



Investor Group on
Climate Change

Potential Earnings Impacts from Climate Change

Airport Infrastructure

Departures

Flight	Destination	Dep. Time	Status
KL 4212	KUALA LUMPUR	15:40	
AI 6148	KUALA LUMPUR	15:40	
SQ 228	SINGAPORE	17:00	
LH 9775	SINGAPORE	17:00	
QF 9	SINGAPORE LONDON	17:10	
BA 7309	SINGAPORE LONDON	17:10	
AF 8091	SINGAPORE LONDON	17:10	
TG 982	BANGKOK	17:30	
NZ 794	CHRISTCHURCH	18:15	

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MONASH University



Hastings Funds Management

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Executive Summary

- This report explores the exposure of airports and, hence, infrastructure investments in airports, to climate change risk.
- The climate change exposures of airports are almost entirely indirect – a result of the inherent dependence of airports on the airline industry, which is greenhouse gas emissions intensive and, therefore, vulnerable to climate change risk. The indirect nature of the exposures presents challenges for airport owners in responding to climate change risk.
- The key climate change exposures for airports relate to changes in demand for air travel through:
 - Increased ticket prices flowing from carbon pricing of aviation emissions;
 - Climate change impacting on the attractiveness of particular tourism destinations; and
 - Climate change impacts on growth in Gross Domestic Product (GDP).
- Many airports are subject to some form of economic regulation. Analysis shows that this can play an important role in mitigating climate change exposure, by allowing for periodic adjustments to prices for aeronautical services in response to changes in costs and revenue. In this way there is some ability to insulate against revenue reductions so that airport owners receive a sufficient return on their investment.
- Based on scenario modelling conducted and after taking the mitigating effects of economic regulation into account:
 - Carbon pricing of aviation emissions has the largest potential impact on airports, ranging from -0.08% to -2.14% of 2020 EBITDA under different carbon price and other assumptions.
 - The impact on GDP growth of climate change on 2020 EBITDA ranges from -0.06% to -1.03% for a range of GDP growth impacts.
 - The impact on tourism from climate change on 2020 EBITDA ranges from +0.29% to -0.38% for different airports.
- There is uncertainty associated with these estimates. In particular, little research quantifies the potential impact of climatic changes on tourist behaviour, and the potential flow-on impacts on airport owners.
- Climate change impacts are expected to increase significantly in the future. Consequently, EBITDA impacts are also expected to increase with time. This paper presents impacts on EBITDA in 2020 and, thus, represents the impact in a single year.
- In assessing the impact of climate change on a particular airport, the key differentiating factor is the level of 'aeronautical-related' revenues (e.g. duty free, food and beverage, car parking). These revenues (ranging between 7% to 20% for Australian capital city airports) are dependent on passenger throughput and are not generally protected by economic regulation. Hence, they are most highly exposed to climate change.

Potential Earnings Impacts from Climate Change

Airport Infrastructure

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1. Airports' Contribution to Climate Change

Airports are not themselves significant direct sources of greenhouse gas emissions. However, airports are inherently highly dependent on the aviation industry, which is a rapidly growing source of emissions. Thus, airports have significant greenhouse gas emissions within their supply chain (indirect emissions).

Aviation is currently a relatively small proportion of total greenhouse gas emissions – in Australia making up around 1.2% of total emissions.ⁱ However, aviation emissions are thought to be more potent contributors to global warming than other sources, as the bulk of the emissions are released directly into the upper atmosphere. While still uncertain, the Intergovernmental Panel on Climate Change (IPCC) estimates that the global warming impact of aviation greenhouse gas emissions is in the range of two to four times greater than the carbon dioxide emissions alone.ⁱⁱ This estimate does not include the potential that airline condensation (or vapour) trails ('contrails') also contribute to global warming, as the extent to which contrails contribute to global warming is still subject to scientific debate.

The airline industry continues to achieve significant improvements in energy efficiency – the US Federal Aviation Administration reports an overall 75% increase in efficiency over the last 40 years.ⁱⁱⁱ Nonetheless, total airline greenhouse gas emissions are expanding. In the European Union (EU), greenhouse gas emissions from international flights grew by 73% from 1990 to 2003.^{iv} Without considering the potential impact of climate change, this trend is projected to continue, driven by sustained growth in air traffic, in particular, through the emergence of low cost carrier airlines.

Airport operations can influence the quantum of aviation emissions, for example, through reducing the amount of time aircrafts spend taxiing. Likewise, it has been estimated that improvements in air traffic management could improve fuel efficiency by 6 to 12% 'by minimising queuing before take-off, using more optimal flight paths and reducing the extent to which aircrafts must fly in holding patterns before landing at congested airports'.

^v This highlights the importance of recognising the shared responsibility for greenhouse gas emissions wherever they arise in the supply chain.

2. Overview of Airport Investment Sector

Table 1: Australian Airport Ownership

Airport	Passengers (2006) ^{vi}	Major Shareholders ^{vii}
Adelaide	5,818,017	UniSuper, MTAA Superannuation, Local Government Superannuation
Brisbane	16,413,463	Amsterdam Airport Schiphol, Port of Brisbane Corporation, Colonial First State, MTAA Superannuation
Darwin	1,441,000	Industry Funds Management, Australian Infrastructure Fund, BAA, Perpetual
Gold Coast	3,581,646	Australian Infrastructure Fund, The Infrastructure Fund
Melbourne	21,430,125	AMP, DB RREEF, BAA, Australian Infrastructure Fund, Utilities Trust of Australia
Perth	7,138,476	Australian Infrastructure Fund, Utilities Trust of Australia, BAA
Sydney	29,576,985	Macquarie Airports, Hochtief Air Port, Ontario Teachers Pension Plan

As at December 2006, the assets held in the Australian airport sector are estimated to be worth in excess of \$16 billion. Table 1 provides a summary of the major airports in Australia, their passenger volume during the 2006 year and their major shareholders.

Most major (including all capital city) airports in Australia are privately owned. These assets, formerly owned by the Federal government, were privatised during the period from 1997 to 2002. A number of regional and local airports are still publicly owned.

For the 2006 financial year, the combined revenues of Australia's six capital city airports amounted to over \$1.7 billion, with EBITDA of over \$1.3 billion.^{viii} Over the same period approximately 85.2 million passengers passed through Australian airports (approximately four times the country's population). Total airport revenue across the capital city airports increased by over 121% between the 2002 and 2006 financial years.^{ix}

In addition to the direct exposure to Australian airport investments, Australian investors also hold investments in a number of airports located in other countries.

For example:

- Macquarie Airports (MAP) holds interests including Brussels, Bristol and Copenhagen Airports.
- Australian Infrastructure Fund (AIX) holds interests including Athens, Hamburg and Dusseldorf airports.

This paper focuses on Australian airports.

Airport revenue is a mixture of:

- Aeronautical revenues (e.g. landing and terminal fees);
- Aeronautical-related revenues (e.g. duty free, food and beverage, car parking); and
- Non-aeronautical revenues (e.g. property rentals).

The proportion of revenue from each source varies from airport to airport (see table below). For major Australian airports, the proportion of aeronautical revenue ranges from 30% for Brisbane airport to as high as 86% for Darwin airport.

A significant proportion of both aeronautical and aeronautical-related revenue streams are critically dependent on passenger throughput and, hence, on the airline sector and its growth capacity. The impact of changes in passenger levels will impact aeronautical and aeronautical-related revenues to different extents.

Table 2: Revenue Mix of Australian Airports 2006*

	Aeronautical	Aeronautical Related	Non-Aeronautical
Adelaide	53%	11%	36%
Brisbane	30%	15%	55%
Darwin	86%	7%	7%
Melbourne	43%	20%	37%
Perth	33%	11%	56%
Sydney	44%	13%	43%

2. Overview of Airport Investment Sector

Most airports are subject to some form of economic regulation. Economic regulation can take different forms, such as price monitoring of aeronautical revenues (as currently exists in Australia), through to rate of return regulation of both aeronautical and non-aeronautical operations (which is seen in some European airports). Such regulation exists to curb the potential for the monopoly power associated with such assets to be used to obtain excessive returns (return upside). However, over the medium term this regulation also results in passing a significant proportion of the risk (e.g. that the expected passenger volumes through the airport are not achieved) back to the users of the airports (i.e. airlines and ultimately passengers) through the ability for airport owners to revise charges to recover potential revenue shortfalls.

Under rate of return regulation, prices for airport services (such as aircraft landing fees and terminal usage fees) are set based on costs of operating the airport (including capital costs, operating costs and financing costs) and the number of users of the airport for specified periods ('regulatory periods', often five years). As such the returns on the investment are largely set for that period. The prices are reviewed at the end of each regulatory period, with regard to the operating costs and the number of users. As such, there exists potential at regulatory review dates (regulatory 'resets') to take account of significant movements (up or down) in costs and traffic volumes, thereby potentially reducing the volatility of returns to investors.

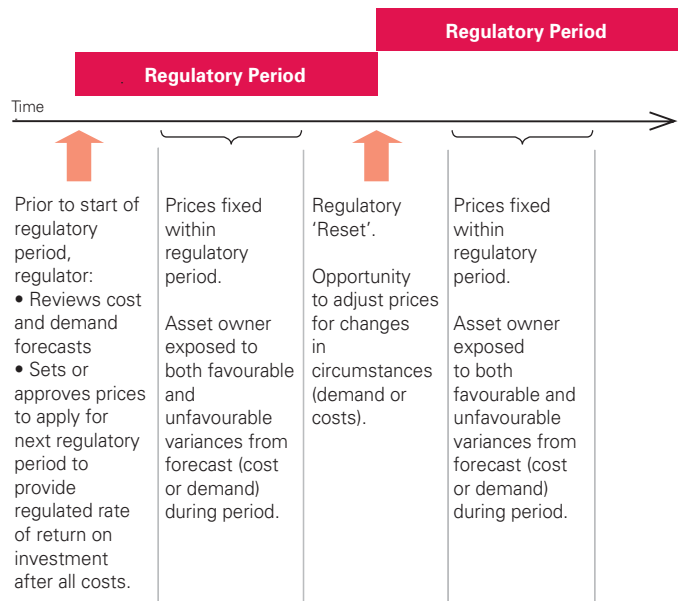
Where economic regulatory arrangements provide for a set return:

- In the short term – if the forecasts of costs or number of users prove to be inaccurate, there is usually limited or no ability to review prices until the next regulatory review and the asset owner is exposed to the impact (positive or negative) of any variance between forecasts and actual outcomes.
- In the longer term – prices are likely to be adjusted to take account of altered costs and the number of users, limiting the impact on returns to owners.

Hence, a significant proportion of both positive and negative exposure from changes in operating costs and the number of users, such as those caused by climate change impacts, may be limited to the impacts within the regulatory period.

Chart 1 presents a simplified overview of a typical regulation process.

Chart 1: Simplified Overview of 'Rate of Return' Regulation Process



Price monitoring is a less stringent form of economic regulation for the pricing of airport services than rate of return regulation. In Australia, the price monitoring framework promotes the direct negotiation of prices for aeronautical services by airports and airlines having regard to (among other things) expected passenger growth, the services required by airlines, and the airports' costs of providing such services.

The Australian Competition and Consumer Commission (ACCC) is responsible for administering airport price monitoring. The ACCC's price monitoring role includes monitoring prices, costs and profits relating to aeronautical services and aeronautical-related services for the five major airports (Sydney, Melbourne, Brisbane, Perth, Adelaide).

Because price monitoring involves direct negotiation between parties, it may not allow for the same degree of pass through of costs and changes in demand as rate of return regulation may allow. Rather, it is expected that downside risks will be shared between airport owner and users to a greater extent than occurs under rate of return regulation.

3. Impact of Climate Change on Airports

The three main climate change exposures for Australian airports relate to:

- Carbon pricing of greenhouse gas emissions from aviation;
- Risks to tourism from climate change; and
- Impacts of climate change regulation or physical impacts of climate change on Gross Domestic Product (GDP) growth.

Each exposure is discussed below and modelled estimates of the impact are presented.

3.1 Modelling Overview

For each climate change exposure, the impact on forecast EBITDA has been modelled for a series of Australian airports. Climate change impacts are expected to increase over time, leading to increasing impacts on EBITDA. The modelling presents impacts on EBITDA in 2020 and, therefore, represents the EBITDA impact in a single year.

Given that the bulk of expected impacts are indirect, the sensitivities that have been considered have in most cases been applied via adjustments to the forecast passenger growth rates. Adjustments can be applied simply to all passengers or separately to relevant passenger segments (such as domestic, international, and other components) as appropriate.

The model was established such that changes impact both aeronautical income (e.g. landing and terminal fees) and aeronautical-related income (e.g. car parking and retail spend). The modelling assumes non-aeronautical revenues are not affected by the climate change exposures considered.

To the extent that revenues are subject to some form of economic regulation (in Australia this is limited to price monitoring of aeronautical revenues), revenues have been adjusted from the next expected review/renegotiation of aeronautical revenues. That is, any positive or negative impact on regulated revenues is assumed to be limited to the impact experienced between reviews (i.e. within a single regulatory period).

Key assumptions applied in the modelling are:

- The revenue mix for each airport is as per Table 2 Revenue Mix of Australian Airports 2006 presented under heading 2: Overview of Airport Investment Sector.
- The mix of traveller types for each airport is as per Table 4 Traveller Types at Australian Airports presented under heading 3.3 Airport Exposure to Climate Change Impacts on Tourism.

- The sensitivity to changes in passenger levels is determined based on the revenue mix, with aeronautical and aeronautical-related revenues both being treated as dependent on passenger levels and non-aeronautical revenues being treated as independent of changes in passenger levels.
- The different types of revenue entail a different ability to renegotiate prices for climate change related impacts:
 - Aeronautical revenues – are assumed to be renegotiated/reset at regular intervals for both changes in passenger levels and costs.
 - Aeronautical-related revenues – are adjusted to take account of changes in forecast passenger levels, but prices are not adjusted.
 - Non-aeronautical revenues – are treated as having no exposure to climate change risks and, therefore, no price adjustment is required.

Further details of the modelling approach are appended.

3.2 Airport Exposure to Carbon Pricing

As a significant contributor to climate change, airlines are increasingly at risk of regulation that results in a price for carbon and this presents exposure for airports that are dependent on them. For example, the EU is considering proposals to include international aviation in its emissions trading scheme from 2012^{xi}, which may impact the cost of air travel within Europe, but also for international travel to other countries such as Australia.

Carbon trading schemes fall into two broad categories:

- Cap and trade; and
- Baseline and credit.

Cap and trade schemes involve:

- Setting an emissions 'cap' – the maximum amount of greenhouse gas emissions allowable in a given period. The difference between the cap and 'business as usual' emissions is the targeted reduction in emissions. It is common for carbon trading proposals to involve modest reduction targets initially, with progressively more stringent targets over time.
- Creating tradeable permits ('carbon credits') for the allowable emissions, i.e. a right to emit. Typically a permit will be for one tonne of carbon dioxide equivalent greenhouse gas emissions (1 tCO₂-e).
- Allocating tradeable permits to affected parties (including those emitting greenhouse gases).

3. Impact of Climate Change on Airports

Liability parties are required to surrender sufficient tradeable permits at the end of each period to cover all of their actual emissions. Liability parties who are able to reduce their emissions below the level of emissions for which they have permits are able to sell excess permits on market. The EU ETS is an example of a cap and trade scheme.

Under a baseline and credit scheme, liability parties are assigned an emissions path or 'baseline', which sets out allowable emissions over time. The difference between the baseline and 'business as usual' emissions is the targeted reduction in emissions. Tradeable permits are allocated with reference to the baseline. The NSW Greenhouse Gas Abatement Scheme (GGAS) is an example of a baseline and credit scheme.

In practice, there are many similarities between the two categories of scheme. For simplicity, the following analysis focuses on cap and trade schemes.

A key issue in applying carbon trading to aviation greenhouse gas emissions is whether to recognise the additional potency of aviation emissions in the scheme design and, if so, how. As noted in Section 1 above, it is estimated that the global warming impact of aviation greenhouse gas emissions is in the range of two to four times greater than the carbon dioxide emissions alone.^{xii} One proposed approach is to multiply aviation greenhouse gas emissions by a factor to reflect this additional potency in arriving at the liability of airlines under a carbon pricing scheme. Thus, if an airline emitted a total of 50,000 tonnes of greenhouse gas emissions and a multiplication factor of two was applied, the airline would be treated as having emitted 100,000 tonnes of greenhouse gas emissions.

If a price were imposed on aviation greenhouse gas emissions, this is expected to flow through as an increase in the ticket price. Ticket price increases have the potential to reduce demand for air travel and, thereby, impact the earnings of airports. The extent to which passengers respond to price increases by reducing the amount they fly is referred to as 'the price elasticity of demand' for air travel.

Air travel demand elasticities vary significantly depending upon the purpose of the travel (visiting friends/relatives, tourism, business) and the distance of the flight. Indicative elasticities are presented in Table 3 showing the range of percentage changes in the amount of travel for each class of passengers for a 1% increase in the price of air travel.

Table 3: Price Elasticity of Demand for Different Passenger Classes^{xiii}

(Percentage change in the quantity of air travel in response to a 1% increase in price)

	Domestic	International
Tourism	-1.74 to -1.29	-1.70 to -1.00
VFR	-1.29 to -0.86	-1.00 to -0.56
Business	-1.23 to -0.50	-0.48 to -0.20

VFR = Visiting Friends and Relatives

Generally, business travel is the least elastic of the customer classes and tourism is the most elastic. International travel is less elastic than domestic travel. For example a 1% increase in price on a domestic ticket will result in a 1.29% to 1.74% reduction in tourist travellers, but only a 0.50% to 1.23% reduction in business travellers.

The exposure of a particular airport to carbon pricing will depend on the proportion of revenue directly dependent on passenger traffic, the mix of different passenger types, and the elasticity of demand of those passengers.

3.2.1 Modelling Results

Using the demand elasticities in the table above, the impact on a range of Australian airports of the introduction of a carbon price for aviation greenhouse gas emissions has been modelled, assuming:

- Per passenger greenhouse gas emissions reductions are in the range of 1.5% to 1.8% per annum, reflecting expected changes in fuel efficiency from fleet upgrades and other abatement action. The per-ticket carbon price is adjusted to take account of the efficiencies. The range of energy efficiency outcomes is reflected in the range of EBITDA outcomes for each scenario presented below.
- 100% pass through of the carbon price in ticket prices with a uniform percentage increase in ticket prices across all classes of passengers. The EU has indicated it may provide some free allowances if airline emissions are introduced in the EU ETS. This will reduce the cost of the scheme to airlines and, so, may reduce the extent to which ticket prices rise compared to the modelled results.

Two scenarios have been presented in the diagram below:

- **Scenario 1:** where each tonne of aviation greenhouse gas emissions is treated as having the same potency as greenhouse gas emissions from other sources.
- **Scenario 2:** where each tonne of aviation emissions has a two times multiple applied to reflect the greater potency of aviation emissions.

3. Impact of Climate Change on Airports

In each scenario, the impact is modelled for three alternate carbon prices:

- \$5 per tonne of CO₂-e – approximately the price of credits under voluntary trading schemes, such as the Australian Greenhouse Office’s Greenhouse Friendly Program and the Chicago Climate Exchange.^{xiv}
- \$10 per tonne of CO₂-e – approximately the spot price of a carbon credit under the New South Wales Greenhouse Gas Abatement Scheme.^{xv}
- \$25 per tonne of CO₂-e – the average spot price in June 2006 for credits under the EU ETS.^{xvi}

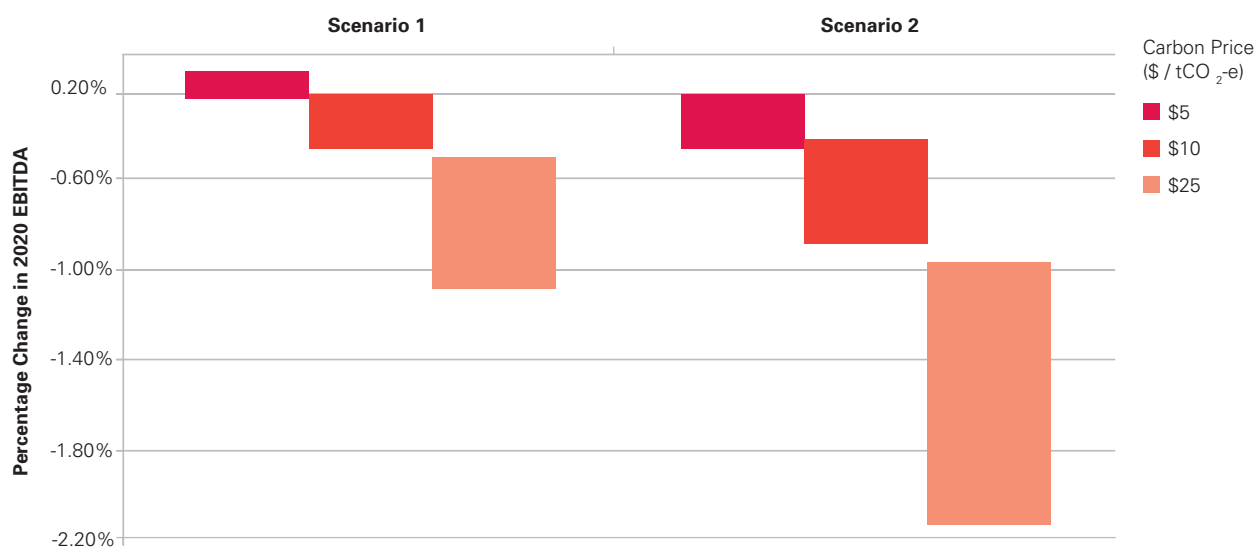
As shown in Chart 2, the impact on Australian airports of a carbon price on aviation emissions ranges:

- From 0.08% reduction of 2020 EBITDA for a carbon price of \$5 per tonne of CO₂-e under scenario 1 and where per passenger greenhouse gas emissions reduce by 1.8% per annum (the higher emission reduction scenario);
- To 2.14% reduction of 2020 EBITDA for a carbon price of \$25 per tonne of CO₂-e under scenario 2, where a multiplier is applied to aviation emissions to reflect their greater potency and per passenger greenhouse gas emissions reduce by only 1.5% per annum (the lower emission reduction scenario).

These results show the reduction in 2020 EBITDA after taking the mitigating effects of economic regulation into account. Whilst only the impact on 2020 EBITDA is presented in this paper, climate change is expected to impact earnings in each year, with progressively larger impacts over time. The size of the impact from carbon pricing will be dependent on the interplay between the reduction targets set and the cost of achieving reductions.

The magnitude of the EBITDA impact range at each carbon price shows that different airports have significantly different sensitivities to carbon price risk. This is driven primarily by the extent to which revenues are regulated at different airports (i.e. the breakdown of aeronautical, aeronautical-related, and non-aeronautical revenues). The airports with the highest proportion of non-aeronautical revenues experience the smallest impacts under all scenarios.

Chart 2: Range of Impacts on Australian Airports of a Carbon Price on Aviation Greenhouse Gas Emissions
(Percentage change in 2020 EBITDA)



3. Impact of Climate Change on Airports

The airports with the greater impacts are those with higher proportions of aeronautical-related revenue and higher proportions of tourist travellers. For an airport with significant aeronautical-related revenues and a high proportion of tourist travellers, the impact of carbon pricing of aviation greenhouse gas emissions ranged:

- From 0.20% reduction of 2020 EBITDA for a carbon price of \$5 per tonne of CO₂-e under scenario 1;
- To 2.14% reduction of 2020 EBITDA for a carbon price of \$25 per tonne of CO₂-e under scenario 2.

3.3 Airport Exposure to Climate Change Impacts on Tourism

There is a strong relationship between tourism and climate, both in terms of weather conditions and specific climate-sensitive natural attractions. Thus, climate change has significant potential to impact the attractiveness of particular destinations.

Expected climate change impacts likely to be relevant to the tourism sector include:

- Greater average temperatures, which are likely to affect the relative attractiveness of particular destinations (some tropical destinations may be perceived as 'too hot'). For northern Australia this may entail shortening of seasons where ambient temperatures are attractive to the tourist market. It is plausible that some areas in southern Australia, such as Melbourne and Tasmania, may become more appealing to tourists as temperatures increase as a result of climate change.
- Changes in weather patterns (such as, increased frequency of extreme rainfall events and cyclones) affecting travellers' perceptions of the relative attractiveness of particular destinations.
- Other climate-induced changes, such as the spread of tropical diseases including malaria and dengue fever with increased temperatures.
- Damage to natural attractions such as bleaching of the Great Barrier Reef, loss of flora and fauna in Kakadu due to the drying of wetlands, and loss of rainforests due to temperature and precipitation changes in northern Queensland.

Climate changes from global warming are expected to vary from region to region. For example, far northern Australia is expected to have higher average rainfalls, while the populous south is expected to have much lower average rainfall relative to historical norms.

As noted, specific natural attractions may be impacted by climate change. The most relevant of these risks for Australia is to the Great Barrier Reef, which currently attracts approximately 1.8 million visitors per year. The reef is vulnerable to a number of the anticipated impacts of climate change, including sea-level rise, sea temperature increase, increased storm frequency and intensity, precipitation patterns, drought, land run-off, oceanic circulation, and ocean acidity. The most likely outlook over the coming decades is that climate change will cause mass bleaching leading to widespread death of coral and impacting the desirability of the Great Barrier Reef as a tourist destination.^{xvii}

Climatic changes are not expected to reduce tourism revenue overall, rather they are likely to result in a redistribution of tourist spending as the relative climatic attractiveness of competing destinations changes. As a result, the impact may be positive for some destinations and negative for others.

While uncertainties remain, there are robust, quantitative predictions of climate change impacts available both at national and regional levels.^{xviii} However, there has been little research on how these changes in climate will affect tourist behaviour. One of the few studies undertaken in Australia found that if the Great Barrier Reef experienced an 80% decrease in coral cover, a 30% decrease in coral diversity and a 70% decrease in fish diversity (which are plausible outcomes by 2050), it would result in a 60% decline in the number of visitors to the reef, with a consequential impact on airport arrivals.^{xix}

Estimates of the impact of climate change on tourism flows at the country level were developed in another study.^{xx} At the two extremes, forecast changes to tourism arrivals by 2025 varied between a 37% increase for Russia and a 31% decrease for a number of North African countries. Countries with positive impacts are generally colder climates such as Canada and Russia, which are expected to benefit from warmer temperatures creating a more appealing destination, whereas many African nations are expected to suffer negative impacts as temperatures increase. Where there was a negative impact on passenger arrivals, an increase in outbound traffic was predicted reflecting the local population's response to the climate change. Likewise, where there was a positive impact on arrivals, as some destinations became more attractive to inbound travellers, outbound travel was predicted to decrease as more people chose to holiday at home.

3. Impact of Climate Change on Airports

Table 4: Traveller Types at Australian Airports^{xxi}

	Domestic			International		
	Business	VFR	Tourist	Business	VFR	Tourist
Adelaide	49%	29%	22%	25%	34%	41%
Brisbane	33%	27%	40%	18%	21%	61%
Darwin	37%	23%	40%	21%	21%	59%
Melbourne	48%	27%	25%	32%	26%	42%
Perth	42%	31%	27%	22%	27%	51%
Sydney	52%	24%	24%	28%	21%	51%

The sensitivity of an airport to tourism-relevant climate change will depend on the impacts experienced in the area serviced by the airport, as well as the proportion of tourism passengers.

Table 4 shows the relative proportion of travel undertaken for tourism, business, and VFR (visiting friends and relatives) purposes, highlighting significant variation across Australia’s major city airports. In many cases, regional airports may have more extreme reliance on tourism flows.

3.3.1 Modelling Results

Impacts have been modelled for three example airports with different expected climate change impacts in the local area and different proportions of:

- **Inbound passengers:** for whom the location is the destination, which in most cases have a much higher proportion of tourism-based journeys; and

- **Outbound passengers:** for whom the location is the origin of their journey, which have a greater proportion of business and VFR passengers.

Where locations are expected to be negatively affected by increased temperatures it is expected that there will be both a decrease of inbound (destination) passengers and an increase in outbound (origin) passengers. This represents fewer tourists being attracted to the destination and more locals wishing to holiday elsewhere who may previously have holidayed close to home.

Table 5: Modelling Assumptions – Change in Passenger Numbers to 2020

	Airport Characteristics	Assumed change in inbound passengers	Assumed change in outbound passengers
Airport 1	Located in a cooler climate (positively affected by warmer temperatures), with a majority of business travellers (unaffected by climate change) and a majority of outbound passengers	+7.5%	0%
Airport 2	Equal numbers of departures and arrivals, where the effects of increased temperatures on departures (increasing) and arrivals (decreasing) are likely to offset each other	-7.5%	+7.5%
Airport 3	In a location negatively affected by climate change both by an undesirable increase in temperatures and a loss of local natural attractions, also has a large proportion of tourist travellers and a majority of inbound passengers	-11.0%	+15.0%

3. Impact of Climate Change on Airports

Based on the projected impacts on inbound and outbound passengers discussed above, estimates of the impacts on the three example Australian airports are presented in Chart 3. Consistent with the impact on EBITDA for other climate change impacts, the results on travel behaviour are estimated through to the year 2020.

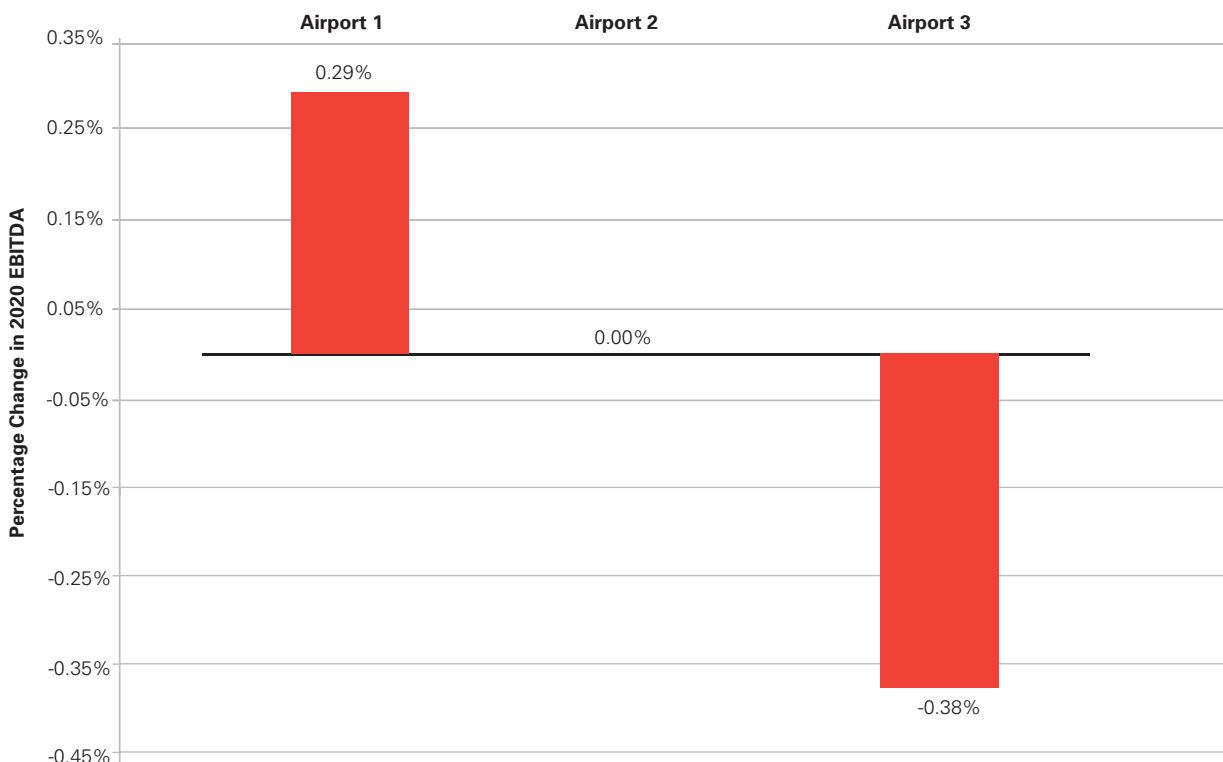
For the three example airports, after taking the mitigating effects of economic regulation into account, modelled impacts ranged from an increase of 0.29% to a reduction of 0.38% in 2020 EBITDA.

- **Airport 1:** experiences a small positive impact (+0.29% of 2020 EBITDA) from increased traffic flows due to perceived beneficial local climate impacts. The impact is only modest as the airport has a low proportion of inbound tourist travellers. If a greater proportion of its total traveller base were either tourists or inbound, results would be more favourable.
- **Airport 2:** has a neutral impact (0% change) as it has an equal share of departures and arrivals in its passenger mix and, so, the impact on each offsets the other.
- **Airport 3:** experiences a reduction in 2020 EBITDA of -0.38%, reflecting its high exposure to tourist travellers as well as the negative impacts from climate change assumed.

As with the other climate change impacts, the results reflect the impact on 2020 EBITDA. The impacts are expected to be seen in each year's EBITDA, increasing in magnitude over time.

These results illustrate how the variations in the individual airports' location together with the relative proportions of inbound (primarily tourist) and outbound (less discretionary) passengers lead to different outcomes. Each airport will present a different mix of these factors, which are often interrelated. The airports that are likely to experience the greatest impacts are those with local tourist attractions that may be affected by climate change. The airports that are likely to experience positive or no effect are those with fewer tourist travellers or those destinations whose attractiveness or accessibility relative to other destinations is expected to increase as a result of climate changes.

Chart 3: Range of Impacts on Three Example Airports Related to Tourism
(Percentage change in 2020 EBITDA)



3. Impact of Climate Change on Airports

3.4 Airport Exposure to Climate Change Impacts on GDP Growth

There is a high correlation between air travel growth and economic growth (GDP), reflecting increasing commercial and business activity and increasing personal income and propensity to travel (see Chart 4).^{xxii} This relationship has also been observed in the growth of air cargo.

Most forecasts of aviation demand are based on the premise that the demand for air transport is determined primarily by economic development (measured by GDP).

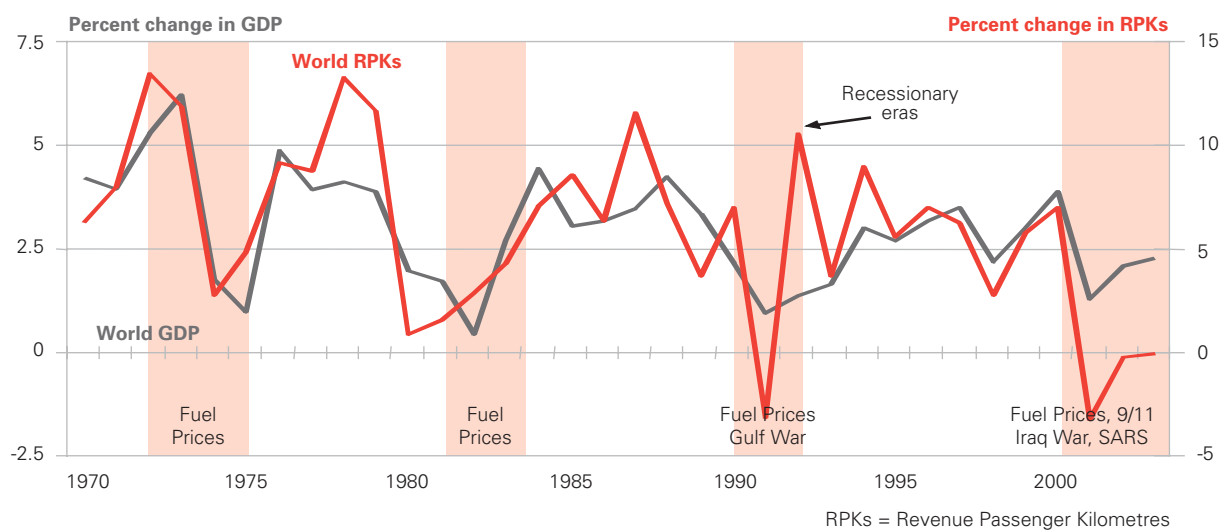
As an economy matures and the market for air travel reaches saturation, the relationship between GDP growth and air travel growth is expected to continue, but at a declining rate. For example, in the United States today a 1% growth in GDP will typically result in a 1.2% growth in domestic air travel, compared with a growth of almost 2% 20 years ago.^{xxiii}

Thus, based on GDP forecasts, global air travel is projected to continue to grow steadily, with much of the future growth expected to come from developing nations. However, these forecasts do not take into account the potential impact of climate change on GDP.

If greenhouse gas emissions were to continue to grow as projected under business as usual scenarios, the resultant climate change is expected to have a serious impact on GDP growth. Despite the uncertainties in climate change projections, a number of studies have sought to estimate the implications of climate change on economic growth. IPCC estimates undertaken in 1995 for Australia and New Zealand indicated an annual reduction of 1.2% to 3.8% of GDP for an equivalent doubling of carbon dioxide concentrations.^{xxiv} These estimates did not account for many now identified effects and adaptations, so the uncertainty is likely to be greater than the range given. The 2006 Stern Review on the economics of climate change found that a 2° to 3°C temperature increase by the end of the century would result in 'an average reduction in global per capita consumption of 5%, at a minimum, now and forever'.^{xxv}

Controls on greenhouse gas emissions may also result in GDP impacts. There have been a variety of estimates developed under different scenarios, most of which assume that the total GDP impact will be a mix of direct climate change impacts and the cost of limiting emissions. Because these estimates are dependent on assumptions about policy decisions, a very wide range of estimates have been developed.

Chart 4: Range of Impacts on Australian Airports of Climate Change Impacts on GDP



3. Impact of Climate Change on Airports

3.4.1 Modelling Results

Three scenarios were considered, across a range of airports, modelling a range of GDP impacts using a 1.5x multiplier effect (i.e. a 1% decrease in GDP results in a 1.5% decrease in passenger volumes) as follows:

- **Scenario 1:** 0.9% decrease in GDP by 2060^{xxvi} as a low end scenario, which is assumed to result in a 0.23% decrease in passenger volumes by 2020;
- **Scenario 2:** 3.8% decrease in GDP by 2060 based on the bottom end of the range estimated by the IPCC report,^{xxvii} which is assumed to result in a 0.99% decrease in passenger volumes by 2020; and
- **Scenario 3:** 5.0% decrease in GDP by 2060 based on Stern Review forecasts, which is assumed to result in a 1.30% decrease in passenger volumes by 2020.

Chart 5 shows the potential impact on 2020 EBITDA for Australian airports under each scenario.

The impact for Australian airports, after taking into account the mitigating effect of economic regulation, ranges:

- From a reduction of 0.06% of 2020 EBITDA for a reduction in GDP of 0.23% by 2020 under scenario 1;
- To a reduction of 1.03% of 2020 EBITDA for a reduction in GDP of 1.30% by 2020 under scenario 3.

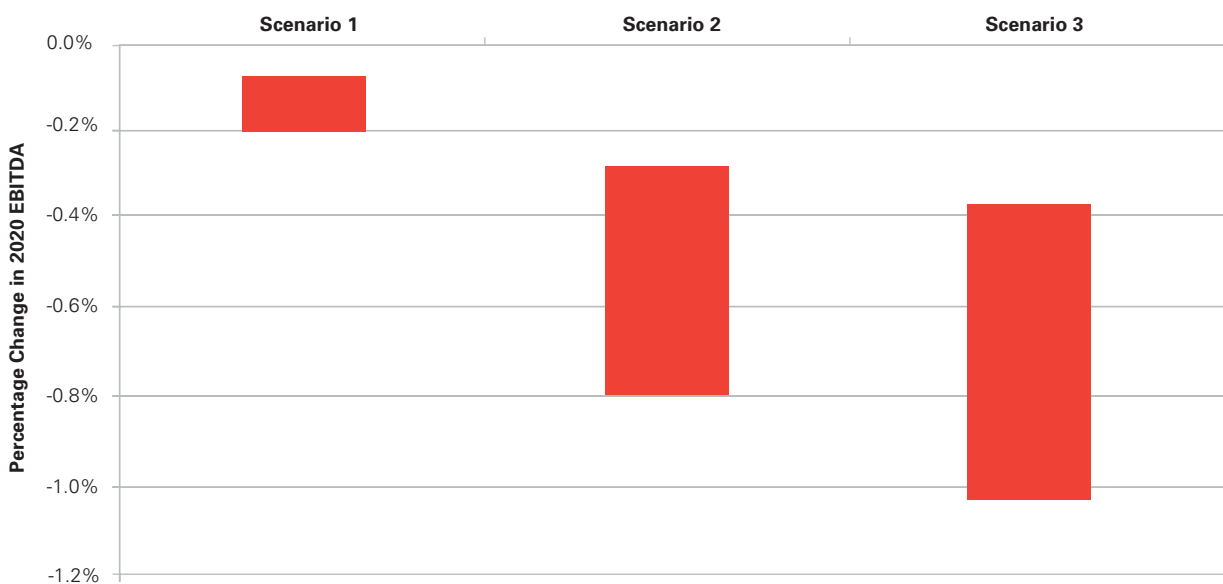
The range of outcomes for each scenario is largely dependent on the mix of revenues for the airports modelled. Those airports with greater proportions of aeronautical-related revenue (which is largely linked to passenger volumes) experience a greater impact from the decrease in passenger numbers.

Thus, the highest impacts were found in the airport with the highest proportion of aeronautical-related revenue (20% of total revenue). For this airport, the impact of decreased GDP ranged:

- From a reduction of 0.19% of 2020 EBITDA for a reduction in GDP of 0.23% by 2020;
- To a reduction of 1.03% of 2020 EBITDA for a reduction in GDP of 1.30% by 2020.

Again these impacts are illustrative impacts for the year 2020 rather than the total effect experienced in all years. Impacts are gradual over time and will continue increasing after the modelled period.

Chart 5: Range of Impacts on Australian Airports of Changes to GDP Growth
(Percentage change in 2020 EBITDA)



3. Impact of Climate Change on Airports

3.5 Airport Exposure to Other Climate Change Impacts

Airports are also exposed to climate change leading to increases in airport closures, increased insurance costs and increased maintenance costs. However, modelling suggests these impacts are not significant, both in absolute terms and in comparison to other climate change risks. Further, given that a significant portion of the costs can be passed through to passengers, the impact on returns is considered minimal.

Many airports in Australia and overseas are located close to sea level. Thus, if climate change leads to significant increases in sea level, this could impact airport operations and, under extreme scenarios, even airport viability.

The likely extent of future sea level rise is a key area of scientific uncertainty. The 2007 report by the IPCC observed that mean sea levels have risen by 0.17m during the 20th century and estimated further rises over the next century in the range of 0.18 to 0.59m. Based on these forward projections, it is very unlikely that the viability of any major Australian airport will be threatened. However, the report noted that 'the sea level projections do not include uncertainties in carbon-cycle feedbacks' and 'larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise'.^{xxxviii}

4. Assessing Individual Asset Exposure to Climate Change Risk

In general, in assessing the exposure of a particular airport to a climate change risk, consideration should be given to how the exposure varies with each of the following elements:

- Geography;
- Ability to pass through cost; and
- Risk mitigation opportunities.

4.1 Geography

4.1.1 Carbon Pricing

As discussed above, airports are exposed to carbon price regulation of aviation greenhouse gas emissions resulting in increased ticket prices and a decline in airline travel. The likelihood of carbon price regulation being introduced (and its timing) varies significantly across jurisdictions.

Generally, countries that have committed to greenhouse gas reduction targets under the Kyoto protocol present the highest likelihood of introducing carbon pricing. However, there is no requirement for ratifying countries to establish domestic carbon pricing schemes and some ratifying nations intend to achieve their reductions without imposing any form of carbon price regulation. Equally, some jurisdictions that are not bound to reduction targets have introduced or proposed carbon trading.

Australia has not ratified the Kyoto Protocol, but has nonetheless stated its intention of meeting its Kyoto target (of increasing greenhouse gas emissions by no more than 8% over 1990 levels over the period 2008-2012). On 3 June 2007, the Prime Minister announced that Australia will introduce a national emissions trading system beginning no later than 2012.^{xxx}

The likelihood of carbon price regulation can vary within a country – from region to region – as many state and territory governments are choosing to implement trading where no national scheme is planned.

Prior to the Federal government's activity around the development of a national emissions trading scheme in 2007, all Australian State and Territory governments had been involved in consultation on a national emissions trading scheme (to be administered at the state level). A possible design for the scheme was proposed by the States in 2006, with the scheme initially limited to emissions from electricity generation.

In addition, New South Wales has a carbon trading scheme in place – the Greenhouse Gas Abatement Scheme – which applies to electricity generation emissions only (with the carbon price obligation imposed on wholesale purchasers of electricity, primarily retailers).^{xxx}

However, there is no jurisdiction anywhere in the world that has introduced carbon price regulation of aviation greenhouse gas emissions.

As noted previously, the EU is considering proposals to include aviation emissions in its carbon trading scheme (the EU ETS). The proposal provides for aviation to be brought into the EU ETS in two steps. From the start of 2011, emissions from all domestic and international flights between EU airports will be covered. One year later, at the start of 2012, the scope will be expanded to cover emissions from all international flights – from or to anywhere in the world – that arrive at or depart from an EU airport.^{xxxi}

These proposals have the potential to impact on airports outside the EU where the carbon price is extended to all international flights that arrive at or depart from an EU airport, with the extent of impact dependent on the proportion of air travel to and from EU destinations.

Hence, it is necessary to consider all of the jurisdictions to which an individual airport is exposed to assess carbon price risk, not simply the jurisdiction in which the airport is located.

4. Assessing Individual Asset Exposure to Climate Change Risk

Table 6: Changes in Climate by 2030 (Relative to 1990) for Regions of Australia ^{xxxii}

(Central estimates for low and high scenarios)

	Average Annual Temperature		Average Annual number of Hot Days (>35°C)		Extreme Daily Rainfall Intensity	
	Low	High	Low	High	Low	High
NSW	+0.6°C	+1.3°C	+1 day	+25 days	0% ^B	+6% (east) ^B
SE QLD	+0.6°C	+1.3°C	0	+5 days*	0% ^A	+30% ^A
Southern SA	+0.4°C	+0.9°C	+2 days	+15 days*	0% ^A	+10% ^A
Tas	+0.5°C	+1.1°C	0	+1 day	+20% ^B	+80% ^B
Vic	+0.5°C	+1.1°C	+1 day	+10 days*	+5% ^A	+70% ^B
SW WA	+0.5°C	+1.1°C	+1 day	+20 days	N/A	N/A

N/A results not available *near coast ^A1 in 20 year event ^B1 in 40 year event

4.1.2 Climatic Impacts

In determining the exposure of a specific airport to climatic changes, it is important to understand the particular impacts that are likely to occur in the region. The expected changes in climate from global warming vary significantly from region to region and the nature, timing, and extent of changes in climate are still uncertain. Estimates of a selection of impacts are presented in Table 6 for a number of Australian regions

4.2 Ability to Pass Through Cost

The extent to which climate change exposures impact on airport earnings depends on the economic regulatory regime for individual airports as mentioned in section 2. The extent to which regulation protects airports from climate change may vary across airports depending on the specific regulatory environment.

4.3 Risk Mitigation Opportunities

4.3.1 Emission Abatement

Airline greenhouse gas emissions can be significantly reduced through greater fuel efficiency in aircrafts. For example, Airbus has a goal of reducing fuel consumption of its new aircraft by 50% by 2020, through a mixture of airframe improvements, engine improvements and more efficient air traffic control.^{xxxiii}

- 25% of the reduction is predicted to come from improving airframes, weight reduction, aerodynamic improvements, and new systems that allow aircraft to operate more efficiently.
- 10% to 15% of the reduction is predicted to come from improved engines, with Airbus claiming this target is achievable due to advances being made by engine manufacturers.
- The remainder of the reduction is predicted to come from improving air traffic control, such as ensuring that the most direct flight routes are taken and there is little or no circling while waiting to land.

Efficiency improvements are not limited to new aircraft. Airbus, for example, is also working on several ways to improve existing planes, such as improving the aerodynamics of the wings.

Both airlines, and other agencies (e.g. air traffic control, aircraft manufacturers, airport operators) can play a role in reducing aviation emissions and, thereby, reduce their shared exposure to carbon price risk.

5. Summary and Conclusions

Estimates of the potential impact of relevant climate change exposures on future EBITDA (in 2020) are summarised below. The low and high values are from different airports, which have different sensitivities to each of these risks.

Table 7: Estimated Potential Impact of Climate Change on 2020 EBITDA

Exposure	Estimated Impact 2020 EBITDA
Carbon Price for Aviation Emissions	-0.08% to -2.14%
Tourism Destination Attractiveness	+0.29% to -0.38%
Changes in GDP Growth	-0.06% to -1.03%
Airport Closures	Not considered material
Maintenance Costs	Not considered material

These estimates are limited by assumptions, simplifications, and uncertainties, in both the climate change models and the financial models used to generate them. As such, they represent an informed initial attempt to understand the potential impact, rather than a definitive assessment.

It should be noted that:

- Modelled impacts presented in this report are those that remain after taking the mitigating effects of regulation of pricing of airport services into account.
- The modelled results are the estimated impact on EBITDA in the year 2020. The total impact to investors will include the impact on EBITDA across all years.
- In order to determine the impact on total value to investors in today's dollar terms, the impact on each year's earnings would need to be reduced by an annual discount factor to take account of the timing impacts.
- Climate change impacts are all expected to increase over time. In particular, climatic changes are expected to grow significantly over the next century. As such, EBITDA impacts are also expected to increase with time. However, the timing and extent of impacts is subject to uncertainty.

Many airports are subject to some form of economic regulation, which to varying degrees can control the returns generated from such investments. Analysis shows that this can play an important role in mitigating climate change exposure, by allowing for periodic adjustments to aeronautical prices in response to changes in costs and revenue, so that airport owners receive a sufficient return on their investment. The proportion of revenue that is subject to economic regulation and the form of regulation are both important factors:

- The higher the proportion of aeronautical (regulated) revenue, the greater the ability to pass through the negative impacts of climate change in price increases.
- Formalised rate of return regulation, which applies to some European airports, may allow for more of the climate change impact to be passed through as price increases, relative to a price-monitoring framework (such as in Australia) where the outcome will be dependent upon the revised prices negotiated between airports and airlines.

In assessing the impact of climate change on a particular airport, the key differentiating factor is the proportion of aeronautical-related revenues – those revenues that are dependent on passenger throughput and are not protected by economic regulation. The proportion of aeronautical-related revenues for Australian capital city airports ranges from 7% to 20%.

As airport owners are exposed to any positive or negative impacts on aeronautical-related returns, care should be taken to consider climate change risk in assessments of new investments that will generate aeronautical-related revenues.

Appendix: Methodology Notes

Most infrastructure projects have long useful lives, so a long-term valuation approach is required to capture the range of factors that can impact on value across the life of the project. In addition, the financing of the project is often complex with multiple layers of secured debt, unsecured debt, and equity securities; such that the specific risk associated with the particular capital structure should be taken into account.

As such it is generally accepted that the projects should be valued using a long-term discounted cashflow (DCF) analysis on the project cashflows available to investors. The discount rate should be set having regard to the sector and the market in general and to account for any risks specific to the project being evaluated that are not captured in the cashflow forecasts. Where possible, it is generally considered preferable to adjust the cashflows (rather than the discount rate) to take account of specific risks. For the climate change scenarios presented in this paper, the cashflows were adjusted rather than the discount rate.

In relation to airport investments, the assets are generally valued with 10-20 year discounted cash flow (DCF) models with a terminal value applied to the remaining term of ownership. In addition to equity returns, the impact on the EBITDA is a key indicator, as it provides insight into the impact on operating earnings and is more comparable across investments, as it excludes the influence of different financing structures and relative capital intensities.

Whilst the cash yield available to equity investors is a key consideration in the listed market, this factor has largely been ignored in this analysis, as the impact will only be seen after a number of years.

Given that the bulk of expected impacts are indirect, the sensitivities that have been considered have in most cases been applied via adjustments to the forecast passenger growth rates. Adjustments can be applied simply to all passengers or separately to relevant passenger segments (such as, domestic, international, and other components) as appropriate. The model was established such that changes to passenger numbers impact both aeronautical income (e.g. landing and terminal fees) and non-aeronautical income (e.g. car parking and retail spend). To the extent that revenues (in most cases only aeronautical) have some degree of price control or regulated rate of return, revenues have been adjusted from the next expected regulatory review date.

In the interest of simplicity, forward capital expenditure forecasts have not been adjusted. If capital expenditure was optimised (further deferred) the impact on equity returns would be reduced.

Increased maintenance costs have been run through the models directly through operating expenses.

In forecasting the impact of controls on aviation greenhouse gas emissions, current Australian aviation emission data^{xxxiv} has been used to determine current average per passenger greenhouse gas emissions. The potential increase in ticket prices from emission controls is, therefore, determined using per passenger emissions, the relevant charge per tonne of greenhouse gas emissions (tCO₂-e) and an assumed average ticket price.

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- ^{xv} \$10 has been chosen for simplicity, actual spot prices at the time of drafting were slightly higher than this figure. For current price information refer to the environmental products page on www.afma.com.au.
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Resources

Climate Science

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- *Fourth Assessment Report – Climate Change 2007*

Australian Greenhouse Office www.greenhouse.gov.au:

- *Stronger Evidence but New Challenges: Climate Change Science 2001-2005*

Australia's Greenhouse Gas Emissions

National Greenhouse Gas Inventory
<http://www.greenhouse.gov.au/inventory/index.html>

Energy and Greenhouse Projections

National Greenhouse Gas Projections
<http://www.greenhouse.gov.au/projections/index.html>

International Energy Agency www.iea.org:

- *World Energy Outlook* www.worldenergyoutlook.org

Australian Bureau of Agricultural and Resource Economics
www.abare.gov.au:

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Projected Impacts for Australia

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- *Climate Change Scenarios for Initial Assessment of Risk in Accordance with Risk Management Guidance*

Commonwealth Scientific and Industrial Research Organisation www.csiro.au:

- *Climate Change Projections for Australia*
<http://www.dar.csiro.au/impacts/future.html>

International Agreements on Climate Change

United Nations Framework Convention on Climate Change and the Kyoto Protocol www.unfccc.int

Asia-Pacific Partnership on Clean Development (AP6)
www.dfat.gov.au/environment/climate/ap6/

Greenhouse Accounting

World Resources Institute and World Business Council for Sustainable Development www.ghgprotocol.org

- *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*

Carbon Trading

European Union Greenhouse Gas Emissions Trading Scheme
<http://ec.europa.eu/environment/climat/emission.htm>

Chicago Climate Exchange www.chicagoclimatex.com

New South Wales Greenhouse Gas Abatement Scheme
www.greenhousegas.nsw.gov.au

The World Bank Carbon Finance Unit
www.carbonfinance.org:

- *State and Trends of the Carbon Market 2007*

International Emissions Trading Association www.ieta.org

Australian Financial Markets Association
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Australasian Emissions Trading Forum www.aetf.net.au

Climate Change and Investment

Institutional Investors Group on Climate Change (UK)
www.iigcc.org

Investor Network on Climate Risk www.incr.com

Investor Group on Climate Change (Australia/New Zealand)
www.igcc.org.au

The Carbon Disclosure Project www.cdproject.net

The Carbon Trust www.carbontrust.co.uk

Potential Earnings Impacts from Climate Change

Airport Infrastructure

Resources

Valuing Climate Change Risk

The Carbon Trust www.carbontrust.co.uk:

- *Climate Change and Shareholder Value*
- *A Climate for Change – A trustee’s guide to understanding and addressing climate risk*
- *Brand Value at Risk from Climate Change*
- *Investor Guide to Climate Change*

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Investor Group on Climate Change (IGCC)

The IGCC represents institutional investors, with total funds under management of over \$375 billion, and others in the investment community interested in the impact of climate change on investments. The aim of the IGCC is to ensure that the risks and opportunities associated with climate change are incorporated into investment decisions for the ultimate benefit of individual investors. One of the key ways in which IGCC can work toward achieving this aim is through involvement in research projects such as this, to help the investment community better understand and assess climate change impacts.



Monash Sustainability Enterprises (MSE)

MSE is a multi-disciplinary research centre which specialises in the development of robust methodologies to analyse linkages between corporate social and environmental management and financial drivers. MSE has pioneered the practical application of environmental and social rating and analysis in Australian financial markets. Through its relationship with Regnan governance research and engagement services, MSE is the leading ESG research provider to many of Australia's largest institutional investors.



Hastings Funds Management

Hastings currently manages nine infrastructure funds, four of which are listed on the Australian Stock Exchange (ASX) and five unlisted wholesale funds investing in infrastructure equity and high yield debt. Hastings also manages two private equity funds and one timber investment vehicle. The Hastings team has the expertise required to invest in, and manage, infrastructure and privatisation investments encompassing project finance, regulation, banking, tax, risk management and an understanding of the infrastructure sector's value drivers.



Australian Government

The Australian Government Department of the Environment and Water Resources (formerly the Department of the Environment and Heritage) develops and implements national policy, programs and legislation to protect and conserve Australia's natural environment and cultural heritage.



Other reports in the series are available at www.igcc.org.au