estimates and interpolations

A summary measure of the composition of international visitors to each of the sample economies is the share of visitors arriving by long- and short-haul flights. Based on a long-haul flight cut-off of 4000 km, the available data suggest that more than half of air arrivals visiting Australia, Brunei, Indonesia, New Zealand, Singapore and Thailand are long-haul; with the remaining sample economies having short-haul air arrivals dominating (Figure 3). This analysis also gives a broad idea of which economies will have relatively high emissions intensity of their international tourism income: more and longer visitor trips imply greater carbon intensity of these tourism dollars.

Figure 3: Distance composition of international visitor arrivals



Sources: national sources, consultant estimates

4. Aviation costs and fare changes

This chapter explores the likely impact that market-based measures to address climate change on airline costs and airfares. Establishing this impact requires an understanding of the cost structure of typical airline operations, including the fuel component that is the source of greenhouse gas emissions.

4.1 Aviation fares and costs

There are two potential approaches to establishing how great the percentage change in airfares is likely to be in response to a price being placed on emissions:

- Observed market **prices** and emissions – this approach often involves choosing a specific type of ticket, length of stay, and time horizon for travel then searching fares on a flight booking website (e.g. Tol, 2007). Fare increases can then be calculated using the carbon price and emissions per flight on the each route pair (either via an engineering approach or using an online emissions calculator). While an easily understood approach, observing market prices at a point in time is not likely to yield particularly stable results. This is because airlines may price seats at any given time according to capacity surpluses and shortages that do not properly represent long-term cost recovery (Hensher and Brewer, 2001).
- Airline **cost** increments – under the assumption that over longer periods airfares will actually reflect operating costs, it is possible to calculate the likely percentage change in fares resulting from the carbon price. This approach requires a knowledge of the operating cost structure of airlines, including how fuel and total operating costs vary over different distances.

The modelling here uses the cost approach both for computational simplicity and in order to ensure robustness of results. Further, the cost approach does not require the calculation of absolute operating costs or airfares since the percentage change is all that is required in the application of price elasticity estimates (see section 5.3).

4.2 Cost structure

The percentage change in operating costs with the inclusion of a price on carbon dioxide emissions can be defined in terms of a number of variables:

$$\begin{aligned}\%\Delta OpCost_{ij} &= \frac{\Delta OpCost_j}{OpCost} \times 100 \\ &= \frac{CP_i \cdot k}{FP_j} \cdot \left(\frac{FCost}{OpCost}\right)_j \times 100, \qquad (1)\end{aligned}$$

where *OpCost* is the operating cost attributable to each passenger on a specific route, CP_i is the carbon price ($US per tonne) in scenario *i*, *k* is a constant reflecting the CO_2

content of a litre of jet fuel, FP_j is the fuel price in scenario j, $(FCost/OpCost)_j$ is the share of operating costs accounted by fuel costs in fuel scenario j. The first half of this expression contains terms that are either selectable in the model according to scenarios (i.e. CP_i and FP_j) or are known constants (k = 2.53 Kg/L). The main difficulty is understanding how large a share fuel costs account for in total operating costs.

IATA (2007) reviewed company reports of 45 international passenger airlines to estimate the shares of each major expense in airline operating costs. The results indicate that the two major line items are labour and fuel expenses (Table 2). While labour shares tend to vary by region (due to wage differences in each economy), they are relatively stable across time, accounting for around 25 percent of operating expenses. The fuel price share is much more volatile across time, due in large part to the volatility in aviation fuel prices, which are linked to oil prices.

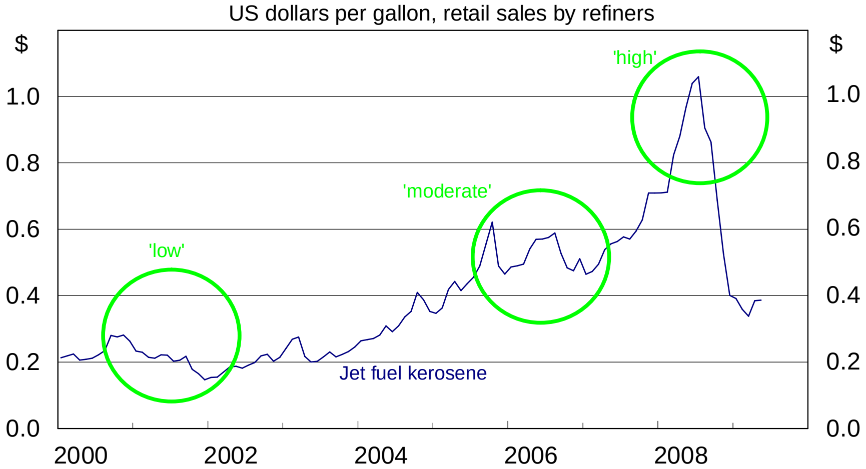
Table 2: Percentage Share of Airline Operating Costs, by Region of Airline Registration

	North America		**Europe**		**Asia Pacific**		**All Major Airlines**	
	2001	*2006*	*2001*	*2006*	*2001*	*2006*	*2001*	*2006*
Labour	36.2	25.2	27.2	25.8	17.2	17.2	28.3	23.3
Fuel	13.4	26.6	12.2	20.5	15.7	30.4	13.6	25.5
Aircraft Rentals	5.5	3.7	2.9	3.1	6.3	2.4	5.0	3.5
Depreciation /Amortisation	6.0	4.9	7.1	6.7	7.4	7.3	6.7	6.0
Other	38.9	39.6	50.6	43.9	53.4	42.7	46.4	41.7

Source: IATA (2007)

Given the volatility in the fuel share of operating costs, we include scenario-based estimates for this variable in the model (Table 3). Estimates correspond to a ‘low’, ‘moderate’ and ‘high’ aviation fuel price in the US (Figure 4) based on a broad relationship between these prices and the cost shares in Table 2.

Figure 4: Aviation fuel prices



Source: US Energy Information Administration

Table 3: Fuel Share Scenarios

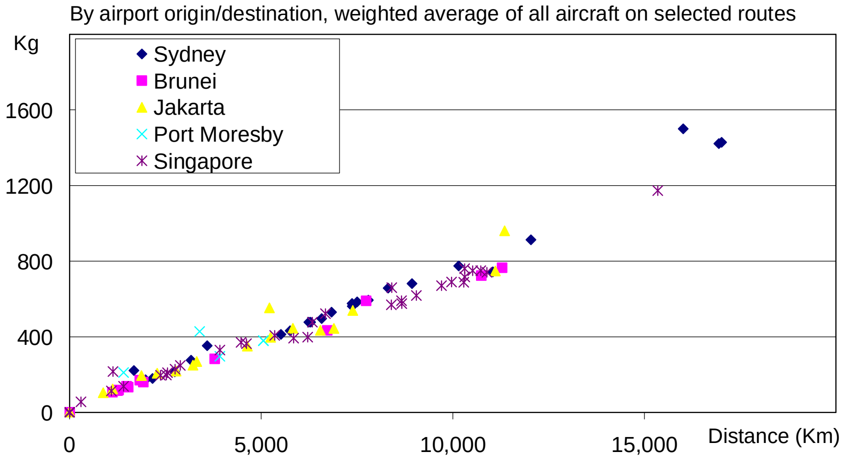
Fuel Price Scenario	Fuel Price ($US/L)	Reference Year	Fuel Share (% of total operating costs)
Low	0.20	2001	15
Moderate	0.53	2006	30
High	0.80	2008	40

Source: IATA (2007), consultant estimates, US Energy Information Administration (2009)

Equation (1) does not encompass percentage changes in operating costs that vary across distances. This variability is likely to be present in the $(FCost/OpCost)_j$ term, which may vary according to distance travelled. Consider the two parts of this term: fuel cost and operating costs. Each of these costs will increase with increasing distance flown. However, they may not increase at exactly the same rate. This implies the ratio between them (i.e. $(FCost/OpCost)_j$) will not necessarily be constant across all distances flown.

Establishing aircraft fuel cost and operating cost models is a significant modelling exercise in itself and is beyond the scope of this project. Instead, a literature review was undertaken in order to gauge the likely forms of the fuel cost and operating cost relationships with distance flown. The ICAO (2008) calculator examines emissions attributable per economy-class air passenger by examining fuel use when flying between linked origins and destinations. These calculations are made according to average loadings, splits between freight and passengers, and the various classes of passengers; it also considers the characteristics of the aircraft actually flown on each route. The final stage of the calculation converts fuel burn to CO_2 emissions per passenger by multiplying by a constant factor (3.157) which represents the “number of tonnes of CO_2 produced by burning a tonne of aviation fuel” (ICAO, 2008, p. 6). An exercise of generating a table of CO_2 emissions per passenger versus distances between (directly linked) origins and destinations within our sample reveals a broadly linear relationship between fuel burn per passenger and distance travelled (Figure 5).

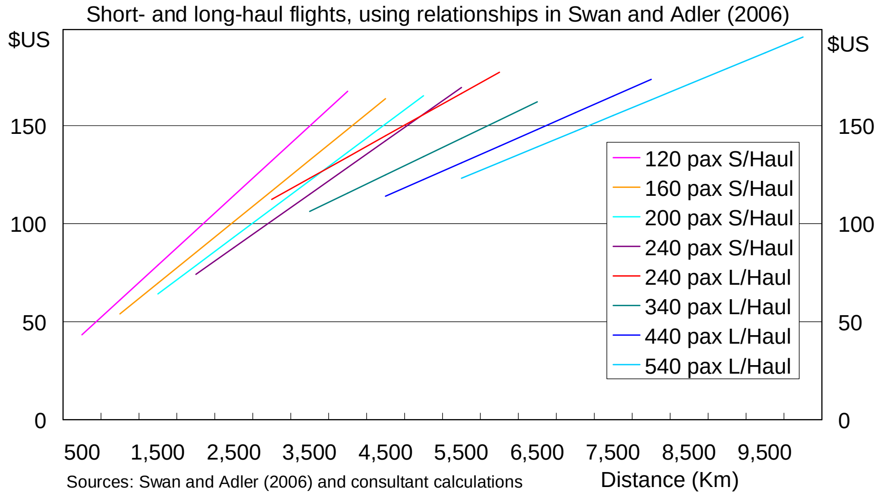
Figure 5: Emissions relationship with distance implied by ICAO calculator



Source: ICAO calculator

Swan and Adler (2006) generate aircraft operating cost functions for short- and long-haul flights for a range of aircraft based upon both the capacity of the aircraft and the distance flown. Application of the results suggests that operating costs per passenger increase at a decreasing rate as distances flown increase – i.e. a non-linear relationship. This is due to two factors: the greater increase in costs per passenger with increasing distance associated with short-haul (compared to long-haul), and the move towards larger aircraft at longer distances that can harness lower average costs (Swan and Adler, 2006). Graphing the examples according to the relationships in Swan and Adler's (2006) work shows that as distances increase, the switch to larger aircraft and from short- to long-haul cost factors results in a less-than linear overall relationship (Figure 6).

Figure 6: Operating cost relationship with distance



Sources: Swan and Adler (2006) and consultant calculations

Combining this information about the 'shapes' of the relationships between fuel cost and distance, and operating costs and distance, we can suggest that the joint ratio (i.e. $(FCost/OpCost)_j$) will not be constant across distance. Instead, the evidence suggests that the ratio will increase with increasing distance. The exact scale of this relationship is not known, since we would have to be able to calibrate the fuel-price-dependent $FCost/OpCost_j$s in Table 3 across distances. This would require full specification of fuel cost functions (possible from the ICAO calculator) and operating cost functions (extremely difficult) that depend upon fuel prices *and* distance. Instead, a simplifying assumption is made that the $FCost/OpCost_j$ ratio values in Table 3 represent an average of each of short-haul or long-haul flights. Therefore, we take the stylised increasing $FCost/OpCost_j$ function to mean that the fuel cost ratio is higher than average for long-haul flights and lower than average for short-haul flights. We therefore have to choose the degree to which the $FCost/OpCost_j$ ratios will be higher than the means in Table 3 for long-haul and similarly the degree to which this will be lower for short-haul flights. This is controlled by a single (symmetrical) parameter, termed the 'fuel price sensitivity', and is selectable by the user in the pilot model.

4.3 Cost increases under a carbon price

As is clear from the preceding section, projecting increases in cost per passenger under a carbon price will depend a great deal on the scenario expected for the fuel price and the carbon price. These costs per passenger will clearly vary between origin and destination pairs in our sample, however, to give some indication of the magnitude of this impact, an average of estimated cost increases across all origin-destination pairs in the sample is provided for a range of fuel prices and carbon prices (Table 4).

Table 4: Average percentage change in costs per passenger among sample-economy-destined flights*

Carbon Price (US$/Tonne)	Fuel Price (US$/L) 0.20	0.53	0.80
10	2.1	1.6	1.4
30	6.2	4.7	4.1
50	10.4	7.8	6.9

*Assumes fuel cost share sensitivity = +/- 15% and long haul cut off = 4000km

These calculations demonstrate the intuitive result that higher carbon prices will imply a greater increase in operator costs than lower carbon prices. They also show that with higher (pre-tax) fuel prices, the impact of a given carbon price will be relatively low since the carbon price accounts for a relatively small share to fuel and total operating costs. The results also suggest that although there is significant variation across the price scenarios, the overall magnitude of the operating cost change is typically less than 10% for most feasible short-term values for both the carbon price and fuel price. This variation can be compared with the 500% increase in fuel prices observed between 2000 and 2008 or the subsequent 50% reduction since the peak in 2008 (Figure 4).

The following chapters use this background information to consider the impacts on aviation demand and national income of the implementation of market-based measures to reduce aviation emissions.

5. Aviation demand under a carbon price

This chapter pulls together the strands from previous chapters in order to estimate the expected demand impact of applying market-based measures to reduce international aviation emissions.

5.1 Factors influencing aviation demand

This chapter focuses on the influence that price has over people's demand for international aviation. However, in practice, a number of factors will influence demand:

- Travel time (in-'vehicle' time plus access time, waiting, frequency, etc.) relative to other modes where available. In practice some international passenger transport can be done by non-aviation modes, such as rail, road or sea in similar amounts of time.
- Airfares relative to other costs of other modes where available. The impact of the inclusion of a carbon price may be complicated by price changes of substitutes.
- Comfort relative to other modes if available.
- Incomes will also determine how much international travel can be consumed.
- Types of travel – business versus personal. Demand characteristics will differ significantly according to the purpose of travel. Business travel tends to be relatively inflexible in time and place, while personal travel can be shifted in time (and even place) according to price signals.

This model does not attempt to undertake any sophisticated modelling of these factors, instead making an assumption that the current conditions (e.g. for country incomes) will remain broadly unchanged in the modelled scenario.

5.2 Price elasticity of demand for aviation

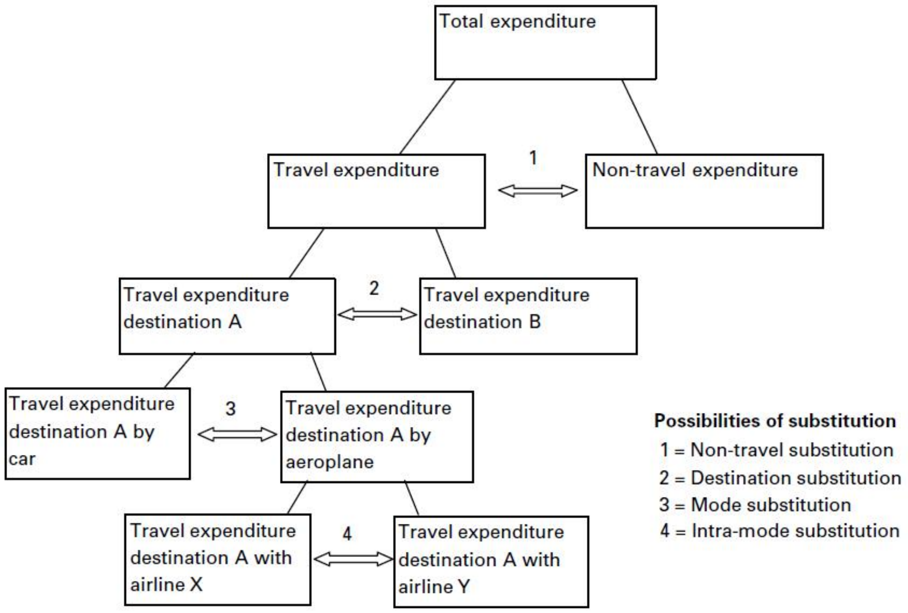
This study takes a relatively simple approach to modelling demand responses which is based on the economic concept of elasticity. In short, an elasticity measures the specific responsiveness of demand to a percentage change in another variable (often a price), while all other variables are held constant. In this instance, we use a (own) price elasticity of demand, which is given by:

$$\varepsilon_p = \frac{\%\Delta Q}{\%\Delta P}, \qquad (2)$$

where $\%\Delta Q$ is the percentage change in international aviation and $\%\Delta P$ is the percentage change in international airfares. The discussion in chapter 4 describes in detail our approach for understanding the likely change in airfares (via aviation costs) that we are considering in the modelling. Rearranging equation (2) shows that with suitable estimates of the price elasticity of international aviation demand will allow the calculation of the percentage change in aviation demand. This section expands on the previous one to establish appropriate elasticity values to apply to our matrix of percentage air costs for travel to APEC sample economies.

Many factors will influence the price elasticity of air travel, including the substitutability of travel on a number of variables (Figure 7).

Figure 7: Substitution possibilities in international aviation



Source: Brons, et al (2002)

In assessing the impacts of an across-the-board increase in airfares on tourism we are interested in substitution possibilities for: (1) non travel, (2) destinations, and (3) modes. (We are not interested in this investigation in intra-mode substitution since it is presumed that fare increases will be proportional across all air carriers.) Each of the relevant factors are considered here to understand if a single elasticity is appropriate or if separate elasticities should be applied to each region, country or route.

1. The travel/no-travel sensitivity to price is likely to be related to the share that fares will be of tourists' incomes. In aggregate, this is likely to be influenced by tourist composition within each region. Specifically, we would expect that in origin regions where there is a sizeable middle class, demand will be more price sensitive than in places without a significant middle class (since aviation demands in the latter will be dominated by high income earners for whom airfares are a low proportion of their incomes) (Brons, et al, 2002).
2. The choice of destination is only likely to be affected by the imposition of a universal fare increase insofar as people may substitute towards *closer* (and typically less expensive) destinations as opposed to any distortion towards low-tax destinations which may occur with non-universal application. With

universal application of the fare increase, this effect is likely to roughly uniform across geographical regions (Brons, et al, 2002).

3. Mode substitution is likely to be a more significant issue for countries that have good international land and sea links, but close to irrelevant for countries such as Australia and New Zealand. In the former case we would expect higher demand responsiveness to airfare increases since other modes may become more appealing. Similarly, other things being equal, short-haul flights are likely to be more substitutable for other modes and so would be likely to have higher price sensitivities than long-haul flights.

A recent elasticity study for IATA estimates region-specific elasticities to account for the factors above, including an adjustment factor to account for higher elasticities of short-haul flights. The estimates relevant to this study are found in Table 5.

Table 5: Elasticities for air travel from region-wide fare changes

Region	Short-haul	Long-haul
Intra Asia	-0.63	-0.57
Trans Pacific (N. America – Asia)	-0.40	-0.36
Europe – Asia	-0.59	-0.54

Source: InterVISTAS (2007)

5.3 Estimated changes in aviation flows under a carbon price

The elasticities from the previous section are applied to the percentage changes in fuel prices implied by certain fuel prices (which are in turn influenced by the base fuel price and the ‘fuel price sensitivity’ defined in section 4.2) to estimate percentage changes in aviation demand for relevant market segments (Table 6). Results indicate, that with ‘moderate’ base fuel prices, the change in international aviation demand to sample APEC economies under a carbon price of around US$50/Tonne is likely to be between 3% and 5%.. These calculations indicate that the aggregate impacts for economic activities associated with international aviation are not likely to be transformative. Within this overall figure, lower demand responses from more distant origins (particularly North America) is reflective of the lack of alternative travel modes and relatively high incomes.

Table 6: Representative percentage changes in aviation demand with various carbon prices*

Region	**Short-haul**				**Long-haul**			
Carbon Price: ($US/Tonne)	**10**	**30**	**50**	**100**	**10**	**30**	**50**	**100**
Intra Asia	-0.8	-2.3	-3.8	-7.7	-0.9	-2.8	-4.7	-9.4
Trans Pacific (N. America – Asia)	na	na	na	na	-0.6	-1.8	-3.0	-5.9
Europe – Asia	na	na	na	na	-0.9	-2.7	-4.4	-8.9

* Assumes that fuel price is 'moderate' at $US0.53/litre and fuel price sensitivity is +/- 15% different to average values for long-/short-haul

The lower demand response from short-haul compared to long-haul passengers evident in Table 6 is to some extent an artefact of a specific parameter choice. Specifically, the fuel price sensitivity, which measures the degree to which fuel operating costs account for a greater share of operating costs in long-haul flights than in short-haul ones, is set at a higher percentage (15%) than the extent to which elasticities on long-haul flights are smaller than those on short-haul flights (10%). This suggests that improving the accuracy of this parameter would be important in better understanding the relative aviation demand response from various locations.

6. Impact of a carbon price on tourism income

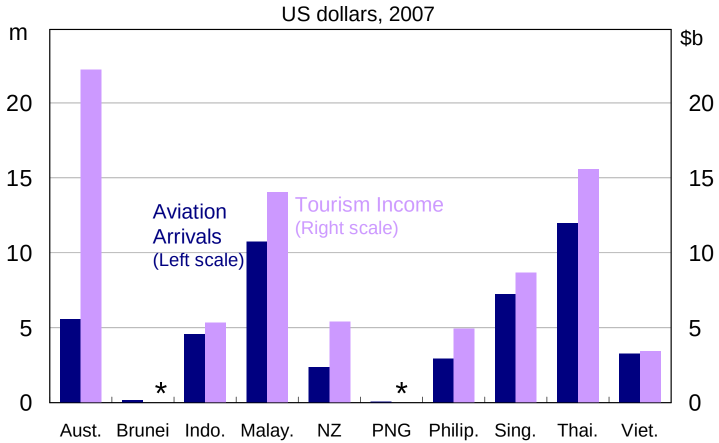
6.1 Tourism in context

This section seeks to place tourism in context to understand its importance to member economies and people within those economies.

6.1.1 Arrivals and Income

To give a sense of the importance of the international tourism industry to the sample economies, statistics about tourism arrivals and income have been collected and estimated. These indicate that many of the economies received over US$5 billion over 2007 (or 2008) (Figure 8). In this same time period, over 10 million tourists arrived by air to Thailand and Malaysia, with most other economies receiving between 2 and 7 million aviation arrivals.

Figure 8: Tourism arrivals and income



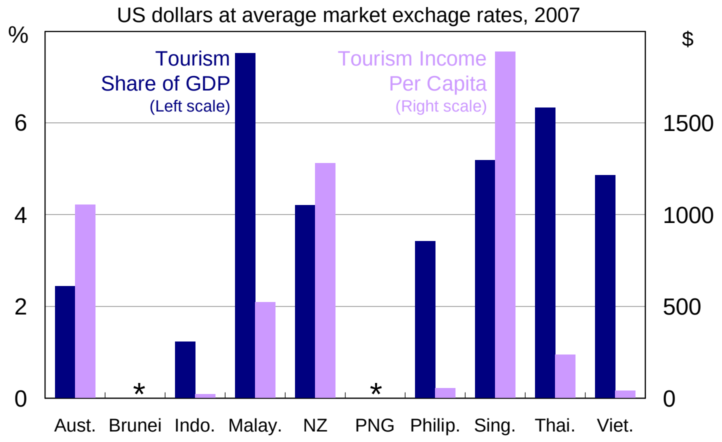
* No tourism income data available

Source: Consultant estimates, UNWTO, IMF

6.1.2 Share of GDP

Perhaps more instructive still on the importance of tourism to people in the sample economies is the share of GDP that tourism accounts for, as well as the income per person that the industry provides. The former measure illustrates that Malaysia, Singapore, Thailand and Vietnam all receive greater than 5 percent of their income from tourism (Figure 9). In absolute terms though, Australia, New Zealand, Singapore and Malaysia are the only economies where on average per capita receipts from tourism are greater than $500 per annum.

Figure 9: Importance of Tourism



* No tourism income data available

Source: Consultant estimates, UNWTO, IMF

6.1.3 Aviation as share of tourist arrivals and income

The issue of insufficient data detail discussed in section 3.3.1 means that the numbers of international arrivals coming by air has been estimated from total international arrivals, which are commonly only available on the basis of origin country (or region) rather than mode. This provides a serviceable estimate of aviation arrivals from each origin country. However, it is less easy to apportion income generated from tourism to these *aviation* arrivals from each country.

In general, we might expect that travellers arriving from lower-income origin economies may have lower tourism expenditure per arrival. However, even this assumption is not necessarily robust since high-income earners within these economies may be the only people who would travel internationally, whose spending on tourism services may equal or surpass the middle-income earning travellers of higher-income economies.

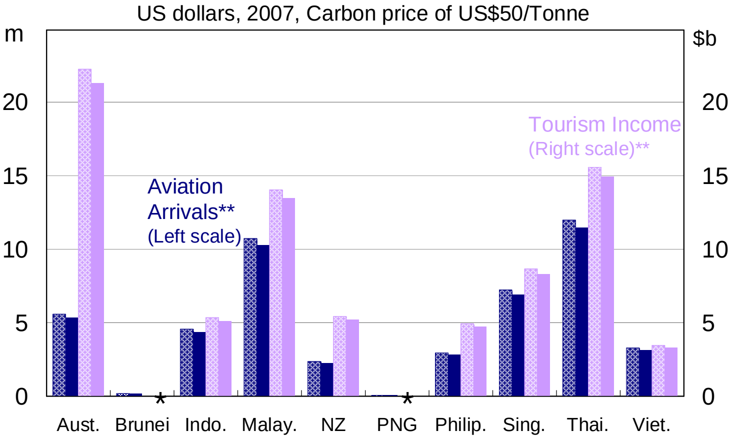
In the present modelling we make the (extreme) assumption that all tourism income is attributable to visitors who arrive by air and that this income is generated equally per arrival regardless of country of origin. In practice, this means that the impacts on tourism income will likely be overstated in the modelling for two reasons. First, reductions in total tourism arrivals are likely to be lower than estimated because some visiting air passengers will be business travellers who tend to have lower responsiveness to price changes (Hensher and Brewer, 2001). Second, income from visitor arrivals by sea and land should be unaffected by the carbon price for aviation emissions.

6.2 Changes in tourism income under a carbon tax

Under the assumption that all tourism income is attributable to visitors who arrive by air, the change in income from tourism is proportional to the change in international aviation arrivals. Examples of the potential changes in international aviation arrivals for a variety carbon prices are shown in Table 6 as being between -0.5 and -5.0% for carbon prices below US$50/Tonne. Figure 10 illustrates the impact that a

US$50/Tonne carbon price would have on aviation arrivals and tourism income for sample APEC member economies. For the reasons discussed in section 6.1.3, these estimates are likely to define the upper bound of the impact of carbon pricing.

Figure 10: Tourism with a carbon price of US$50/Tonne



* No tourism income data available ** Shaded columns are the values without a carbon price

Assumptions: fuel price = US$0.53/L, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km

Source: Consultant estimates and model results, UNWTO, IMF

6.3 GDP impacts of carbon price

Section 6.1.2 describes the difference in the importance of tourism to each of the sample APEC economies. Due to these differences, the impact on GDP of changes in tourism income will vary across the economies.

The impact on national income (GDP) from a change in aviation arrivals may exceed the direct impacts captured above for two reasons. First, it is possible that some tourism-related income may not be captured in the UNWTO measures of tourism income used in the model (e.g. purchases of clothing or food that may not be separately reported in national accounting). Second, there is likely to be a multiplier effect of income reduction from a once-off reduction in tourism income. For example, if fewer tourists arriving in Penang meant that fewer people purchased meals from a restaurant then the restaurant vendor would have less to spend on a range of goods and services that might otherwise be consumed. A reduction in income from the reduction in direct tourism income may therefore result in indirect income reductions in other sectors of the economy.

The economic model captures these two factors by including an ‘indirect tourism income multiplier’, which is a multiple of the direct tourism income that is considered to produce income in excess of that direct tourism income. This multiplier is selectable by the model user. We use a relatively high multiplier of 1, implying each dollar of (direct) tourism income lost results in a 2 dollar loss of GDP in total.[8] Applying these

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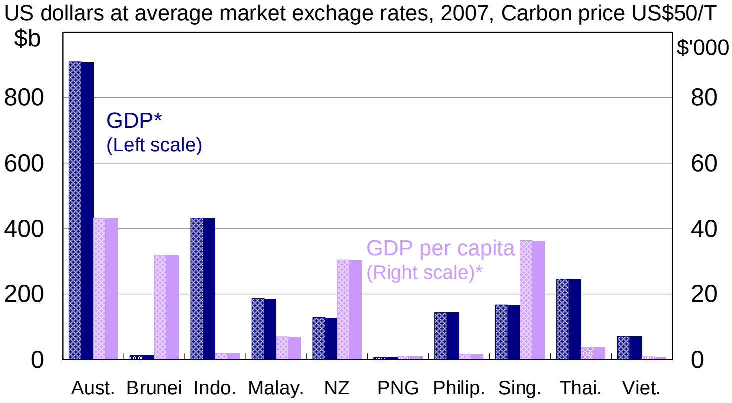
[8] Frechtling (1994) provides a table of estimates which shows that a ‘doubling’ multiplier effect is at the high end of the spectrum of available estimates. These effects appear to diminish with the size and stage of economic development of the region under consideration.

assumptions to the above information, we see that under a US$50/Tonne carbon price, the reduction in GDP falls with the range of -0.1 to -0.6% (Figure 11).

Figure 11: GDP impacts of a US$50/Tonne carbon price



* Shaded columns are the values without a carbon price
Assumptions: fuel price = US$0.53/L, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km, indirect tourism income multiplier = 1
Source: Consultant estimates and model results, IMF

This analysis considers only the costs of implementing market-based measures to reduce emissions from aviation. A more thorough analysis would need to consider the benefits of such policy action. Specifically, by including emissions from aviation in a global mitigation effort, some degree of climate change impacts (e.g. rising temperatures) may be avoided. Such an outcome should be considered a benefit of the action and compared to the economic costs of these actions. The two main studies that have attempted to compare costs and benefits are the Stern (UK, 2006) and Garnaut (Australia, 2008) reviews, which each found that the benefits of early, significant and collective mitigation action were in excess of the costs of action for each economy. Furthermore, under some proposals for the implementation of market-based measures there would be transfers of revenue to affected economies, further offsetting any negative economic impacts for these economies.[9]

6.4 Effects on well-being of women under a carbon tax

The potential flow-on effects from the above tourism and GDP impacts on women are subject to significant uncertainty. Anecdotally, several of the sample economies visited as part of consultation for this study suggested the gender dimension was not significant in their economies.

6.4.1 Employment of women

For selected economies the World Bank has statistics covering gender issues such as the labour force (Figure 12). These statistics suggest that female participation in the economy varies significantly across the sample economies – from around 50 percent

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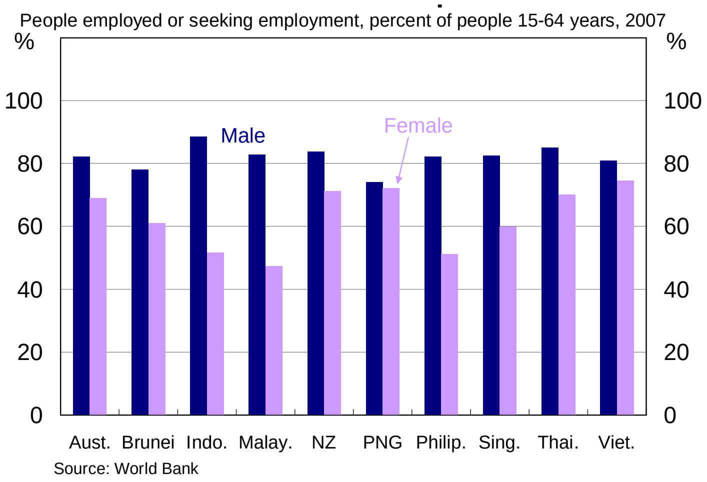
[9] See, for example, the “Maldives Proposal” (Müller, 2009).

of working-age women in Indonesia, Malaysia and Philippines up to around 70 percent in Australia, New Zealand, Papua New Guinea, Thailand and Vietnam.

Figure 12: Labour Force Statistics



Source: World Bank

Further research is required to identify data concerning the relative gender employment situation in the tourism industries of the sample economies. Our review of available information suggests that little data of this nature is readily available, suggesting significant new data collection may be required in order to properly assess the gender aspect of tourism employment. A short case study examines some of the gender aspects of tourism employment and impacts of climate change mitigation in international aviation for the sample economy Indonesia (Box B).

It should be noted that the likely impacts on women may be somewhat masked by the overall employment numbers in the economy. Specifically, women may be more likely to work in lower income employment in the tourism sector and therefore have fewer alternative options if there is an industry specific downturn. It is also likely that there will be variation in gender employment impacts across economies depending on the gender balance in various sections of the labour market.

It is well established that women suffer disproportionately as a result of negative outcomes associated with climate change – such as natural disasters. Further research would need to be conducted on the potential harmful aspects of climate change for women in sample economies, to determine whether any reduction in tourism related income would be offset by positive outcomes for women from a policy that reduced emissions from international aviation.

There is also a lack of data on women's status in the tourism industry, including the possibility of poor work conditions, inequitable wages and harassment, which should also be considered as a possible offset to any drop in income as a result of climate change initiatives.

Box B – Case Study: Gender in the Indonesian Tourism Industry

Part of the motivation for the present study is the potential for disproportionate (negative) impacts on women in APEC economies from measures to reduce aviation emissions. The reason is that women were considered to be potentially disproportionately employed in the tourism industry. The scarcity of gender-disaggregated data for the tourism industry suggests a case study may provide more useful preliminary insights into this issue than an exhaustive data search. Indonesia has been chosen for a specific case study, in part due to the gender employment disparity in aggregate terms (Figure 12).

Anecdotal evidence from an experienced professional[10] on the ground was used to provide informal information to supplement the scarce available data in this case study.

Women's labour force participation

Despite considerable progress, poverty indicators for women in Indonesia lag behind several other economies in the study region, with women lacking economic opportunities, access to credit and other productive resources (AusAID, 2008).

UN figures indicate that 44.3 percent of women between ages 15 and 64 years are in employment. However the World Bank (2006) highlights that "women are over-represented in unpaid and low-paid jobs, and are underrepresented in the more lucrative formal wage sector".

The Bank also reports that labour force discrimination continues to exist across Indonesia and, within the formal (reported) sector at least, women receive lower wages. Furthermore, eighty percent of the difference between men's and women's wages is estimated to be due to the unequal treatment of women, rather than differences in qualifications or experience (World Bank, 2006).

Although tourism is one of Indonesia's main industries, women are more involved in the agriculture sector, given the majority of the poor live in rural areas where the agriculture sector has been the backbone of rural employment (ADB, 2006). The share of women in wage employment in Indonesia's non-agricultural sector – while higher in the past – declined to 28.3 per cent in 2002 (UN, 2008).

The aim of this case study is not to explore the underlying reasons for the rate or nature of women's participation in the work force, and the above data is provided for context to appreciate any significance of women's involvement in the tourism industry.

Women's participation in the tourism industry

Available data indicates that overall more men were involved in tourism than women in 2006 (Indonesian Central Bureau of Statistics, 2006). This is not a surprise given the overall gap between male and female participation in the labour force. Overall, the available data suggest that women are employed proportionally less in the tourism

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[10] Ms. Agustina Erni, Indonesia's focal point in the APEC Gender Focal Point Network

industry compared with the economy overall (Table B1). This involvement in tourism encompasses a range of segments, including accommodation, travel agencies and tourist companies. It should be noted that this information does not cover all aspects of tourism employment and income – especially in the informal sector which is not reported.

Table B1: Gender profile of tourism industry segments, 2006

	Men	Women	Women (% of total)
Accommodation*	171,200	62,596	27
Travel agencies**	9,858	7,424	43
Restaurants**	23,620	15,465	40
Other food and beverage**	8,232	5,438	40
Total tourism employment	212,910	90,923	30
Total employment	53,161,984	30,384,062	36

Sources: Indonesian Central Bureau of Statistics (2006** and 2008* – contact-supplied), UN (2008)

The ADB (2006) identifies that one of the factors that could contribute to achieving greater gender equality in employment for women, particularly in the tourism industry, is for them to be better trained and to improve their skills.

Potential outcomes for women

While women occupy more positions in some tourism-related enterprises, men appear to have a greater role in the industry proportionally and overall. In addition, given the share of national income accounted for by tourism (some of which is domestic tourism), the participation of women in the tourism industry will mean that the impact of a decrease in tourism income on women is not expected to be greatly different to a generalised decrease in GDP – and if anything it appears slightly lower based on the available data. Put another way, market based-measures to reduce aviation emissions that reduce income equally in all sectors could be expected to have a similar impact on women as measures that disproportionately affect the tourism industry (but with the same GDP impacts).

Furthermore, the potential benefits of avoided climate change from the mitigation measures would also need to be evaluated. This is likely to be a significant issue in Indonesia given women are disproportionately involved in the agricultural sector, which is vulnerable to adverse effects from climate change (McMichael and Bertollini, 2009).

7. Caveats, extensions and sensitivity analysis

7.1 Caveats

The foregoing modelling is clearly capable of further enhancement. Given the detail of the available data and the time available, the overall philosophy of the modelling was to provide sufficient degree of sophistication in order to capture the main relationships and responses that are expected to be relevant in understanding the impacts of market-based measures to reduce aviation emissions.

The implication of this is that while the broad order of magnitude of impacts may be realistic, the *specific values* for impacts (e.g. the percentage change in GDP) should not be relied upon. There are two reasons for this. First, the quality of the data and low degree of precision possible in the calculations means that there are likely to be wide error bands around estimates. Second, the model relies on the selection (or prediction) of a number of key variables that will be determined elsewhere (such as the prevailing cost of carbon dioxide emissions). Any specific estimate embodies a specific choice of a number of parameters, which are all to some extent uncertain. To highlight the potential impacts of the latter effect, sensitivity analysis has been undertaken and reported in section 7.3.

7.2 Extensions and improvements

As is clear from the caveats above, there is significant scope for further improvements to the current model. Potential improvements and extensions are suggested under chapter headings:

- Greenhouse gases and aviation

As time passes, it is likely that extra information will appear about the magnitude of a world carbon price. This price will be affected by the type, scale and coverage of any international agreement to reduce greenhouse gas emissions. In particular, the Copenhagen negotiations in December 2009 will provide an indicator on all three fronts.

- Current aviation routes and usage

Perhaps the most useful extension of the economic model will be to gain more accurate aviation flow data. This could come from two potential sources. First, International Air Transport Association's (IATA) statistical database, which would be able to provide annual international passenger flows based on actual routes flown. The second option would be to commission member economies to undertake a detailed analysis of their arrivals information in order to provide a full matrix of arrivals broken down by mode and country of origin.

In calculating flight distances between origins and destinations, greater sophistication could be applied to accounting for stopovers and for indirect routing. For instance, a scaling factor could be applied to reflect indirect flight paths around ‘unfriendly’ air space. Stopovers may be better dealt with by adding both an extra landing and take-off cycle and by increasing the distance flown above the direct circle distance assumed here.

- Aviation costs and fare changes

The results of the model hinge upon the use of several simplifications. The most important simplification is that the $FCost/OpCost_j$ ratio varies only with the fuel price (in three increments) and distance (in just two increments). With greater time and resources it would be more accurate to develop direct relationships for each of the components of this ratio.

Specifically, a relationship that describes fuel burn (per passenger) in terms of distance flown and number of stopovers (or stages); fuel costs would then be related to the current fuel cost. A second relationship to describe operating costs (per passenger) in terms of distance, fuel price and number of stopovers, would be required. The first of these relationships could be derived through a detailed investigation of the engineering relationships between fuel burn, distance, fleet composition and passenger loadings (as has been done for the ICAO calculator). The second relationship would probably involve significant disaggregated research into individual flight costs under specific fuel price assumptions.

- Aviation demand under a carbon price

The main improvement in this part of the economic model would be to refine the elasticity estimates. This could be done by running a new study that incorporated the detailed origin-destination/price data from IATA.

- Impact of a carbon price on tourism income

The reductions in aviation arrivals will affect only the tourism income generated from visitors arriving by air, whereas the assumption of the current analysis is that the drop in total income from tourism will be proportional to the drop in the number of arrivals by air. Detailed tourism income information may assist in assigning the correct proportions of total international tourism income to aviation-related tourism income.

Improved accounting for ‘indirect’ tourism income, such as the Australian Bureau of Statistics’ Tourism Satellite Accounts, may assist in understanding the full GDP effects that international tourists provide. The model could be better calibrated if this information were available.

- Effect of emission mitigation measures on women

An increased understanding of the context in sample economies is required for a meaningful analysis of gender issues in the tourism industry. We recommend that in any further phases of study, additional field research is necessary to develop this understanding. The research would likely still be limited to a case study approach and would not aim to produce robust figures for use in modelling. However it would assist in verifying or otherwise the case study’s preliminary findings in this area and could be valuable in identifying other gender issues arising as a result of this broader study. This could be achieved for example, though undertaking a survey of a small sample of women working in tourism as well as gender and labour professionals in sample economies.

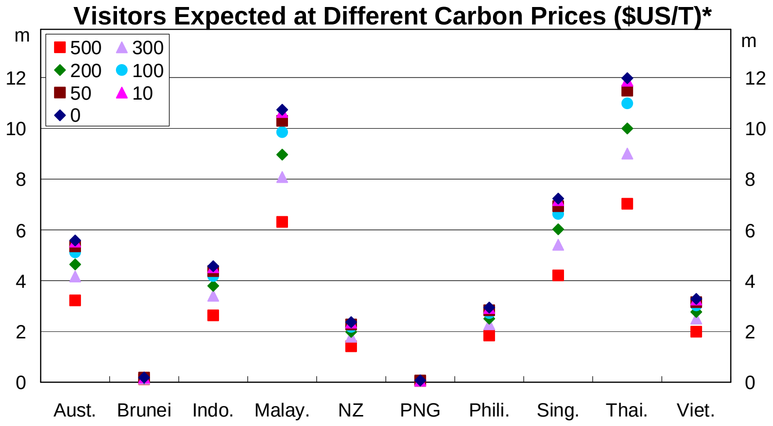
7.3 Sensitivity analysis

This section examines how sensitive the results of the economic modelling are to variations in the parameters used. Of most interest are the impacts of parameter inputs on the visitor numbers expected and GDP changes from the reference scenario. In each case, values of one parameter are varied, while all other parameters are held constant at representative values. Results are presented under headings based on the parameter to be varied.

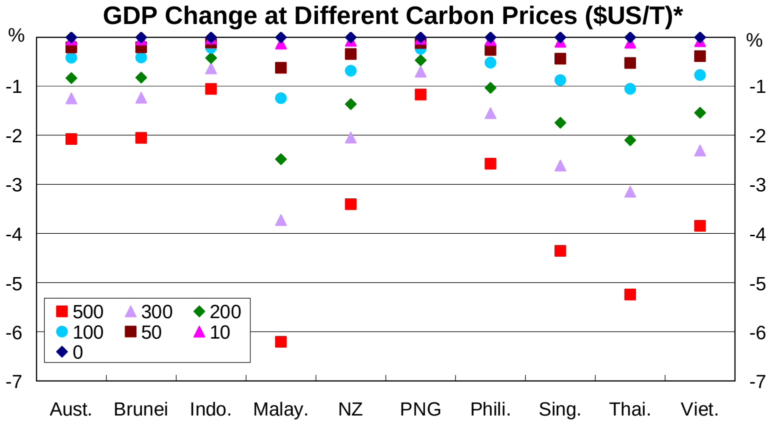
7.3.1 Carbon price

The changes to international aviation visitor arrivals in response to the application of a carbon price appear relatively muted for carbon prices up to US$100/Tonne (Figure 13). The varying GDP impacts across the sample economies is observed in the second panel, whereby GDP is anticipated to decrease by around 1% in Malaysia, Thailand and Singapore, but the impact is less than -0.5% for Australia, Brunei Darussalam, Indonesia and Papua New Guinea for a carbon price of US$100/Tonne. For much larger carbon prices impacts on aviation arrivals and GDP are proportionally larger, with a carbon price of US$500/Tonne suggesting a near halving of aviation arrivals and GDP impacts of over -2% for many of the sample economies.

Figure 13: Impacts of varying the carbon price



* Millions of international arrivals per year. Assumptions: fuel price = US$0.53/L, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km, demand responsiveness adjustment = 1

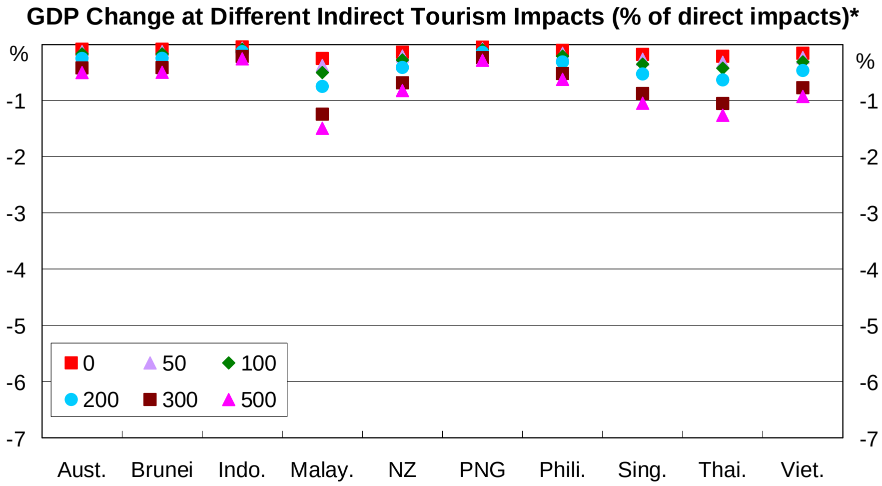


* Assumptions: fuel price = US$0.53/L, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km, demand responsiveness adjustment = 1, indirect tourism impacts = 100% of direct impacts

7.3.2 Indirect tourism multiplier

The indirect impacts of tourism income amplify the GDP effects of a given loss of tourism income. As such, the greater the choice of parameter for the indirect impacts, the greater the GDP impact will be in the model. For example, even with a US$40/Tonne carbon price, if the indirect impacts are 2 to 5 times the original impact of the carbon price, the overall impact can be pronounced, particularly for Malaysia, Singapore and Thailand (Figure 14). If higher indirect tourism impacts were combined with higher carbon prices, the overall impact on GDP would be higher still.

Figure 14: Effect of altering the indirect tourism impacts



* Assumptions: fuel price = US$0.53/L, carbon price = US$40/T, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km, demand responsiveness adjustment = 1

7.3.3 Other parameters

Most other parameter choices do not produce dramatic changes in either visitor arrivals or GDP, even with considerable variation. These variables include the (tax-free) fuel price, the 'fuel price sensitivity', the cut-off distance between short and long-haul flights and an adjustment to the scale of the elasticities. The sensitivity tests on these remaining variables are contained in Appendix A. These variables are all independently alterable in the model.

8. Conclusion

Climate change is a serious challenge for the world to deal with. Aviation plays a small but growing part of this problem. Based on current proposals, it appears there is a reasonable chance that world economies will strike a global agreement for emissions reductions in the near future. This agreement may include international aviation emissions, which have thus far been excluded from the mitigation effort.

Recognising that international aviation flows currently deliver significant mobility and economic opportunities in destination economies, this study has modelled, in broad terms, how large the likely impacts of mitigation policies for aviation might be on tourism numbers, income and GDP for sample APEC member economies. The effect of carbon pricing on tourism numbers will be very dependent of actual carbon price, which is as yet unknown. It will also vary between economies, because of factors such as the different mix of short-haul and long-haul travellers and availability of alternative travel modes. But, as a general guide, results indicate, that with 'moderate' base fuel prices, the near-term change in international aviation demand to sample APEC economies under a carbon price of around than US$50/Tonne is likely to be between 3% and 5%..

The combined direct and indirect GDP impacts of this reduction in aviation will be more significant for economies that have a high reliance on tourism. At a carbon price of $US50/tonne, the effect ranges from around -0.1% percent of GDP (Indonesia) to around -0.6% (Malaysia).

The simplifications in this study will in general tend to over-estimate rather under-estimate the impact of carbon pricing, and the results should be interpreted as upper bound estimates of the likely impact of the proposed market-based measures. A study that undertook a similar analysis using a much different methodology found smaller (aggregate) impacts from higher carbon prices (Tol, 2007).

At several stages, the accuracy of the modelling has been limited by the availability of sufficiently rich data. In some cases, more detail may make modelling more difficult without delivering significant improvements in accuracy. However, in specific areas, such as visitor arrivals by mode and origin country, better data quality would likely improve modelling accuracy measurably.

The current study is intended as a pilot modelling exercise, and as such has been limited in resources and geographical coverage. This report (and the supporting model) demonstrates that a more detailed modelling exercise is both feasible – particularly with more extensive data – and potentially useful using the current modelling framework.

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Appendix A

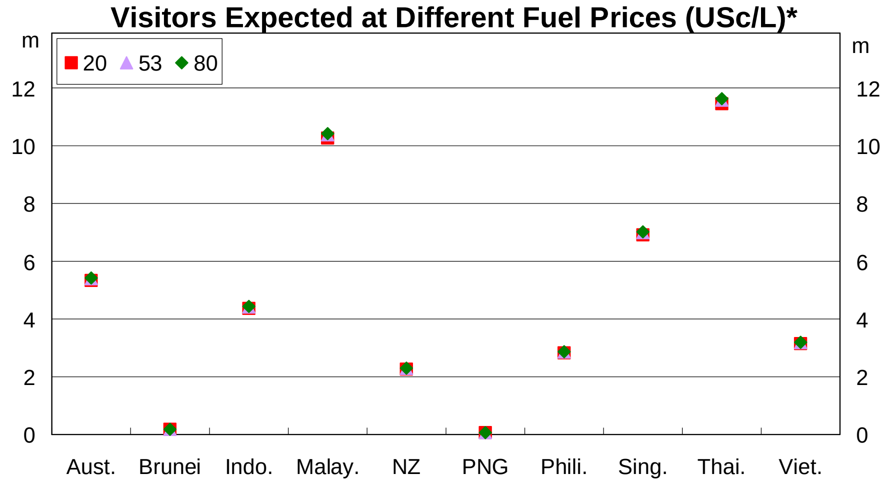
Additional Sensitivity Analysis

This appendix (A) extends the discussion of section 7.3 of the report about sensitivity tests undertaken with the economic model. The results reported here contain those parameter changes found not to elicit major changes in either visitor arrivals or GDP impacts.

A1: Base fuel prices

Selecting different (pre-tax) fuel prices does not appear to alter the impact of moderate carbon prices. With a carbon price of US$40/Tonne, visitor arrivals vary only slightly for each sample economy (Figure A1). Higher base fuel prices mean that a given carbon price represents a lower proportion of the total air cost (and fare), meaning that (other things being equal) a lower impact will be expected.

Figure A1: Impact of varying base fuel price

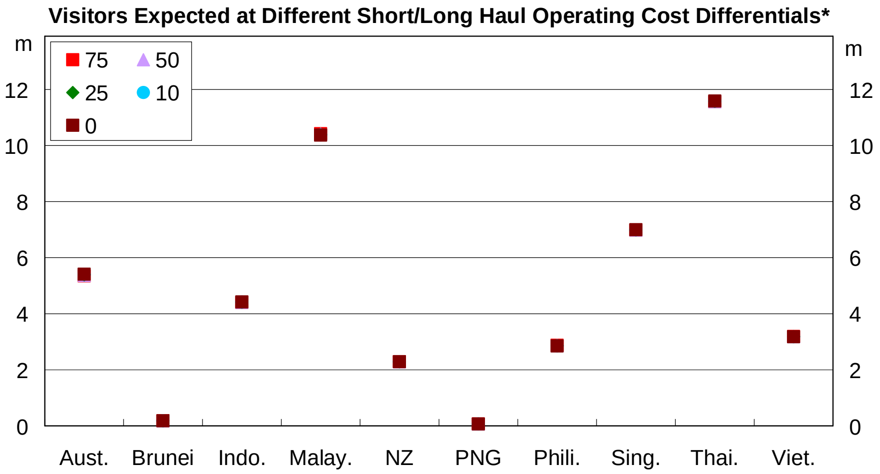


* Millions of international arrivals per year. Assumptions: carbon price = US$40/T, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km, demand responsiveness adjustment = 1

A2: Fuel price sensitivity

This factor measures the degree to which fuel operating costs account for a greater share of operating costs in long-haul flights than in short-haul ones (see section 4.2). For values between 0 (no difference) and 75% (fuel costs account for much larger shares of operating costs in long- compared to short-haul) and a carbon price of US$40/Tonne, there is little variability in visitor arrivals expected (Figure A2).

Figure A2: Impact of varying fuel price sensitivity

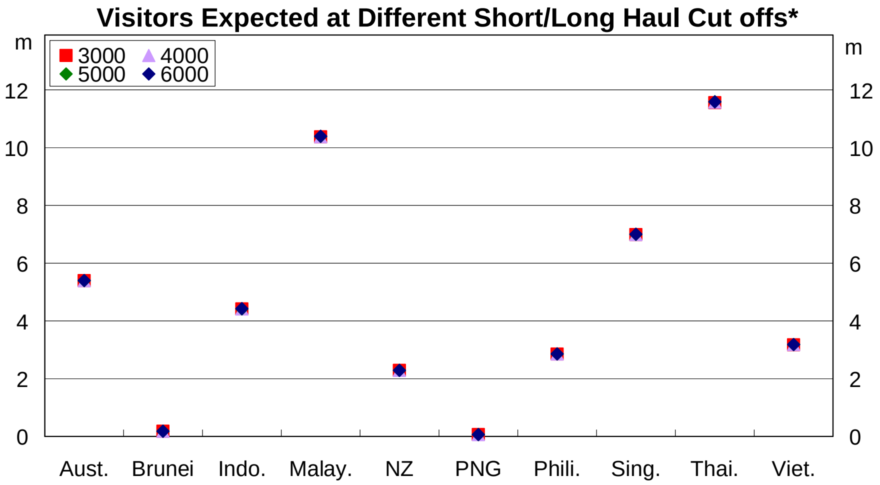


* Millions of international arrivals per year; differential accounts for percentage divergence from average fuel share of operating costs: % above (long haul) = % below (short haul). Assumptions: fuel price = US$0.53/L, carbon price = US$40/T, long haul cut off = 4000km, demand responsiveness adjustment = 1

A3: Short-haul / long-haul cut-off

The possibility of different definitions of short- and long-haul flights was discussed in section 3.2.2. Sensitivity analysis reveals that for the current model, this definition is not likely to cause a significant change in the results. At a carbon price of US$40/Tonne and a fuel price sensitivity of 15%, estimated visitor numbers are not likely to be very different across long-haul cut-off values chosen (Figure A3).

Figure A3: Impact of varying Long-haul cut-off distance

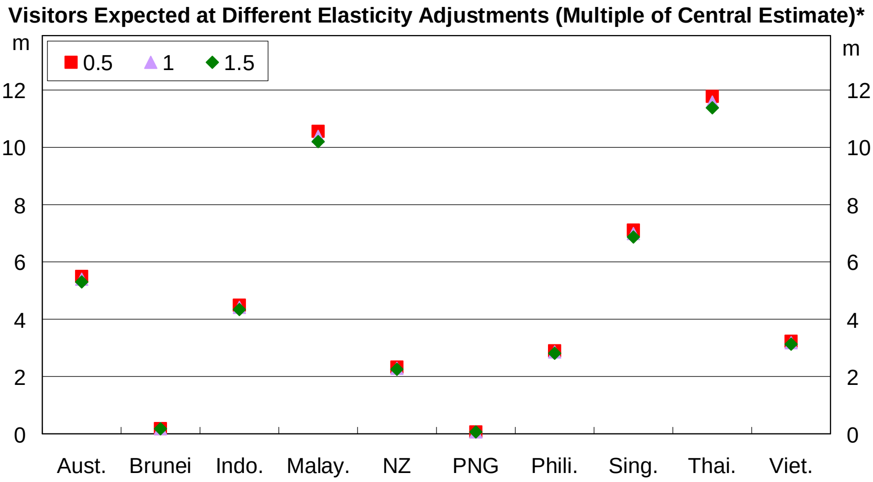


* Millions of international arrivals per year. Assumptions: fuel price = US$0.53/L, carbon price = US$40/T, fuel cost share sensitivity = +/- 15%, demand responsiveness adjustment = 1

A4: Elasticity of demand

The price elasticity of demand parameter chosen dictates how strong the demand response will be to a change in the air price (here proxied by costs) on a given route. The model is set up to allow a manual adjustment to this elasticity parameter by selecting a multiple of the original estimates sourced from the literature. A value of 0.5 for this multiple means the demand response will be 50% of the central estimate; a value of 1.5 suggests the demand change will be 50% greater than the original. The degree to which this parameter will affect the visitor arrivals, tourism income and GDP of an economy will depend largely on the magnitude of the carbon price – altering the elasticity will dampen or amplify these effects accordingly. With a carbon price of US$40/Tonne, however, the impacts are relatively small (Figure A4).

Figure A4: Impact of varying the elasticity of demand



* Millions of international arrivals per year. Assumptions: fuel price = US$0.53/L, carbon price = US$40/T, fuel cost share sensitivity = +/- 15%, long haul cut off = 4000km

Appendix B

Operation of the model

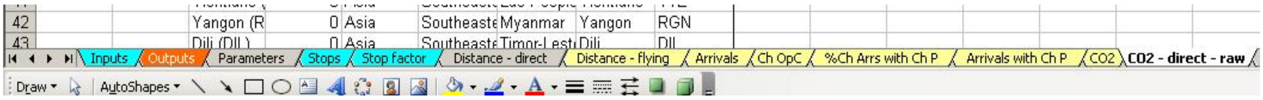
This appendix (B) provides a description of the economic model developed for the present study as well as some operating instructions for users.

B1: Model description

The model is created in a Microsoft Excel workbook (though some background calculations were performed in separate spreadsheets). Each sheet within the workbook is colour-coded:

- Blue sheets are sheets that can be altered by the user
- The orange sheet contains all relevant outputs
- Yellow sheets are the key model sheets which calculate many of the intermediate stages from inputs to outputs – these are all linked and will adjust to new values for inputs
- The grey sheets contain raw data an parameter values that should not generally be altered by the user (Figure B1).

Figure B1: Screenshot showing sheet colour scheme



Much of the model is matrix based, i.e. most of the data inputs and outputs are available for each origin (globally) and destination (within the APEC member economy sample). As in the report, only a summary of the matrix results are presented in the Outputs sheet. The most important sheets are:

- **Inputs** – here the user can select a value for the main variables discussed in the report, such as the carbon price, fuel price, fuel sensitivity, long-haul cut-off, elasticity adjustment and the indirect tourism multiplier. Furthermore an additional variable which controls fuel efficiency can be altered to test technology scenarios. Ranges of values are suggested for most variables (Figure B1).
- **Outputs** – this provides a range of linked summary outputs from the modelling – both before the introduction of a carbon price (i.e. 2007/8 baseline data) and after its introduction – including visitor arrivals by origin region and destination economy, the split of short- and long-haul visitors, the average (weighted and unweighted) distance that visitors travel to an economy from, each sample economy's GDP and tourism income (direct and indirect).
- **Parameters** – this sheet contains the core parameters taken from either literature or physical relationships and generally should not be altered by users.
- **Stops** – this sheet allows the user to introduce stopovers into a flight route between an origin and destination pair to relax the 'direct route' assumption if required.
- **Stop factor** – is the distance factor that applies to each stop captured in the Stop sheet. A 25% increase in distance associated with indirect routing from a stopover is represented by a stop factor of 1.25.

- **Distance – direct** – is the matrix of direct great circle distances between the airports in the matrix. These are raw values from the online distance calculator.
- **Distance – flying** – is the matrix that accounts for additional distances associated with stopovers.
- **Arrivals** – this draws on raw arrivals data to apportion all of the estimated aviation arrivals to specific countries.
- **Ch OpC** – calculates the change in operating costs attributable to the assumed carbon price based on the other variables in equation (1).
- **%Ch Arrs with Ch P** – applies the elasticity and change in operating costs to derive a matrix of estimates of the percentage change in arrivals attributable to the carbon price.
- **Arrivals with Ch P** – the percentage change is applied to the original numbers of arrivals between origins and destinations to estimate a new value for these arrivals in the presence of a carbon price.
- **CO2** – uses the estimated relationship from the ICAO calculator to estimate the CO_2 emissions associated with a single passenger's travel between the origin and destination economy.
- **Other sheets** – these include raw source data, such as those obtained from the ICAO calculator to estimate the relationship between CO_2 and distance flown – these have been 'hidden', but can be revealed by 'Format' > 'Sheet' > 'Unhide'.

B1: Instructions for using the model

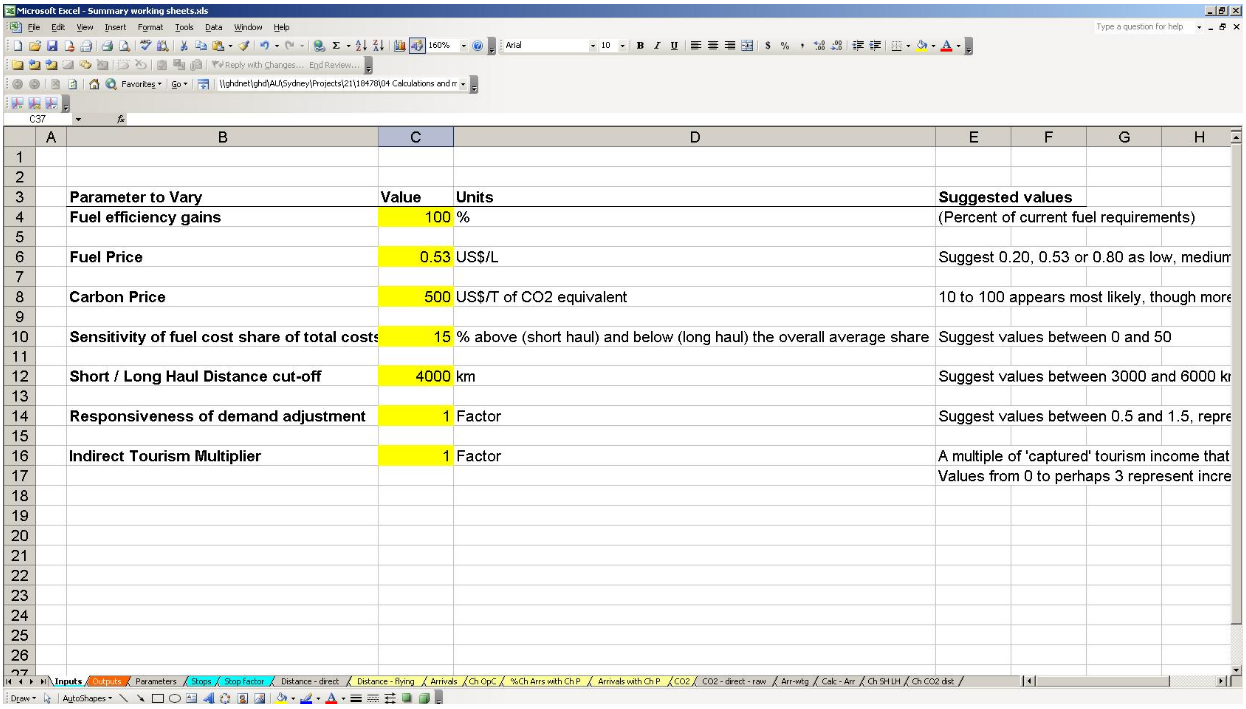
Users of the model may wish to alter some parameters of the model, such as the carbon price, the technology applied that may reduce fuel/emission requirements or relax the assumption that flights make no stopovers. As explained above, there are two main input areas that users should focus on: the Inputs sheet and the two input sheets relating to stopovers ('Stop' and 'Stop factor').

- In the Inputs sheet, users can alter the yellow cells to test hypotheses (Figure B1).
- In the 'Stops' and 'Stop factors' sheets, users can alter the zero stopovers assumption by changing the zeroes between each origin economy (columns) and each destination economy (rows) (Figure B2).

Outputs are observed in the 'Outputs' sheet, with the first block of results displaying the original summary data and the second block of data containing summary data under the carbon price. These data can be used for graphing or analysing results visually.

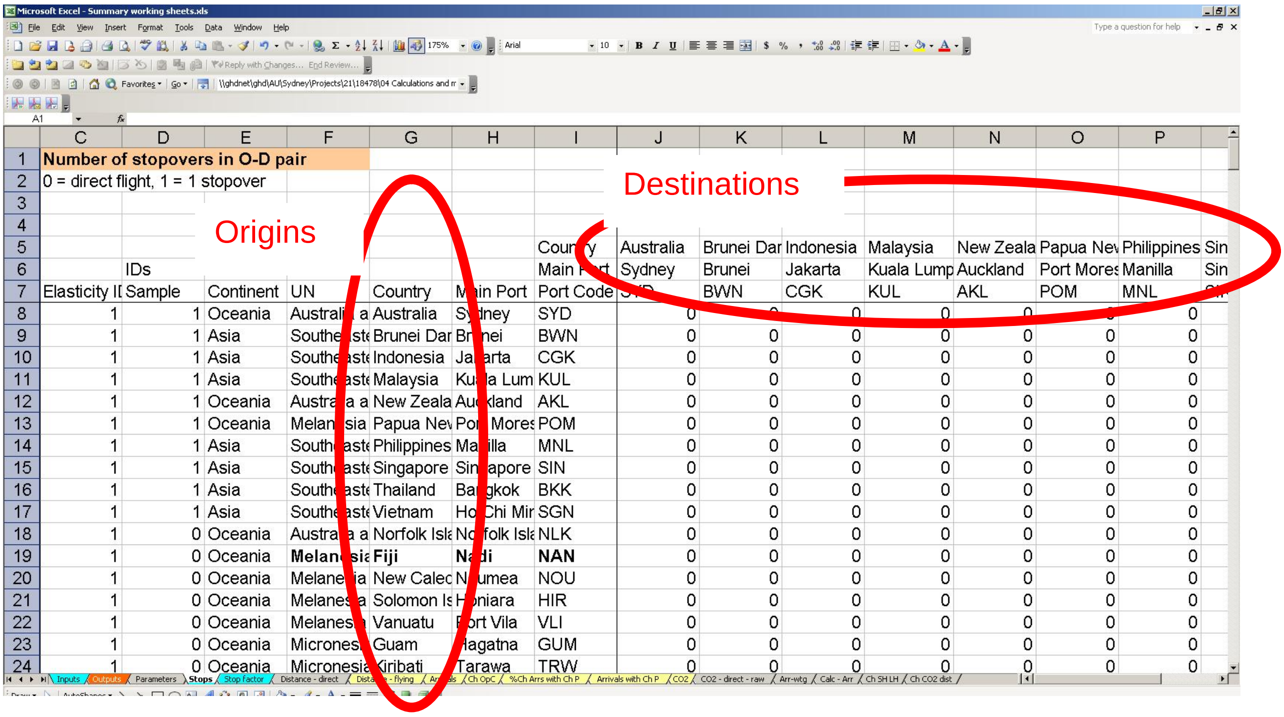
Most cells in most sheets have been 'protected' to avoide accidental changes. If there are specific values that the user would like to alter, this can be done by 'unprotecting' the sheet: 'Tools' > 'Protection' > 'Unprotect sheet'. The password = **APEC** .

Figure B1: Screenshot of Inputs sheet



	A	B	C	D	E	F	G	H
1								
2								
3		**Parameter to Vary**	**Value**	**Units**	**Suggested values**			
4		**Fuel efficiency gains**	100	%	(Percent of current fuel requirements)			
5								
6		**Fuel Price**	0.53	US$/L	Suggest 0.20, 0.53 or 0.80 as low, medium			
7								
8		**Carbon Price**	500	US$/T of CO2 equivalent	10 to 100 appears most likely, though more			
9								
10		**Sensitivity of fuel cost share of total costs**	15	% above (short haul) and below (long haul) the overall average share	Suggest values between 0 and 50			
11								
12		**Short / Long Haul Distance cut-off**	4000	km	Suggest values between 3000 and 6000 kı			
13								
14		**Responsiveness of demand adjustment**	1	Factor	Suggest values between 0.5 and 1.5, repre			
15								
16		**Indirect Tourism Multiplier**	1	Factor	A multiple of 'captured' tourism income that			
17					Values from 0 to perhaps 3 represent incre			
18								
19								
20								
21								
22								
23								
24								
25								
26								

Figure B2: Screenshot of the Stops sheet



	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	**Number of stopovers in O-D pair**														
2	0 = direct flight, 1 = 1 stopover														
3															
4															
5							Country	Australia	Brunei Dar	Indonesia	Malaysia	New Zeala	Papua Nev	Philippines	Sin
6		IDs					Main Port	Sydney	Brunei	Jakarta	Kuala Lump	Auckland	Port Mores	Manilla	Sin
7	Elasticity II	Sample	Continent	UN	Country	Main Port	Port Code	SYD	BWN	CGK	KUL	AKL	POM	MNL	
8	1	1	Oceania	Australia a	Australia	Sydney	SYD	0	0	0	0	0	0	0	
9	1	1	Asia	Southeaste	Brunei Dar	Brunei	BWN	0	0	0	0	0	0	0	
10	1	1	Asia	Southeaste	Indonesia	Jakarta	CGK	0	0	0	0	0	0	0	
11	1	1	Asia	Southeaste	Malaysia	Kuala Lum	KUL	0	0	0	0	0	0	0	
12	1	1	Oceania	Australia a	New Zeala	Auckland	AKL	0	0	0	0	0	0	0	
13	1	1	Oceania	Melanesia	Papua Nev	Port Mores	POM	0	0	0	0	0	0	0	
14	1	1	Asia	Southeaste	Philippines	Manilla	MNL	0	0	0	0	0	0	0	
15	1	1	Asia	Southeaste	Singapore	Singapore	SIN	0	0	0	0	0	0	0	
16	1	1	Asia	Southeaste	Thailand	Bangkok	BKK	0	0	0	0	0	0	0	
17	1	1	Asia	Southeaste	Vietnam	Ho Chi Mir	SGN	0	0	0	0	0	0	0	
18	1	0	Oceania	Australia a	Norfolk Isla	Norfolk Isla	NLK	0	0	0	0	0	0	0	
19	1	0	Oceania	**Melanesia**	**Fiji**	**Nadi**	**NAN**	0	0	0	0	0	0	0	
20	1	0	Oceania	Melanesia	New Calec	Noumea	NOU	0	0	0	0	0	0	0	
21	1	0	Oceania	Melanesia	Solomon Is	Honiara	HIR	0	0	0	0	0	0	0	
22	1	0	Oceania	Melanesia	Vanuatu	Port Vila	VLI	0	0	0	0	0	0	0	
23	1	0	Oceania	Micronesi	Guam	Hagatna	GUM	0	0	0	0	0	0	0	
24	1	0	Oceania	Micronesia	Kiribati	Tarawa	TRW	0	0	0	0	0	0	0	

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