Analysing Air Passenger Flows between New Zealand's Smaller Regions and Australia

A Gravity Model

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Abstract

Due to the geographic location of Australia and New Zealand, air transport is the dominant mode of travel between the two nations and to and from the rest of the world. While the trans-Tasman air passenger market between the two countries has grown over the last 20 years, direct air routes to Australian destinations from New Zealand's regional cities of Dunedin, Hamilton and Palmerston North have seen a major decline and, in most cases, the complete closure of those routes. This study uses the two-stage least squares (2SLS) gravity model to investigate the determinants of air passenger numbers on eight sampled city-pair routes. Empirical results show that for these trans-Tasman markets, expanded seat capacity has a strong positive impact on air passenger numbers. A longer driving time to travel to the nearest alternative international airport, the 2008/09 GFC and the winter season in New Zealand are also associated with an increase in air passenger numbers. In contrast, the presence of full-service network carriers has a negative impact on air passenger numbers. These findings have some important policy implications for stakeholders.

Keywords: 2SLS, gravity model, trans-Tasman market, air passenger numbers, policy implications

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1. Introduction

The commercial airline industry is widely considered to be a typically low-margin and volatile industry (Belobaba et al., 2016; Dempsey, 2008). For this reason, airlines can often experience periods of success and failure in a range of markets. Consequently, airlines and stakeholders need to gain a better understanding of the factors that influence the success or failure of the aviation markets so that they can more efficiently address current flight services or reinstate flight services (Belobaba et al., 2016; Fiig et al., 2019). While the trans-Tasman air travel market is currently growing overall (see Section 3), historically some routes have been unsuccessful and have ceased operating. It is necessary to understand why these trans-Tasman routes failed in order to assess if a re-entry could be possible in the future. Therefore, this study focuses on determining the factors that have contributed to the downturn of those routes.

One of the trans-Tasman markets that has gradually ceased service is that between regional New Zealand's smaller cities and the large east coast cities of Australia. In the late 1990s, three smaller New Zealand cities (Dunedin, Hamilton and Palmerston North) had non-stop air services to a range of destinations in Australia. Over a period of 20 years, these services have dwindled to the point that just one New Zealand city (Dunedin) continues to have service to only one Australian destination (Brisbane). As these routes have generally ceased within an otherwise growing trans-Tasman market, it is important to understand the factors that have impacted these unsuccessful routes and subsequent reductions.

Prior studies have shown non-stop flights increase passenger numbers and tourist arrivals. For example, Hazledine (2017) found this association in an analysis of New Zealand's domestic passenger numbers, and Tveteras (2014) showed long-haul non-stop flights increased tourist arrivals to Peru. In the case of regional New Zealand and Australia's city-pair routes, the hypothesis is that having non-stop flights encourages more Australian tourists to travel to a given New Zealand region and thus the region will see more tourist arrivals and a boost to its economy. Such a concept was the basis of the direct Air New Zealand Rotorua–Sydney route that the Rotorua Council in New Zealand proposed to subsidise in order to bring Australian tourists directly to the region (Bathgate, 2014). It comes as no surprise, therefore, that in other New Zealand regions, Hamilton and Palmerston North City Councils were also seeking new non-stop trans-Tasman airline services after their routes ceased in 2008 and 2012, respectively (Fox, 2012; Matthews, 2007; Rankin, 2018).

Empirically, this study aims to answer the research question:

What are the factors that impacted passenger flows on selected trans-Tasman routes?

The most widely used econometric model for estimating the flows of goods and services between two points is the gravity model (Boonekamp et al., 2018; Chang, 2012, 2014; Hazledine, 2017). In its basic form, the model suggests that the flow of transactions between two destinations increases with increasing economic sizes and populations, while proportionately decreasing with increasing distance. The model has been applied extensively to the analysis of air traffic volumes. A number of studies have also focused on city-pair and regional route estimations (Grosche et al., 2007; Hazledine, 2009, 2017). The literature is limited, however, on air passenger flows between the New Zealand cities of Dunedin, Hamilton and Palmerston North and Australia's Brisbane, Gold Coast, Melbourne and Sydney. This study, therefore, aims to address the gap in the air transport literature and provide insight into the determinants of air passenger demand for flights between these city pairs on the trans-Tasman market. In further analysing air passenger characteristics of these city pairs, the findings will also point to policy implications for stakeholders such as airports and airlines. This study, therefore, will be valuable for New Zealand's stakeholders, including local councils, airlines, airports and tourism authorities, as it determines the factors that impact passengers travelling on trans-Tasman routes between New Zealand's smaller regions and Australian destinations. The findings of this study could also be used to assess what areas need focus and more resources in order to launch possible new airline services in the future.

The rest of this thesis is constructed as follows. Section 2 reviews relevant literature on the use of the gravity model in analysing air passenger flows. It also reviews the determinants of air travel demand in the markets of New Zealand and Australia. Section 3 provides background on the trans-Tasman market and historical air services, as well as a discussion of the need to examine air passenger flows in this market. Section 4 presents the methodology and data used in this study. The empirical results and their implications are presented in Section 5, before Section 6 concludes the thesis.

2. Literature Review

Two key areas will be reviewed in this section. The first area reviews the use of the gravity model in air passenger flow analysis. The second area reviews the determinants of air passenger demand in general and on the trans-Tasman market.

2.1 The Use of the Gravity Model in Air Passenger Flow Analysis

The gravity model is originally derived from Newton's Gravitational Law, which states that the gravity between two objects is proportional to their masses and inversely proportional to the distance between these objects (Boonekamp et al., 2018). The shift from a physics concept into an economic one can be first credited to Isard (1954), who used the gravity model to estimate trade flows between two countries. In its basic form, the model follows the hypothesis that flows of goods, services and people between two locations (i.e., countries, regions or cities) is the function of gross domestic product (GDP) and the population of two locations, as well as the distance between them, which is expected to have a negative impact on trade flows (Hazledine, 2009, 2017). In the wider transport and tourism industries, the gravity model has been used in many applications; for example, Gabe et al. (2006) assessed cruise ship passengers' intentions of returning to ports, and Jozef et al. (2020) examined regional rail transport and infrastructure potential.

Given the gravity model has been used in a wide range of global transport applications, and has been regarded as the popular model in empirical trade research (Hazledine, 2017), its use in the aviation field would seem a natural fit (Grosche et al., 2007). Some of the earliest uses of the gravity model in air passenger forecasting were seen in Richmond (1955, cited in Matsumoto, 2007). In all applications, most of the gravity models incorporated additional explanatory variables (see Table 1). For example, Jan and Shah (2019) incorporated exchange rates in the model when analysing international trade flows. In air passenger traffic gravity models, it is expected that air travel is derived from activities such as tourism and business travel, and relevant variables are put into two groups: the geo-economic and the supply (or service) side factors (Binova, 2015; Rengaraju & Arasan, 1992).

Geo-economic factors are the economic and geographic characteristics of the two regions or cities being studied; the factors most frequently found to correlate with air passenger volume are population, average income (e.g., GDP per capita) and employment (Binova, 2015; Chang, 2012; Grosche et al., 2007; Hazledine, 2017; Hwang & Shiao, 2011). Many other geo-economic variables have been used, including number of phone calls between two specified locations (Verleger, 1972), buying power index (Grosche et al., 2007) and unemployment rate (Chang, 2014). The size of an airport's catchment has also been considered in the gravity models of Grosche et al. (2007) and Zhou et al. (2018).

Service or supply side factors are related to airline offering, price and the quality of service as the basis of most variables (Jorge-Calderón, 1997). Pricing is often instrumented with other variables such as fuel prices, due to the difficulty in obtaining actual pricing data (Hazledine, 2017). Trip time is commonly used as the supply side factor, reflecting total time between destinations, and is augmented by variables such as flight frequency, ground time, and distance to alternatives, as in Grosche et al. (2007), Rengaraju and Arasan (1992) and Russon and Riley (1993). Other factors used are airline quality factors such as aircraft size (Wei & Hansen, 2006) and on-time performance and loyalty programmes (Grosche et al., 2007).

Table 1. *Variables Used in Air Passenger Flow Gravity Models*

Authors and Studies	Variables Examined	Results
Jorge-Calderón (1997). Demand model for scheduled European air passenger traffic routes	Distance, income, population, if the route crosses a body of water, if the destination is a hub airport, if hub airport exists at all	Distance negatively correlated with number of air trips. All other variables have positive correlation
Wei and Hansen (2006). Major hub air traffic demand in the USA	Distance, income, local passengers, aircraft size, flight frequency, aircraft arrival capacity, hub destination's 'spokes', airfares	Aircraft size, frequency, arrival capacity and distance positively correlated with number of air trips. Local passengers, airfares and income negatively correlated
Grosche et al. (2007). Estimation of passenger volume on European city pairs	Population, GDP, catchment size, buying power index, average travel time, distance	Travel time and GDP negatively impact on number of air passenger trips. All other variables positively impact on number of air passenger trips
Hazledine (2009). Air passenger estimation of Canadian city-pair routes	Distance, income, population, language dummy variable, destination dummy variable (i.e., international *vs*. domestic)	Distance and language dummy variable negatively correlated with number of air passengers. All other variable positively correlated
Chang (2014). Air passenger flows between APEC nations	Population, income, distance, GDP, unemployment, differences in language, CPI, export import value	Income, import value, distance, unemployment, GDP and CPI have some significant impact in determining passenger flows. Unemployment rate, distance and, in second model, CPI have negative impacts on passenger flows
Hazledine (2016). Projections of regional air passenger flows in New Zealand 2018–2043	Distance, average fares, regional GDP per capita, number of non-stop flights, if backtrack is required, if ferry is required for land travel, airport catchment, number of visitors	Average fares, distance (squared) and backtrack dummy had negative impact on passenger flows while all other variables had some degree of positive impact
Hazledine (2017). Air passenger flow estimation for the cross-border Canadian and USA markets and New Zealand domestic market	Population, distance, visitors (based on travel reason), backtrack required (NZ), ferry required (NZ), average fares, competition (inverse Herfindahl-Hirschman Index), if a non-stop flight is available, frequency	In the cross-border model, average airfares have a negative impact on passenger trips. All other variables have a positive impact. In the New Zealand domestic model, backtrack, average fares and distance had a negative impact while all other variables had a positive impact

Note. APEC = Asia Pacific Economic Cooperation. CPI = consumer price index. GDP = gross domestic product.

2.2 Determinants of Air Passenger Demand Globally and in New Zealand and Australian Markets

Although the literature on the determinants of air passenger demand is rich, many of the studies on the trans-Tasman market have focused on generalising tourism determinants for either Australia or New Zealand. Tourism and air travel are clearly linked, with an even stronger association in the case of leisure traffic (Lei & Papatheodorou, 2010; van de Vijver et al., 2016). This link is emphasised in Australia and New Zealand, which are not geographically connected by land to any other nations, thus air travel is the primary transport mode of facilitating tourism. Consequently, more than 99% of visitors to New Zealand travel by air (Ministry of Business, Innovation and Employment, 2016). For this reason, insight into the determinants of air passenger traffic (including tourism) is crucial for understanding air travel demand in this market.

As seen in Table 1, the gravity models analysing air passenger traffic flows usually include both geo-economic factors and supply side factors. For the geo-economic factors, theoretically, GDP and population are used to measure a nation's wealth and relative size. Tretheway and Oum (1992) considered air travel to be highly responsive to income, and evidence would reinforce this claim as Australian inbound tourism markets appear to be highly sensitive to income (Bureau of Transport and Communications Economics, 1995). Similarly, GDP is considered to be a strong determinant of Australian outbound tourism demand (Seetaram, 2010). In the tourism literature, however, the combination of GDP and population (i.e., GDP per capita) is well used as a measure of disposable income (Garín-Muñoz, 2009; Lim, 1999; Turner & Witt, 2001). Because disposable income in its own right is subjective and imprecise, van de Vijver et al. (2016) also argued that income proxied as GDP per capita will be a key indicator of tourism growth within the region.

While income is an established determinant of tourism demand, and GDP per capita is the most widely used metric, other variables have also been examined in some analyses. Seetaram (2012) used average weekly earnings to capture income rather than GDP per capita by dividing average weekly earnings by consumer price index (CPI) when analysing Australian outbound tourism demand. New Zealand's tourism literature follows a similar trend, frequently using GDP per capita as a proxy for income (Tsui, 2017). In addition, the exchange rates between two nations have often been used in tourism demand modelling, given the value of one dollar against another can be a determining factor in the choice to travel to a particular region (Prideaux, 2005; Schiff & Becken, 2011). Exchange rate has been used in the tourism literature in Australia (Tsui & Balli, 2017) and in New Zealand (Tsui et al., 2019).

Following the gravity model, many studies have also used the geographic distance between two markets or city pairs as a proxy for airfares that can influence tourism demand (Eilat & Einav, 2004). Total travel time should be considered similarly, as Grosche et al. (2007) and Zhou et al. (2018) have done.

Airfare is often used as a demand side variable in the gravity models for analysing air passenger demand. In addition to distance and travel time, one of the acknowledged determinants of airfares is the presence of low-cost carriers (LCCs) in a market (Pulina & Cortés-Jiménez, 2010; Vowles &

Tierney, 2007). Due to their typically lower cost base and scaled-back services, LCCs generally offer lower airfares than full-service network carriers (FSNCs) (Forsyth, 2003; Gillen & Hazledine, 2016). Given travellers in the leisure and visiting friends and relatives (VFR) categories outnumber business travellers and typically have greater price elasticity, Dresner (2006) suggested that as LCCs gain market share globally, ultimately leisure travellers will represent an even higher proportion of the total tourism market, while growing the air travel market overall.

In this sense, low airfares with the rise of LCCs can also be considered to be a supply side factor. In New Zealand's domestic market, Tsui (2017) showed a relationship between the growth of LCCs and New Zealand's tourism demand. Similar effects are discussed in the Australian domestic market (van de Vijver et al., 2016). An open sky agreement between Australia and New Zealand, which allows for cabotage, has existed since 2002. This presents LCCs from either country with an easier entry path to domestic and trans-Tasman services, particularly if passenger feed exists in their wider market, as Wang et al. (2020) discussed. For the trans-Tasman market itself, the effect of LCCs has been significant, to the extent that it has even been regarded as one of the most competitive markets globally (Vowles & Tierney, 2007). The same study showed the entry of Pacific Blue (an LCC) to some trans-Tasman markets in the early 2000s grew air travel markets rapidly, with a 25% increase in passenger numbers over the 15 months after Pacific Blue began operating in the markets.

In addition to the impact of LCCs, jet fuel has a large impact on airfares because it represents a large portion of the operating costs of airlines (Gelhausen et al., 2018; Ringbeck et al., 2009; van de Vijver et al., 2016). As fuel prices have been highly volatile and have varying impact on airfares, they have also been used as a proxy for airfares (Becken, 2011). In New Zealand, rising fuel prices and subsequently rising airfares have been shown to have an impact on international tourist arrivals (Becken & Lennox, 2012; Schiff & Becken, 2011). Similarly, the CAPA Centre for Aviation (2011) suggested that increasing airfares have an impact on tourism prices and thus on tourism demand in Australia. Fuel prices have also been used as one of the variables in explaining trends in Australia's international tourist arrivals (Tsui & Balli, 2017). In addition, it is common for the aviation and tourism literature to use distance between two markets or city pairs as a determinant of airfares or tourism demand (Eilat & Einav, 2004).

Finally, exogenous events can also impact on air passenger demand and tourism demand. Events such as the 9/11 terrorist attacks, severe acute respiratory syndrome (SARS) and the 2008/09 global financial crisis (GFC) have been regarded as having a negative impact on the airline and tourism industries (Sarod & Silvia Zia, 2017; Wang, 2009).[1] In the Australian market, research showed the impact of the GFC on tourism was considerable (Perlich, 2013). In New Zealand, Tsui et al. (2019) found the GFC had a negative impact on regional air travel demand. Similarly, Tsui et al. (2014) revealed that the 2011 Christchurch earthquakes had a negative effect on passenger numbers at Christchurch Airport. Flight frequency is the supply side factor that influences tourism and air travel demand, because more frequent flights will be better able to cater to different preferences for arrival and departure times, as well as reducing overall travel time (Grosche et al., 2007). Confirming the strength of this impact, Henderson et al. (2019) found that the frequency and availability of flights were incredibly important to consumers when choosing between FSCs and LCCs in the New Zealand domestic market.

3. Background

3.1 Regional New Zealand Airports and the History of Direct International Services

In 1994, a small start-up airline in New Zealand, Kiwi Travel International, trialled direct charter flights between the New Zealand regional city of Hamilton and the major Australian city of Sydney. At this time, the trans-Tasman market was dominated by Air New Zealand and Qantas: both served the market with direct flight services between three Australian cities (Brisbane, Melbourne and Sydney) and three New Zealand cities (Auckland, Christchurch and Wellington) with a combined market share of 89% (Haugh & Hazledine, 1999). The remaining market share was mostly taken up by international carriers operating flights with the fifth freedom right, which allowed them to carry passengers between Australia and New Zealand. Before charter flights were offered, all residents in New Zealand outside Auckland, Christchurch and Wellington had to take ground transportation or connecting flights to one of these three airports to travel internationally.

The success of the Hamilton charter flight trial services led Kiwi Travel International to commence scheduled operations between Hamilton and Sydney in August 1995. Thereafter, the airline rapidly expanded its scheduled services to include Auckland, Christchurch and Dunedin (New Zealand) and Brisbane, Melbourne and Perth (Australia). At its peak, there were 30 weekly flights served with a single Airbus A320 and Boeing 737. Kiwi Travel International was the first airline to offer scheduled international flight services from Dunedin and Hamilton, and its fares, dubbed 'nuts and cola' class, challenged the ticket prices of Air New Zealand and Qantas to the point that Air New Zealand

[1] The impact of COVID-19 on air passenger traffic on the trans-Tasman market is not fully understood yet and is outside the scope of this study.

established a subsidiary airline, Freedom Air, in late 1995 to compete with the low-cost model of Kiwi Travel International (Haugh & Hazledine, 1999).

Ultimately, fierce competition from Freedom Air resulted in the demise of Kiwi Travel International in September 1996. However, Freedom Air continued and grew to serve Auckland and Christchurch, as well as becoming the first international airline to serve Palmerston North (New Zealand). In addition to Brisbane, Melbourne and Sydney, Freedom Air served Gold Coast (Australia) and Nadi (Fiji). The airline served these routes until 2008, when the parent company of Air New Zealand closed its operations. The closure of Freedom Air and thus its services to Palmerston North marked the end of international flight services from that airport. Air New Zealand briefly served the remaining routes until later ceasing these in 2009. Hamilton and Dunedin, however, were not without trans-Tasman flight services for long, as Pacific Blue (later rebranded as Virgin Australia) began providing such services from these airports in late 2009 (New Zealand Press Association, 2009; Pacific Blue, 2009). The rebranded Virgin Australia ended Hamilton's regular flight services in 2012, citing poor loads and uneconomical service. This was ultimately the end of Hamilton's international services (Fox, 2012). With the exception of Queenstown, Dunedin is the only remaining regional airport in New Zealand to offer direct trans-Tasman flight services, but even this operation has dwindled to just three to four weekly direct flights to Brisbane after Melbourne and Sydney's flight services ceased in 2014 (Martin, 2014). In addition to Dunedin, Hamilton and Palmerston North, Rotorua has previously had direct international services to Australia, with Air New Zealand providing direct flights to Sydney between 2009 and 2015.[2]

Over a 20-year period, then, Dunedin, Hamilton and Palmerston North airports have seen a significant downturn and, for two of those airports, the eventual removal of direct trans-Tasman flight services. Figure 1 shows the changing fortunes of the weekly direct trans-Tasman flight arrivals and departures from 2003 to 2019, during which the recorded peaks were over 30 weekly flights in late 2005 for Hamilton, 25 weekly flights in late early 2005 for Dunedin and 18 weekly flights in late 2004 for Palmerston North. These numbers were possibly even higher prior to 2003, when Kiwi Travel International operated alongside Freedom Air for a limited period (Haugh & Hazledine, 1999).

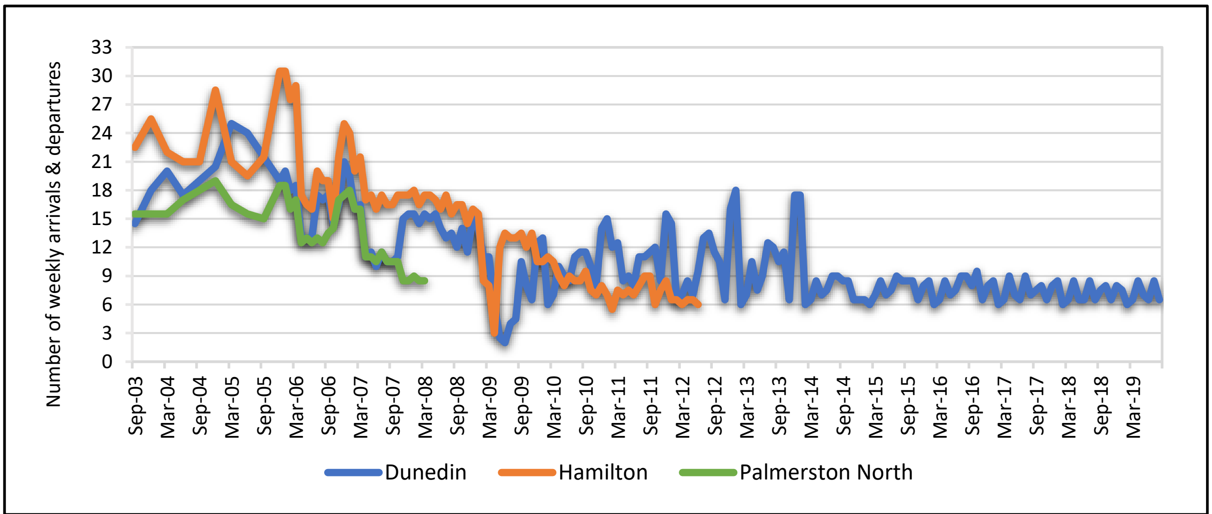
Figure 2 shows the total number of direct international passengers arriving and departing between 1998 and 2018 for the three New Zealand regional airports. While the data of Hamilton and Palmerston North airports contain a small number of Fiji-bound air passengers, the overall trend was

[2] Rotorua Airport will not be investigated in this study as its international service was shorter lived than other New Zealand airports and publicly subsidised by up to NZ$1 million per year by the Rotorua District Council (Bathgate, 2014).

for air passenger numbers from these two airports to peak in the period of 2005–2006, and to move downwards after that. Most notably, Hamilton Airport recorded over 35,000 arriving and departing international passengers in the first quarter of 2006.

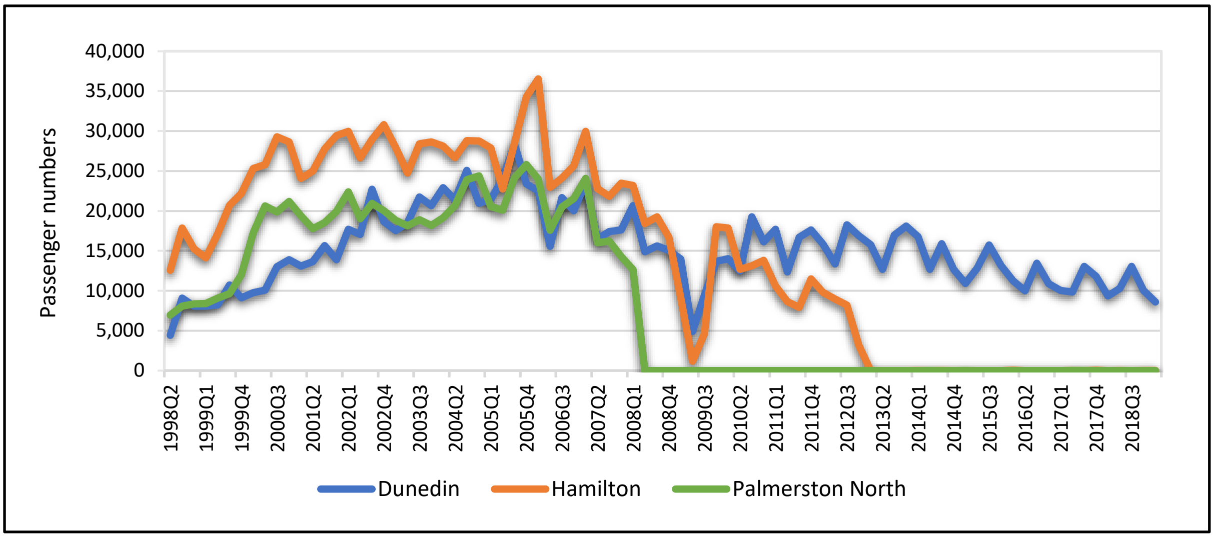
Freedom Air maintained a reasonably consistent flight seat utilisation or load factor throughout its life of 70–80% on average, with seasonal fluctuations, as Figure 3 shows. This data represents the entire Freedom Air flight network. While a slight downward trend occurred over this period, this may be offset by Freedom Air's change to larger aircraft during the life of its services, from Boeing 737-300s (133–140 seats) to Airbus A320s (150+ seats). After Pacific Blue (and later Virgin Australia) took over both Hamilton and Dunedin routes in 2009, its flight frequencies were much lower than those of Freedom Air. The downturn from this time, as shown in Figure 1, reflects how the daily international flight services occurred only at Dunedin Airport for some months, before reducing to the three to four flights each week in the current schedule.

Figure 1. Number of weekly trans-Tasman Flight Arrivals and Departures from Dunedin, Hamilton and Palmerston North



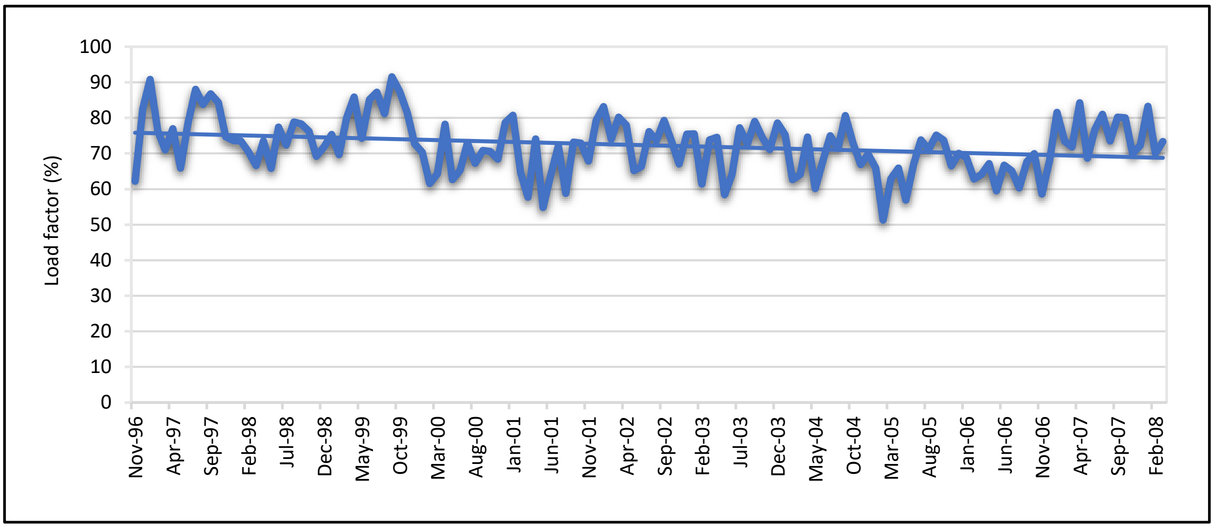
Source: The Bureau of Infrastructure Transport and Regional Economics (2020a).

Figure 2. Total Direct International Passenger Numbers Quarterly (arriving and departing)



Source: Statistics New Zealand (2020b).

Figure 3. Freedom Air Total Average Seat Utilisation



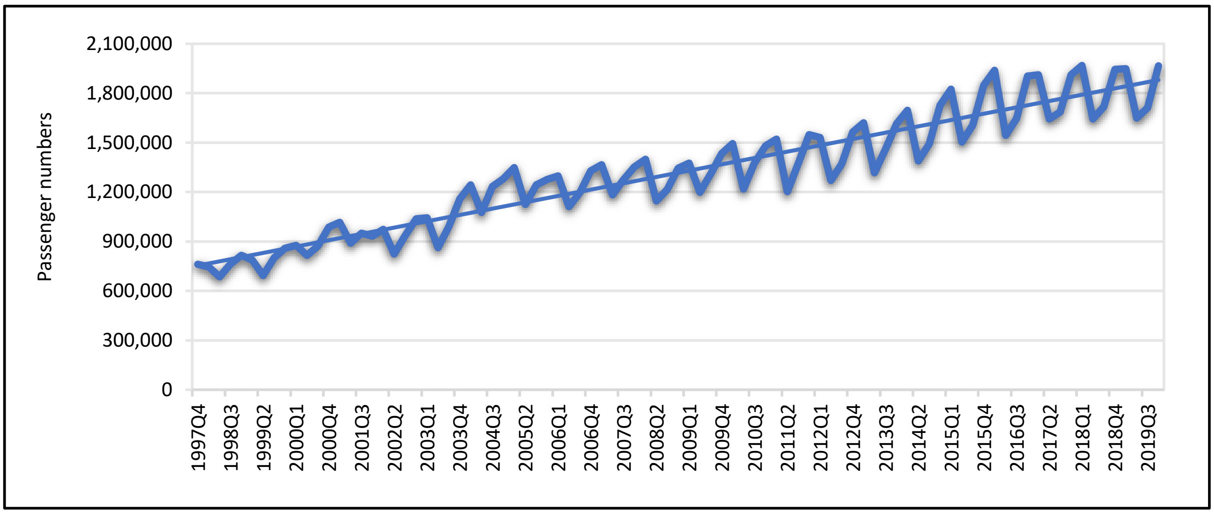
Source: The Bureau of Infrastructure Transport and Regional Economics (2020b).

3.2 Development of the Trans-Tasman Market

The slow decline of direct air services between regional centres in New Zealand and Australia does not necessarily reflect the position of the entire trans-Tasman market. On the contrary, air passenger volume for all trans-Tasman routes has increased steadily between 1997 and 2019 (see Figure 4). Similarly, the decline of regional services is not related to population trends in the three New Zealand regional centres in this study (Dunedin, Hamilton and Palmerston North), where the populations have actually grown over this period, as Figure 5 shows. It should also be noted that, because no new airports have been built in New Zealand during the study period, the ground travel times or air transit times to alternative airports in New Zealand have not changed significantly for residents living at those three New Zealand regional cities who travel internationally.

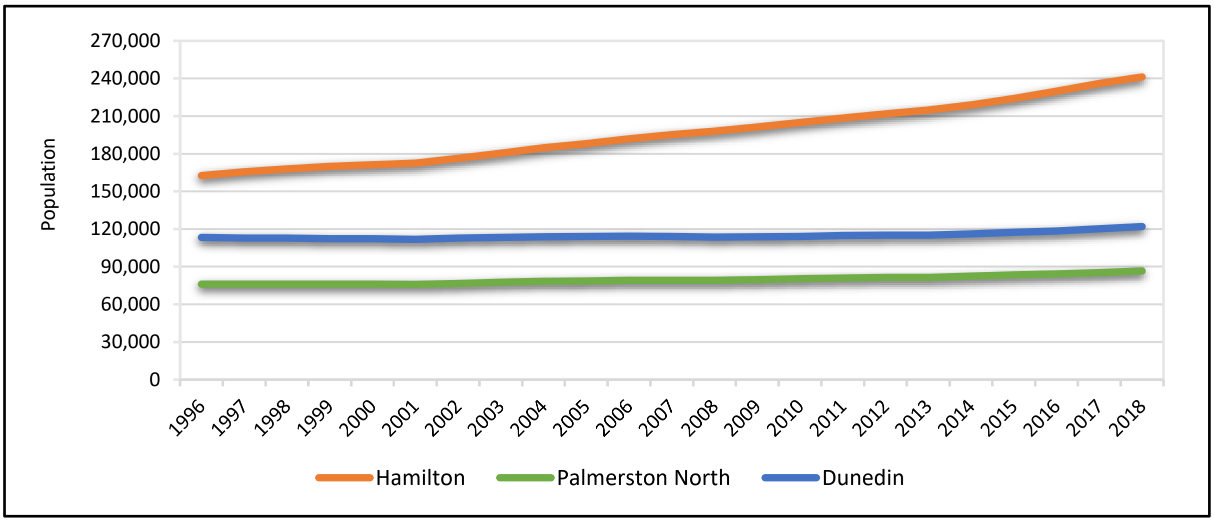
In this context, four airline brands (Air New Zealand, Freedom Air, Pacific Blue and Virgin Australia) have served three of New Zealand's regional cities (Dunedin, Hamilton and Palmerston North) with flights to Australia over a period of 20 years. In theory, these three trans-Tasman markets had an opportunity to grow, in practice those markets declined. Accordingly, other factors must have influenced or led to the demise of international flight services in these three trans-Tasman markets. This study, therefore, aims to identify and analyse the demand and supply-side factors as well as the geo-economic factors that influenced air passenger numbers on the selected trans-Taman routes over their lifespan.

Figure 4. Total Passenger Movements between all New Zealand Airports and Australian East Coast Airports



Source: Statistics New Zealand (2019).

Figure 5. Urban Population Data for Dunedin, Hamilton and Palmerston North from 1996 to 2018



Source: Statistics New Zealand (2019).

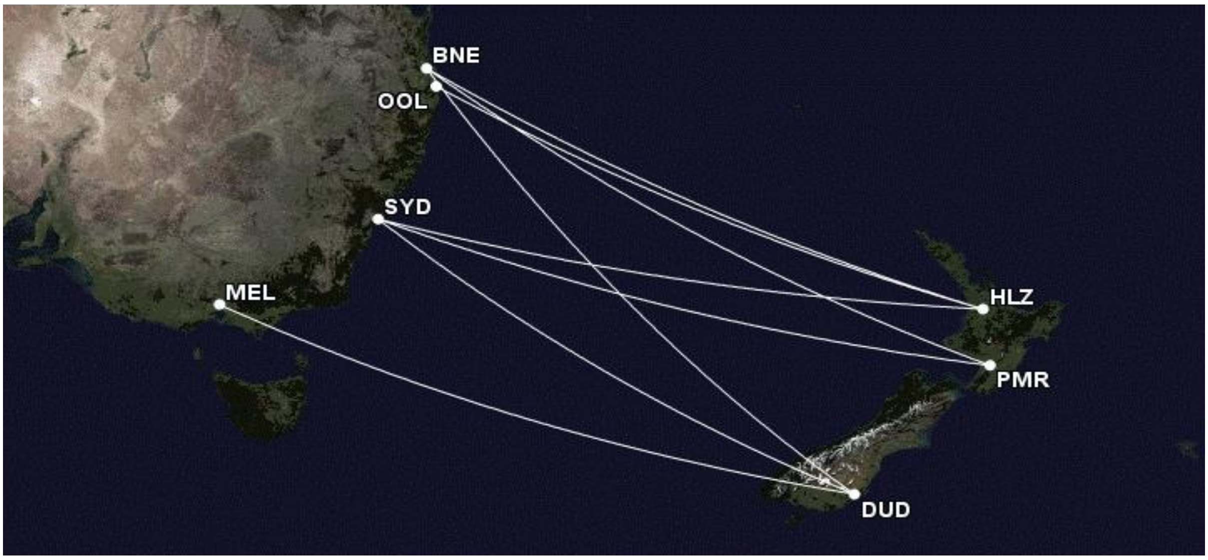
4. Data and Methodology

4.1 Sample and Data Collection

As this study investigates the factors that impact air passenger numbers for the sampled city pairs, its main variable of interest (i.e., the dependent variable of the gravity model) is total passenger numbers (both inbound and outbound) travelling on the sampled city pairs. Data were accordingly collected on international scheduled flights that operated between Australia and New Zealand from 1996 to 2019 for Dunedin, from 1996 to 2012 for Hamilton, and from 1997 to 2008 for Palmerston North. To combine the data of all the sampled city pairs, an unbalanced panel dataset was created covering the period of Quarter 1, 1997–Quarter 2, 2019.

To be included in the gravity model, the sampled city pairs needed to have been served by regular flights for at least five years.[3] Quarterly data was used because many of the potential explanatory variables are measured quarterly, and it would be beneficial to identify any seasonal fluctuations and any correlations with the identified explanatory variables over the combined three-month period. Ultimately, eight city-pair routes have been included in the dataset (see Figure 6). These city-pair routes represent the majority of air passengers travelling between Dunedin, Hamilton and Palmerston North airports in New Zealand and east coast Australian airports (see Figure 7).

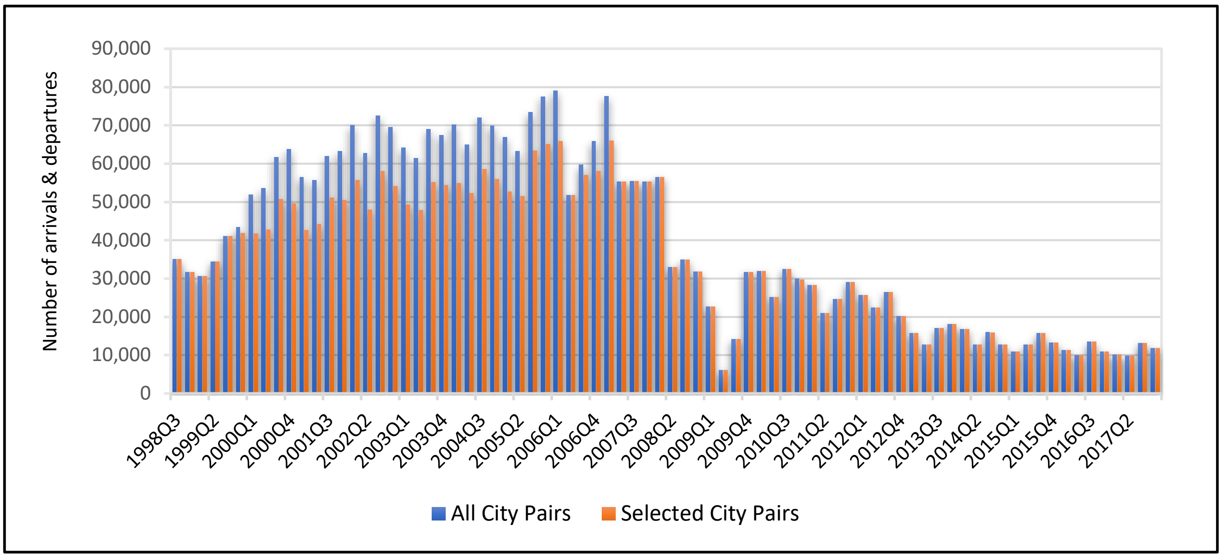
Figure 6. Map of the Sampled City Pairs on the trans-Tasman Market



Note. Australian airports (BNE= Brisbane, MEL = Melbourne, OOL = Gold Coast, SYD = Sydney); New Zealand airports (DUD = Dunedin, HLZ = Hamilton, PMR = Palmerston North).

[3] The criterion of five years of flight service was set to ensure the number of observations was sufficient to allow meaningful analysis. Some city pairs on the trans-Tasman market were omitted for this reason; for example, the city pair of Dunedin and Gold Coast was served intermittently over some years and quarters.

Figure 7. A Comparison of the Number of Arrivals and Departures for All International City Pairs Involving PMR, HLZ and DUD and Australian Cities and for the Eight City Pairs Selected for the Dataset.



Source: Statistics New Zealand (2020).

4.2 Model Specification and Variables

This study uses the gravity model, described generally in Section 2, to examine air passenger traffic flows on the trans-Tasman market. It can be expressed as follows:

$$ln(PAX_{ijt}) = \alpha + \beta_1 \, ln(GDPNZ_{it-1}) + \beta_2 \, ln(GDPAU_{jt-1}) + \beta_3 ln(SEATCAP_{ijt}) + \beta_4 \, ln(FUEL_t) + \beta_5 ln(DIST_{ij}) + \beta_6 HOURSALT_{it} + \beta_7 ln(EXRATE_t) + \beta_8 GFC_t + \beta_9 FSNC_t + \beta_{10} WINTER_t + \varepsilon_{ijt}$$

where i is New Zealand airport, j is Australian airport, t represents time (quarter), ε is the error term, β_s is the coefficient to be estimated and ln is the logarithmic form. The model uses an unbalanced panel dataset with eight sampled city-pair routes over the period of Quarter 1, 1997–Quarter 2, 2019. The gravity model is estimated using the two-stage least squares (2SLS) model with random effects generalised least squares estimators and an instrument variable (see Section 4.6). Table 2 shows the notations, definitions and data sources of variables of interest, as well as the expected relationship between the dependent variable and each of the explanatory variables.

Table 2. Variables Used in the Gravity Model

Variables	Definitions	Sources	Expected relationship with dependent and explanatory variables	References
$ln(PAX_{ijt})$	Combined inbound and outbound air passenger numbers of the sampled city-pair route	Statistics New Zealand; Australian Bureau of Infrastructure, Transport and Regional Economics	Dependent variable	(Grosche et al., 2007; Hazledine, 2016, 2017)
$ln(GDPNZ_{it-1})$	The previous period of real GDP per capita of New Zealand	Statistics New Zealand	Positive	(Balli et al., 2019; Hwang & Shiao, 2011; Tsui et al., 2017)
$ln(GDPAU_{jt-1})$	The previous period of real GDP per capita of Australia	Australian Bureau of Statistics	Positive	(Balli et al., 2019; Hwang & Shiao, 2011; Tsui et al., 2017)
$ln(SEATCAP_{ijt})$	Combined inbound and outbound airline seat capacity of the sampled city-pair route	Australian Bureau of Infrastructure, Transport and Regional Economics	Positive	(Boonekamp et al., 2018; Tsui et al., 2017)
$ln(FUEL_t)$	Average kerosene fuel prices per gallon (in USD)	United States Energy Information Administration	Negative	(Gelhausen et al., 2018; Tsui & Balli, 2017)
$ln(DIST_{ij})$	Flying distance between each sampled city-pair route (in kilometres)	Google Maps	Negative	(Hazledine, 2009; Wei & Hansen, 2006)
$HOURSALT_{it}$	Average driving time to selected alternative international airport in New Zealand (in hours)	Google Maps	Positive	(Grosche et al., 2007; Hazledine, 2017)
$ln(EXRATE_t)$	The exchange rate between New Zealand dollars (NZD) and Australian dollars (AUD)	Reserve Bank of New Zealand	Positive	(Jan & Shah, 2019; Sharma et al., 2019; van de Vijver et al., 2016)
GFC_t	Dummy variable that takes the value of 1 for the GFC for the period of 2007Q3–2008Q4; 0 otherwise	Author's own calculation	Negative	(Tsui et al., 2017; Wang, 2009)
$FSNC_t$	Dummy variable that takes the value of 1 if a FSNC operated in the sampled city-pair routes; 0 otherwise	Author's own calculation	Negative	(Gillen & Hazledine, 2016; Vowles & Tierney, 2007)
$WINTER_t$	Dummy variable that takes the value of 1 if the quarter is quarter 3 (winter peak); 0 otherwise	Author's own calculation	Positive	(Haugh & Hazledine, 1999)

Air Passenger Numbers

Air passenger numbers (inbound and outbound), $ln(PAX_{ijt})$, on each of the sampled routes is the dependent variable. The data only shows passengers who travelled on non-stop flights. The two databases that provide these data are from Statistics New Zealand (Stats NZ) and the Australian Bureau of Infrastructure, Transport and Regional Economics (BITRE). Stats NZ's database of total passenger movements provides air passenger data for all trans-Tasman routes from every New Zealand international airport on a quarterly basis – the selected scale. However, prior to 2000, the Stats NZ database is missing many entries and does not reflect the level of airline capacity. In comparison, the Australian BITRE database was more accurate prior to 2000. From 2000 onwards, both databases matched each other in accuracy. For this reason, this study uses the BITRE database until 2000. Thereafter, it uses the Stats NZ database because it presents data quarterly – which is consistent with the approach in this study.

GDP per Capita of New Zealand and Australia

As discussed above, GDP is the most widely used variable in the gravity model to measure income and economic growth. The basic gravity models use some form of income measure, often GDP or population, to measure air passenger flows or tourism demand. Many previous studies combined the two variables to form GDP per capita, which simplified the model and avoided multicollinearity between population and GDP or other variables (Balli et al., 2019; Hwang & Shiao, 2011). Stats NZ's regional GDP per capita data are only published yearly and from 2000 onwards, making it difficult to incorporate them into the dataset. Ultimately, GDP per capita is the best measure of income in this study as both the Australian and New Zealand's GDP per capita data are measured quarterly and are available for the entire study period.

The data of New Zealand GDP per capita, $ln(GDPNZ_{it})$, are sourced from Stats NZ (in New Zealand dollars – NZD), while the data of Australian GDP per capita, $ln(GDPAU_{jt})$, are sourced from the Australian Bureau of Statistics (in Australian dollars – AUD).

Seat Capacity

Many previous air passenger gravity model studies, including Wei and Hansen (2006) and Hazledine (2016, 2017), used flight frequency as an explanatory variable in their models. Taking a different approach, Boonekamp et al. (2018) and Tsui et al. (2017) used seat capacity as an explanatory variable. Given seat capacity reflects the combination of frequency and aircraft capacity, it is a good variable for showing any impact of increased overall capacity on air passenger numbers. In this study, all four airline brands (Air New Zealand, Freedom Air, Pacific Blue and Virgin Australia) that have served the sampled city-pair routes have used a similar capacity aircraft type, which ranges from 133–

176 seats (Airbus A320 or Boeing 737-300 and -800). Because of this, seat capacity, $ln(SEATCAP_{ijt})$, is a measure that can provide insight into overall seat capacity on each route. In addition, this variable offers a better understanding of frequency: greater frequency increases the range of times and days of flights available for travellers – for example, both morning and afternoon flights – thus increasing flexibility. These options are factored into a passenger's decision on taking a specific flight.

As Dunedin, Hamilton and Palmerston North airports saw a peak in weekly international flight frequency in the period of 2005–2006 (see Figure 1) and a downturn thereafter, it is beneficial to include a measurement of seat capacity in determining its impact on changes in total air passenger numbers on the sampled city-pair routes. Therefore, this is a valid variable for reflecting the overall options customers had available during the study period on each city-pair route.

Fuel Prices

Global kerosene prices (fuel prices), $ln(FUEL_t)$, were added to the model to reflect the impact of fuel prices on air passenger demand, as evidenced in Becken and Lennox (2012) and Schiff and Becken (2011), in addition to the possibility of using the price of kerosene as a proxy for airfares, as Becken (2011) and van de Vijver et al. (2016) suggested. Note that collecting airfares is particularly costly and difficult, given neither the Australian nor the New Zealand government has a database of airfares on the trans-Tasman markets or covering the entire study period. Anecdotal evidence suggests that earlier in the period, Kiwi Travel International and Freedom Air offered lower fares than the mainline competitors (e.g., Air New Zealand and Qantas) on the trans-Tasman routes (Haugh & Hazledine, 1999). Ultimately, using fuel prices is a reliable proxy for airfares for this study. The fuel price data are measured monthly by the United States Energy Information Administration and were converted into quarterly data for analysis.

Flying Distance

Following the basic gravity model format that suggests weaker flows in air passenger traffic over longer distances, the geographic distance of each selected city pair is added into the model in kilometres. The distance for each city-pair route, $ln(DIST_{ij})$, is obtained from Google Maps. Hazledine (2009) discussed the impact of distance on trade and air passenger numbers. He asserted that, while the variable of distance does not always have a proportionate impact on trade in a gravity model, distance is an important predictor of ticket prices, as in Gillen et al. (2006). Given that this study contains no direct ticket price variable, flying distance may act as a proxy for this and show any impact on air passenger numbers on the city-pair routes chosen.

Hours to Alternative International Airport

When measuring air passenger demand for Dunedin, Hamilton and Palmerston North (New Zealand), it is important to add a variable that measures the travel time to the closest alternative international airport, $HOURSALT_{it}$, that passengers may fly out from. As Hazledine (2016, 2017) and Grosche et al. (2007) found, total travel time and the need to backtrack to other airports can have an impact on air passenger numbers. Nonetheless, air passengers, particularly leisure travellers, are price sensitive and will look for the cheapest fares for their journey. If a Hamilton–Brisbane direct flight is faster and more convenient, but an Auckland–Brisbane flight is cheaper, a passenger may choose to drive 1 hour 45 minutes from Hamilton to Auckland Airport and fly from there to Brisbane. Ultimately, it is a trade-off between convenience, price and travel time that the closest alternative international airport offers.

This consideration is particularly important for this study as driving time to the nearest alternative international airport varies substantially among the three New Zealand cities chosen: for Hamilton's residents, as noted above, it is 1 hour 45 minutes on average to Auckland Airport; for Palmerston North's residents it is 2 hours 25 minutes on average to Wellington Airport; and for Dunedin residents it is 4 hours and 30 minutes on average to Christchurch Airport [4]. It is valid to consider the average driving time to the closest alternative New Zealand's international airport in this study because it helps to identify the relationship between changes in air passenger numbers and the time required to get to the closest alternative international airport that provides more convenient flights or cheaper fares.

Exchange Rate

As evidenced in Jan and Shah (2019) and Sharma et al. (2019), changes in exchange rate are considered to be a key determinant of international tourism demand. A similar effect is likely to apply to the trans-Tasman market, with changes in tourism demand in turn affecting air passenger numbers. Therefore, this study considers the exchange rate between New Zealand and Australian dollars, $ln(EXRATE_t)$, as a determinant of air passenger numbers on the sampled routes.

The case for including this variable is perhaps even stronger for a study of New Zealand's smaller regions, which have fewer businesses and thus less business travel in comparison with the larger cities of Auckland, Christchurch and Wellington. As such, the exchange rate variable was

[4] Christchurch is considered the alternative international airport for Dunedin in this study. This is because it offers a much wider range of international services over the entire study period when compared to Queenstown (a 45 minute drive closer).

included in the gravity model. The monthly NZD:AUD exchange rate data were obtained from the Reserve Bank of New Zealand and converted to quarterly data for analysis.

GFC Dummy Variable

The 2008 GFC was added as a dummy variable, GFC_t, to examine any possible relationship between the economic downturn and air passenger demand on the sampled routes. Perlich (2013) and Tsui et al. (2019) acknowledged the impact of the GFC in decreasing tourism demand, as well as in reducing economic activity and disposable incomes overall. Because the Reserve Bank of Australia classifies the GFC timeframe as extending from mid-2007 to late 2008 (Reserve Bank of Australia, 2020), this dummy variable takes the value of 1 for the period of Quarter 3, 2007 to Quarter 4, 2008, and the value of 0 for times outside this period.

FSNC Dummy Variable

Over the study period of Quarter 1, 1997–Quarter 2, 2019, four airline brands have operated on the sampled routes: Air New Zealand, Freedom Air, Pacific Blue and Virgin Australia. Freedom Air was an LCC offering limited flight service and cheaper fares while its parent company Air New Zealand was an FSNC offering premium flight services (e.g., frequent flyer programme, onboard food and services, and baggage). Pacific Blue started as an LCC offering budget fares before rebranding to Virgin Australia as an FSNC in 2012.

In this study, a $FSNC_t$ dummy variable was added into the model to explore whether FSNC models affected air travel demand on the sampled routes (Gillen & Hazledine, 2016). This dummy variable takes a value of 1 when an FSNC operated in the sampled routes during a particular quarter, and 0 for LCC operations. As described in Section 2.2, LCCs typically have lower ticket prices due to cut-back services and, as a result, increasing air travel demand (Pulina & Cortés-Jiménez, 2010; Vowles & Tierney, 2007). This dummy variable aims to show any effect that the presence of an FSNC may have on air passenger numbers on the sampled routes.

Winter Season Dummy Variable

As Oppermann and Cooper (1999) observed, New Zealand's outbound travel has historically peaked in Quarter 3 (July, August and September) with shoulder seasons in Quarters 2 and 4 and an off-season in Quarter 1 each year (see Figure 4). The peak occurs during the three winter months, which also includes a school holiday period, because many families and leisure travellers escape New Zealand's cold weather in search of hotter destinations (e.g. Gold Coast). For inbound demand from Australia, Lim and McAleer (2008) reported warmer New Zealand months in Quarter 4 were most popular. Evidence from Oppermann and Cooper (1999) and Haugh and Hazledine (1999) also suggested that the sampled routes are representative of the New Zealand outbound tourism market to Australia more generally.

Therefore, it is reasonable to expect a possible spike in outbound tourism demand from New Zealand to Australia and thus an increase in air passenger numbers in Quarter 3 of each year. The $WINTER_t$ dummy variable takes a value of 1 for Quarter 3 in each year of the study period, and 0 for the other quarters.

4.3. Descriptive Statistics of Variables

Table 3 presents the descriptive statistics of the variables of interest in this study. In summary, an average of 6,965 passengers travelled between New Zealand and Australia on each sampled city-pair route per quarter. New Zealand's GDP per capita is about NZD$11,000 while Australia's is about AUD$15,000. The average flying distance between the sampled routes is about 2,349 km, ranging from 2,109 to 2,559 km. Seat capacity for each city-pair route per quarter (combined) averages 9,867 seats. Fuel prices over the period average USD1.34 per gallon. Driving time to alternative international airports in New Zealand averages 2.92 hours while the NZD:AUD exchange rate averages 0.86 over the study period.

Table 3. Descriptive Statistics of Variables of Interest

Variables	Unit	Mean	Minimum	Maximum	Standard deviation
PAX_{ijt}	Passengers	6,964.11	941	19,012	3,217.09
$GDPNZ_{it}$	NZD	10,477.21	8,564	13,649	1,013.90
$GDPAU_{jt}$	AUD	15,734.09	12,587	19,302	1,410.33
$SEATCAP_{ijt}$	Number	9,867.23	1,630	27,360	4,526.24
$FUEL_t$	USD per Gallon	1.34	0.38	3.66	0.81
$DIST_{ij}$	km	2,349.13	2,109	2,559	153.45
$HOURSALT_{it}$	hour	2.92	1.75	4.50	1.27
$EXRATE_t$	NZD:AUD	0.86	0.75	0.96	0.05

Note. Dummy variables of GFC_t, $FSNC_t$ and $WINTER_t$ are not shown. The figures above are the original numbers.

4.4 Test for Stationarity of Variables

Prior to commencing the regression analysis, all variables of interest need to be tested for stationarity or unit roots in order to avoid spurious regression (Tsui et al., 2019). The dummy variables of GFC_t, $FSNC_t$ and $WINTER_t$ are not tested for unit roots. For each of the other variables, the augmented Dickey–Fuller (ADF) unit root test was performed. In this test, the null hypothesis is that the variable contains a unit root. If a variable is rejected at the 0.05 significance level, it means the variable is stationary. The initial results of the ADF unit root test showed all variables to be stationary, except for $ln(FUEL_t)$ and $ln(EXRATE_t)$ (rows 5 and 6 of Table 4, respectively). $ln(FUEL_t)$ (row 5 of Table 4) has a *p*-value of 0.997, thus the null hypothesis that it contains a unit root cannot be rejected. Similarly, the p-value of 0.496 for $ln(EXRATE_t)$ (row 6 of Table 4) supports the null hypothesis. To solve this issue, the first differencing technique was applied to convert these non-stationary variables in order to make them stationary. It brings p-values of both variables to under 0.05 (rows 7 and 8 of Table 4), suggesting that they have become stationary and can be used for regression analysis.

Table 4. Results of ADF Unit Root Test of the Variables of Interest

Variables	***p*-value**
$ln(PAX_{ijt})$	0.000
$ln(GDPNZ_{it-1})$	0.010
$ln(GDPAU_{jt-1})$	0.001
$ln(SEATCAP_{ijt})$	0.000
$ln(FUEL_t)$	0.997
$ln(EXRATE_t)$	0.499
$ln(FUEL_t)$ (first differenced)	0.000
$ln(EXRATE_t)$(first differenced)	0.000

Note. GFC_t, $FSNC_t$ and $WINTER_t$ are not tested by the ADF unit root test as they are dummy variables.

4.5 Test of Multicollinearity of Variables

Both $ln(GDPNZ_{it})$ and $ln(GDPAU_{jt})$ have presented unacceptable values (larger than 10) for the variance inflation factor (VIF) test, meaning that multicollinearity exists among the explanatory variables and may bias the gravity model's results. To address this multicollinearity issue, one lagged value was created of GDP per capita for New Zealand, $ln(GDPNZ_{it-1})$, and another for that of Australia, $ln(GDPAU_{jt-1})$. This approach reflects the impact of the last quarter of each country's GDP per capita on air passenger numbers on the sampled routes. Importantly, this is a valid rationale and option as the changes in GDP per capita (i.e., the last quarter's GDP per capita), such as economic growth and changes in disposable income, may impact air passenger numbers or air travel demand during the current quarter (i.e., three months' time), and the changes in GDP per capita from the last quarter could actually flow on to affect air travellers' purchasing power or decisions about their travel. This approach helps bring the VIF values of all the explanatory variables to acceptable levels under 10 (Elsayir, 2013).[5]

4.6 Endogeneity Issue of Variable and Instrument Variable

In the gravity model, the variable of $ln(SEATCAP_{ijt})$ is considered to be an endogenous variable as it may have the loop of causality with the dependent variable, $ln(PAX_{ijt})$ (Wooldridge, 2016). Boonekamp et al. (2018) and Mohammadian et al. (2019) also discussed the endogeneity issue of

[5] For brevity, the results of VIF for explanatory variables are not reported here but are available on request.

airline seat capacity, recognising that higher passenger demand results in greater scheduled seat capacity of airlines. Therefore, the 2SLS approach is used to solve the endogeneity problem of $ln(SEATCAP_{ijt})$ in this study. However, the key challenge is to find a valid instrumental variable (IV) that is correlated with airline seat capacity but not the error term (Boonekamp et al., 2018).

In Boonekamp et al. (2018), the IV used is the variable of 'feeder value', which represents the number of hub connections per direct flight. They chose this because seat capacity is likely to be higher on direct routes that originate or depart at a hub airport as passengers can connect to other destinations and thus 'feeder (connecting) passengers' may take up a larger share of total passenger demand and airline seat capacity. To correct the endogeneity issue of $ln(SEATCAP_{ijt})$, therefore, this study uses a similar IV, namely the variable of possible flight connections, $CONN_{ijt}$. This IV identifies whether a direct sampled city-pair route has possible connections at either end. As per Boonekamp et al. (2018), the basic idea behind the choice of this IV is derived from the hub-and-spoke concept, whereby airlines use hub airports to connect more people to more destinations. Using a hub-and-spoke airline network or offering flight connections presents more booking or travel options to travellers from their origins to destinations seamlessly. One would assume the ability to book flight connections to destinations would increase the demand for direct flight services, thus airlines may increase flight frequency or seat capacity accommodating increasing air travel demand. Pai's (2010) study confirmed this link, suggesting that hub airports are associated with an increase in flight frequency and aircraft size, and thus a growth in overall capacity. Cook and Goodwin (2008) also discussed this concept and note that the networked (hub) airlines tend to operate more flight frequencies and offer more seat capacities to all destinations when compared with point-to-point carriers, which do not offer flight connections.

During the analysis period of this study, four airline brands (Air New Zealand, Freedom Air, Pacific Blue and Virgin Australia) operated. Between them, these airlines offered a mix of both types of operation: Pacific Blue (LCC) and Virgin Australia (FSNC) offered flight connections at Australian airports on their domestic Australian network, and Freedom Air (LCC) and Air New Zealand (FSNC) offered no flight connections on the sampled routes at either Australian or New Zealand airports, as they did not fly domestically in Australia and did not offer connections within New Zealand. As such, $CONN_{ijt}$ appears to be a valid IV, theoretically, because it is assumed that, for example, if someone purchases an air ticket from Dunedin to Brisbane from an airline that has a further network in Australia, they can purchase a through ticket from Dunedin to anywhere connecting via Brisbane. If the airline does not have any further network in Australia, then further flight connections are impossible and passengers using the flight always terminate in either city on the route (i.e., origin–destination traffic), thus limiting the overall air travel demand and potential capacity for the route. Importantly, the $CONN_{ijt}$ variable should not be impacted by other variables in the model, including the $FSNC_t$ variable, because whether an airline is an FSNC or LCC seems to have little relevance to connections in the Australia and New Zealand region, given the LCC Pacific Blue allowed connections via Australia airports, as Wang et al. (2020) discussed.

The $CONN_{ijt}$ variable was established and added to the model as IV for estimation. As each quarter had different operating airlines, a value of 1 was added where Pacific Blue or Virgin Australia was operating as they offered connections at their hub airports in Australia, while a value of 0 was added where Freedom Air or Air New Zealand was operating in the quarter as these two airlines did not offer onwards connections Australia or New Zealand for the sampled routes. Importantly, the correlation between $CONN_{ijt}$ and the endogenous variable $ln(SEATCAP_{ijt})$ is statistically significant and positive with a Spearman's correlation value of 0.519 (see Table 5). When possible flight connections are available for passengers on the sampled routes, airline seat capacity for the route is expected to increase as air travel demand increases. In the first-stage regression, $CONN_{ijt}$ has a reasonably strong positive effect on $SEATCAP_{ijt}$, which is similar to the results in Boonekamp et al. (2018). Therefore, the Spearman's correlation results suggest that $CONN_{ijt}$ is a robust IV for $ln(SEATCAP_{ijt})$ and thus the 2SLS approach used in this study can be justified.

Table 5. Spearman's Correlation Results

Endogenous variable	$ln(SEATCAP_{ijt})$
Instrumental variable	$CONN_{ijt}$
Spearman's correlation	0.519
p-value	0.000
Observations	406

5. Empirical results

The modified gravity model in this study used the lagged values of GDP per capita of New Zealand and Australia, $ln(GDPNZ_{it-1})$ and $ln\left(GDPAU_{jt-1}\right)$, and first differencing values of fuel prices, $ln(FUEL_t)$, and exchange rate, $ln(EXRATE_t)$ along with the IV, $CONN_{ijt}$, to deal with the endogeneity problem of seat capacity, $ln(SEATCAP_{ijt})$. The final 2SLS gravity model produced the estimation results reported in Table 6.[6]

[6] For the sake of brevity, the first-stage estimation results are not reported here but are available on request.

Table 6. Results of the 2SLS Gravity Model

Dependent variable	$ln(PAX_{ijt})$	
Explanatory variables	**Coeffients**	***p-value***
Constant	6.007	0.219
$ln(GDPNZ_{it-1})$	–0.312	0.208
$ln(GDPAU_{jt-1})$	–0.605	0.153
$ln(SEATCAP_{ijt})$	1.206**	0.000
$ln(FUEL_t)$	0.079	0.208
$ln(DIST_{ij})$	0.058	0.873
$HOURSALT_{it}$	0.016*	0.049
$ln(EXRATE_t)$	0.165	0.588
GFC_t	0.071*	0.033
$FSNC_t$	–0.073*	0.012
$WINTER_t$	0.044*	0.023
$\boldsymbol{R^2}$	0.925	
Observations	406	

Note. * Statistically significant at the 0.05 level. ** Statistically significant at the 0.01 level.

5.1 Overview of Findings for Each Variable in the Model

The overall fit of the model is high with R^2 of 0.925, suggesting that the model can explain about 92.5% of the information in the dataset. The variables of $ln(SEATCAP_{ijt})$, GFC_t, $FSNC_t$, $HOURSALT_{it}$ and $WINTER_t$ are reported to be statistically significant at or above the 0.05 level.

The variables of GDP per capita of New Zealand and Australia, $ln(GDPNZ_{it-1})$ and $ln(GDPAU_{it-1})$, show a negative relationship but not to a statistically significant level in the model. These findings contrast with the expected positive impact of income on air passenger numbers as found in Hazledine (2009, 2016), Chang (2014), Jorge-Calderón (1997) and van de Vijver et al. (2016). However, Tsui et al. (2017) similarly found a significant negative relationship between GDP per capita and business travellers from New Zealand’s trading partners. It is possible that in this study a larger proportion of air passengers of the sampled routes are leisure travellers, and GDP per capita is seen as a determinant that has a stronger impact on business travel (Hazeldine, 2009). Another reason why the insignificant negative effect of both New Zealand and Australian GDP per capita on air passenger number flows can be valid in this study is that when the economies of both countries improve, the demand for more distant leisure destinations may increase (e.g., more New Zealanders may visit the United States of America (US) and the United Kingdom (UK). Athanasopoulos and Hyndman (2008) also found similar negative GDP results in their study, which they considered could possibly be due to a change in leisure travel choices from domestic destinations to more distant international destinations as economic activity increases.

The variable of seat capacity, $ln(SEATCAP_{ijt})$, has a strong significant positive effect on air passenger numbers. A 1% increase in seat capacity leads to a 1.2% increase in air passenger numbers for the sampled routes. This positive effect of $ln(SEATCAP_{ijt})$ is consistent with the results found in the literature (Hazledine, 2017; Tsui & Balli, 2017; Tsui et al., 2017; Wei & Hansen, 2006), which suggested that expanded direct flight capacity can increase international passenger numbers. In this study, given all four airline brands serving the sampled routes on the trans-Tasman market used aircraft with a similar capacity (133–176 seats), it appears that the main influence on total seat capacity is flight frequency as seat capacity on each indiviudal flight stays relatively constant. This association is logical as increasing flight frequency on a given route allows passengers and travellers more choice and so they are less likely to consider travelling from alternative airports, as discussed in Grosche et al. (2007). Although the sampled routes in this study are considered to be primarily leisure focused, and leisure passengers are generally less time-sensitive, at some point the frequency of non-stop flights will become a stronger influence if it becomes so low that the only options available on many days are from alternative airports (Fageda & Flores-Fillol, 2012). This point may have been reached in this study. Initially when Freedom Air operated from Dunedin, Hamilton and Palmerston North airports between 2003 and 2007, passengers had the option of flying to Australian destinations daily from their origin airports. However, when Virgin Australia operated to Hamilton and Dunedin in 2012, flight frequency dropped to three to four flights per week (see Figure 1). At this point, many passengers can accept the lower frequency and plan their travel accordingly, but for others the options are too limiting and if travel is necessary on the non-operating days, they must travel from an alternative airport, thus reducing air passenger numbers on the sampled city-pair routes.

The influence of fuel prices, $ln(FUEL_t)$, is not statistically significant in the model. This result is in line with Tsui and Balli (2017), which found an insignificant relationship between fuel prices and international passenger arrivals for the majority of Australian airports. In addition, Schiff and Becken (2011) showed fuel prices and their impact on airfares have a limited effect on the number of international arrivals to New Zealand (see also van de Vijver et al., 2016). Bilotkach et al. (2015) also suggested that leisure travellers are more likely to book further in advance as they often have specific travel dates in mind. Given that leisure travellers form a large proportion of passengers on the sampled routes in this study, it is possible that fuel prices and, by extension, air ticket prices have a limited impact on passenger numbers.

The distance variable, $ln(DIST_{ij})$, has a positive but not statistically significant impact on air passenger numbers in the model. This is unsurprising as flying distance between any two trans-Tasman destinations in this study does not vary substantially (ranging between 2,109 km and 2,559 km). Although greater travel distance is expected to have a negative impact on air travel demand, as van de Vijver et al. (2016) found, the small differences in flying distance on the selected trans-Tasman routes are unlikely to have the same negative effect. The furthest distance of 2,559 km adds only about 25 minutes of flight time compared with the shortest distance of 2,109 km, assuming a 900 km/hr cruise speed of a Boeing 737 or Airbus A320 (the two most common aircraft types operated by airlines on the studied city-pairs). This situation is logical in this study as alternative international leisure destinations for New Zealand and Australian travellers, such as Bali (Indonesia), Fiji and Rarotonga, are further in flying distance and, therefore, the small differences in distance on the sampled trans-tasman city-pair routes are unlikely to have impact on passenger choice. Similarly, while flying distance can have impact on ticket prices, as Gillen et al. (2006) found, it may be that the impact of the small differences in flying distance on ticket prices is too small to affect air passenger numbers of the sampled routes.

The variable of driving time to the nearest alternative international airport in New Zealand, $HOURSALT_{it}$, has the expected significantly positive effect on air passenger numbers. That is, an increase in the driving time to the closest alternative New Zealand international airport will result in an increase in air passenger numbers on the studied city-pair routes. The significant impact of the proximity of nearby airports in New Zealand on air passenger demand in this study is consistent with Grosche et al. (2007) and Hazledine (2017). It is also consistent with the rationale that the longer the driving time to an alternative New Zealand's international airport is, the less likely passengers will be to accept the additional driving time, even if they can get cheaper fares, in preference to flying direct from their local airports to Australian destinations. Because only five airports in New Zealand have direct services to fewer than ten Australian airports, passengers often need to include ground transport or additional connecting flights via those New Zealand international airports in their travel to Australian destinations, which increases their total travel time. This is an important consideration in light of Hazledine's (2016) finding that having to switchback or backtrack to take another flight can have a significant negative impact on the number of domestic air trips in New Zealand.

The model finds the influence of the exhange rate variable, $ln(EXRATE_t)$, not statistically significant. This finding is to be expected given that the New Zealand Institute of Economic Research (2007) showed the appreciation of New Zealand dollar (NZD) has a weak impact on air travel demand on the trans-Tasman market: a 1% appreciation of NZD is estimated to lead to only a 0.02% decrease in total tourist arrivals from Australia and a 0.02% increase in total passenger departures to Australia.

The Institute also mentioned that it takes an extended time for these small estimated changes to show their effect on passenger numbers – more than three quarters for arrivals and more than seven quarters for departures on the trans-Tasman market – which lends further support to the finding that $ln(EXRATE_t)$ has no significant impact on air passenger flows in this study.

Among the dummy variables, the 2008 global financial crisis, GFC_t, has a significant positive influence on air passenger flows in the model. This finding is counter to the expected negative effect of economic downturn on air passenger flows on the sampled routes, which was evident in Sarod and Silvia Zia (2017) and Wang (2009). Like this study, however, Balli et al. (2019) found no statistically significant relationship between the growth of New Zealand's tourist arrivals from Australia and the impact of the GFC.

In another expected result, the dummy variable that compares the roles and operations of FSNC and LCC services on the trans-Tasman market, $FSNC_t$, was found to have a significant negative effect on air passenger numbers. This finding suggests that when an FSNC operates on the sampled routes, air passenger numbers decrease, which is logical given that FSNCs generally charge higher airfares than LCCs, which are favoured in the primarily leisure market of the sampled city-pair routes (van de Vijver et al., 2016).

Lastly, the dummy variable to explore the impact of the winter season on air passenger numbers, $WINTER_t$, has shown a significant postive influence, as expected, showing that during New Zealand's winter months (July, August and September) air passenger traffic to Australia on the sampled routes is higher. This finding backs up the evidence from Oppermann and Cooper (1999) that New Zealand's outbound travel has historically peaked in the third quarter of the year. Further support for this finding from Haugh and Hazledine (1999) and Oppermann and Cooper (1999) is their evidence that the sampled routes are primarily aimed at New Zealand's outbound tourism travel.

5.2 Implications of Key Findings for Stakeholders

The gravity model analysis in this study shows that airline seat capacity, driving time to the closest alternative international airport in New Zealand, full-service network carrier presence and the winter season are important in explaining air passenger numbers between New Zealand airports (Dunedin, Hamilton and Palmerston North) and Australian airports (Brisbane, Gold Coast, Melbourne and Sydney) (i.e., the sampled eight city-pair routes). Given the empirical results of this study, it is of value to discuss the implications of key findings for both current and future stakeholders.

- ***Seat Capacity, Frequency and Air Passenger Numbers***

This study finds a strong link between airline seat capacity and air passenger numbers. As aircraft size does not change substantially between the four sampled airline brands – Freedom Air, Air New Zealand, Pacific Blue and Virgin Australia – (ranging between 133 and 176 seats), the main way that airline seat capacity in each quarter for the sampled routes is increased or decreased is by changes in flight frequency. On this basis, it is reasonable to claim that the relationship between flight frequency and air passenger numbers is strong. As discussed in Section 5.1, reduced flight frequency is likely to limit international travel options for many New Zealand travellers, causing them to travel from their regions to an alternative international airport in New Zealand to fly to Australian destinations. For airlines, as the key aviation stakeholder, it may seem counterintuitive to increase flight frequency as a way of increasing passenger demand, given that it may result in lower load factor and thus reduce profit margins. As discussed in Fageda and Flores-Fillol (2012) and Pai (2010), airlines will often aim to maximise their load factor in order to achieve higher yields (average ticket prices). If air travel demand is only enough for less than daily frequency, airlines tend to scale back flight frequency in favour of load factor. This is a logical trade-off for airlines, which will lose passengers to competing airports on the off days but will benefit financially on the days they fly. All four airlines that operated the sampled routes in this study used either Boeing 737 or Airbus A320 series aircraft, seating between 133 and 176 passengers. The aircraft that Freedom Air, Air New Zealand and Pacific Blue used were the smallest aircraft in their fleets that are capable of operating the sampled routes. Although Virgin Australia had the smaller 100-seat Embraer E190 which it might have used on these city-pair routes, it opted to not fly these internationally.

Given this study has shown such a strong link between airline seat capacity and air passenger numbers on the sampled routes, which is mostly due to changes in flight frequency, perhaps it shows that a more effective option for these city-pair routes is to operate with higher frequency services but smaller aircraft (lower seat capacity). This approach achieves higher capacity overall, but also gives passengers more choice in departure times and dates. It is a common practice on smaller city-pair routes in the US, where smaller regional aircraft are used to connect passengers to hubs more frequently, as Pai (2010) and Fageda and Flores-Fillol (2012) reported. This allows the US airlines to gain higher yields while also maintaining flight frequency.

The main issue to address in implementing this practice is to choose a suitable aircraft type, which is difficult for many airlines in Australia and New Zealand as they have no aircraft smaller than an Airbus A320 or Boeing 737. Yet models such as the Airbus A220 (120 seats) and Embraer E190 (100 seats) are capable of operating most of the trans-Tasman routes, so perhaps current carriers and future entrants may see an opportunity to take on an initiative of this nature. For example, an airline could serve the Dunedin–Brisbane route for three flights per week with a 176-seat Boeing 737 (528 seats per week), or could operate six flights per week with a 100-seat Embraer E190 (600 seats per week). The latter arrangement offers the benefits of giving travellers on the trans-Tasman market sampled city-pairs more flight choice throughout the week through increased seat capacity, as well as possibly making it easier for airlines to fill a smaller aircraft and improving the load factor. For other aviation stakeholders, such as airports, it is apparent that using larger aircraft creates issues where passenger demand is insufficient to achieve high yields over higher frequency. This situation in turn reduces flight frequency for an airport to the point where more travellers prefer to use alternative New Zealand's international airports (e.g., Auckland, Christchurch and Wellington) because they offer greater flexibility with more frequent flight times. The consequent change in traveller preferences will impact airport traffic volume and revenues (aeronautical and non-aeronautical revenues).

- ***FSNC and LCC Airline Types and Air Passenger Numbers***

Another finding from this study is that FSNCs are a negative determinant of air passenger numbers on the trans-Tasman market. It fits with expectations given FSNCs often set higher airfares than LCCs and offer more premium services than a leisure-focused market requires. As Haugh and Hazledine (1999) and Oppermann and Cooper (1999) considered the air passenger market between regional New Zealand and Australia (from which the sampled eight city-pair routes are derived) to be primarily leisure travel routes, with a focus on New Zealand's outbound tourism, it comes as no surprise that FSNCs may transport fewer tourists compared with LCCs. Forsyth (2003) and Pulina and Cortés-Jiménez (2010) also discussed the impact of the increase in leisure travel demand that resulted from the entry of LCCs to the market due to the typically lower ticket prices they offer. This perspective is particularly valid in this study as for each sampled route, passengers or tourists in New Zealand do have a choice of driving to alternative international airports for cheaper fares offered by LCCs (preferably available at the closest alternative international airport). After all, for travellers living near the New Zealand airports of Dunedin, Hamilton and Palmerston North, the driving time is less than five hours to their closest alternative international airports to fly to Australia, which is possibly the more economic option for a family if cheaper fares are available at the alternative airports.

In addition, leisure travellers are likely to forgo up to five hours of driving if they can get significantly cheaper fares closer to home (Boonekamp et al., 2018). As evidence for this impact, Air New Zealand chose to set up a dedicated LCC subsidiary, Freedom Air, which specifically served the trans-Tasman routes, rather than use its full-service brand for international travel from regional airports. Furthermore, the potential for LCCs to have a significant impact on tourism development can lead local stakeholders (e.g., airports, city councils) to change their marketing initiatives and campaigns to attract an LCC operator or develop future international routes on and beyond the trans-Tasman market. Similarly, Tsui (2017) and Wang at al. (2020) suggested that Jetstar (LCC) has significantly boosted

New Zealand's tourism demand because it has improved air access within New Zealand and to Australian destinations, as well as offering discounted tickets. In those studies, the underlying message was that local and regional governments and tourism authorities should further consider the impact of LCCs on tourism growth.

- ***Driving Time to Nearest Alternative New Zealand Airport and Air Passenger Numbers***

This study finds that driving time to the closest alternative international airport in New Zealand has a positive impact on air passenger numbers. As the driving hours to alternative New Zealand's international airports increase, passenger numbers on the sampled city-pair routes increase. Considering the discussion above, this association is logical because, although alternative major international airports in New Zealand (Auckland, Wellington, Christchurch) may have more frequent and possibly cheaper flight options to Australia, travellers from regional cities need a connection to them which is often via road and the travel time involved in making this connection may influence their decision. For example, travellers may be more likely to drive from Hamilton to Auckland Airport (1 hour 45 minutes) or from Palmerston North to Wellington Airport (2 hours) for cheaper fares and more flight options than they would if they have to take 4.5 hour drive from Dunedin to Christchurch Airport, which extends the overall trip time considerably.

As Grosche et al. (2007) discussed, total travel time is a major consideration for air passengers on their journey. This perhaps helps to explain why Dunedin's trans-Tasman services continue in service today whereas Palmerston North and Hamilton services have ceased, as it is further from an alternative New Zealand international airport. Hazledine (2016) found similar results when projecting regional air passenger flows in New Zealand: 'switchback' or the requirement to backtrack to connect to the final destination had a negative impact on passenger numbers.

For airports and airlines, this finding about the impact of travel distance (or travel time) to alternative airports has important implications when considering the viability of future trans-Tasman routes. Given the leisure-focused nature of the trans-Tasman market, many passengers and tourists in New Zealand are expected to forgo a short drive to benefit from more flight options and lower fares at the nearest alternative international airports. Therefore, stakeholders such as airports may benefit from creating value (e.g., free or cheap parking, faster and enjoyable travel experience) to local residents in order to attract them away from nearby international airports. As discussed, focusing efforts on attracting LCCs or more frequent flights from airlines may be beneficial. Other aspects such as additional marketing may increase the value to travellers choosing to depart directly from their local airports rather than connecting via alternative international airports to Australia.

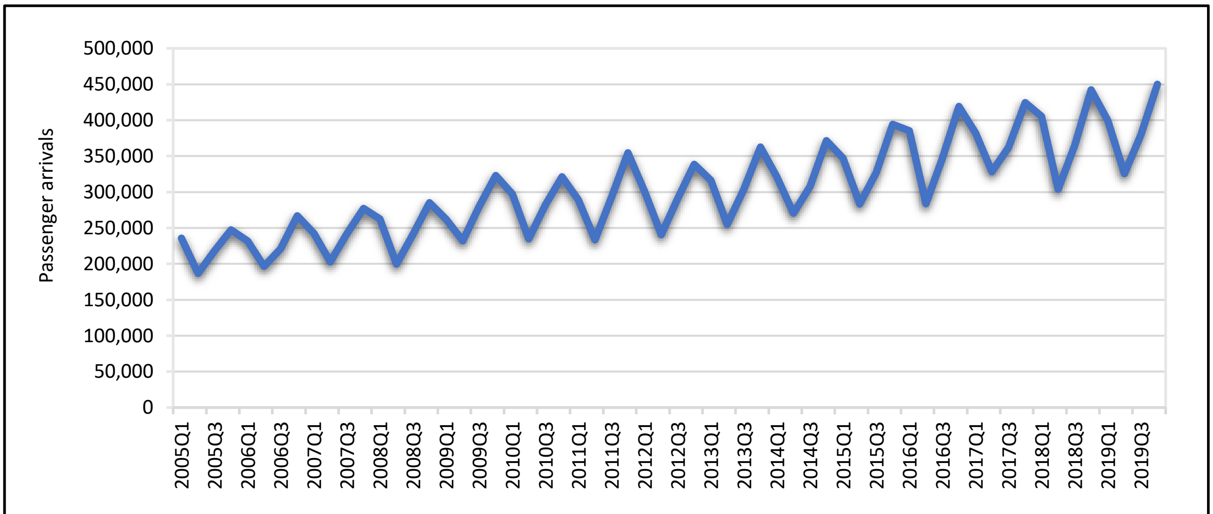
- ***Winter Season and Air Passenger Numbers***

This study finds the winter season (Quarter 3) in New Zealand has a positive impact on air passenger numbers on the sampled routes. As Figures 8 and 9 show, Australian tourist arrivals to New Zealand typically peaked in Quarter 4, while New Zealand's international outbound tourists peaked in Quarter 3 of each year during the study period. This indicates that the sampled routes are primarily aimed at New Zealand's outbound leisure travellers, adding to the evidence on air travel demand on the trans-Tasman market previously reported by Oppermann and Cooper (1999) and Haugh and Hazledine (1999).

While Australian tourist arrivals to New Zealand are often second highest in Quarter 3 (see Figure 8), this may be due to the market demand for skiing in New Zealand. The sampled routes are unlikely to directly appeal to this market segment because they are not particularly close to the popular ski regions in New Zealand such as Queenstown, and easier access to these regions is available by alternative means (e.g., direct flights).

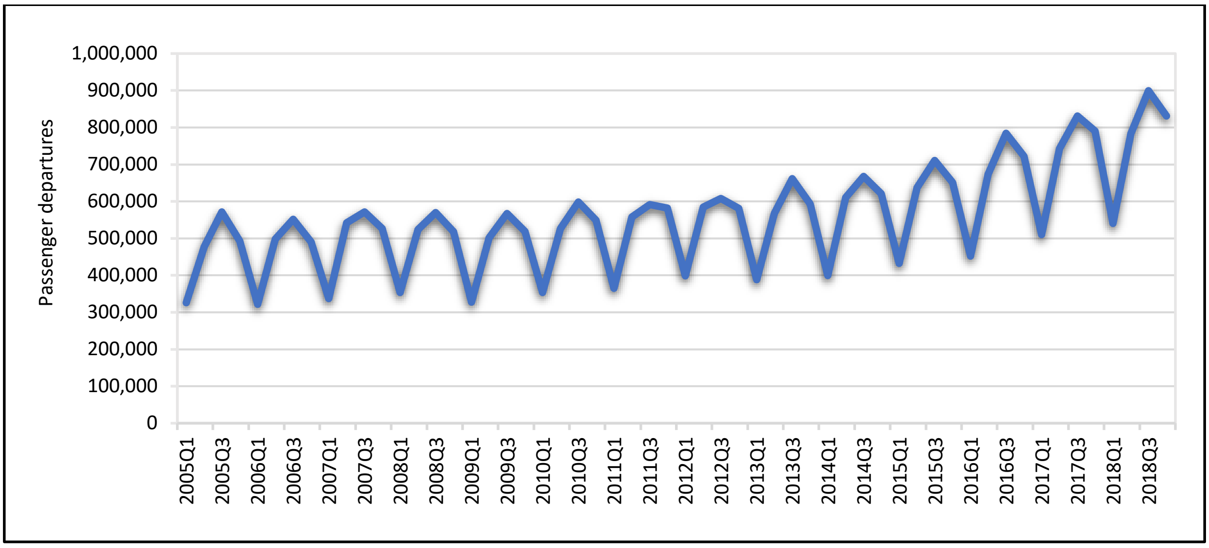
For airlines and airports, it is valuable to understand the key market segment of these sampled routes. Given the increase in air passenger numbers in Quarter 3, it may be useful for airlines and tourism operators to propose more frequent flight schedules and more capacity during that period. In addition, given the outbound leisure focus of the sampled routes, airlines and airports may find benefit in creating further value (e.g., more flight options and lower fares) for travellers on the sampled routes. They may do this by focusing marketing locally and aiming to increase flight schedules for the New Zealand inbound and outbound tourism markets, for example, by offering daytime arrivals and departures.

Figure 8. Total Australian Passenger Arrivals to New Zealand



Source: *Statistics New Zealand (2020a).*

Figure 9. Total New Zealand International Passenger Departures



Source: Statistics New Zealand (2020a).

6. Conclusion

Air passenger numbers on direct trans-Tasman routes between the New Zealand airports of Dunedin, Hamilton and Palmerston North and the Australian airports of Brisbane, Gold Coast, Melbourne and Sydney have slowly declined between 1997 and 2019, with all of the sampled routes except for the Dunedin–Brisbane route now having no flight services. The 2SLS gravity model was used to investigate the determinants of air passenger numbers on the eight sampled routes for the period of Quarter 1, 1997–Quarter 2, 2019. The empirical findings of this study show four statistically significant determinants to impact air passenger flows, including airline seat capacity, the 2008 GFC, the presence of FSNCs and the winter season in New Zealand. This study contributes to the existing literature by providing some empirical insights into the determinants of passenger demand for trans-Tasman routes between the sampled city pairs. While there is existing literature on air travel demand on the trans-Tasman market (e.g., Hazledine, 2008; Tsui et al., 2017; Vowles & Tierney, 2007), few studies have focused on air passenger demand for New Zealand's regional cities to Australian cities, and this is the first study to examine the rise and fall of airline services on the sampled trans-Tasman routes specifically. In this context, this study helps to address the research gap in this area.

The empirical findings provide useful insights for stakeholders (e.g., local governments, airports, airlines and tourism authorities) that they can use in shaping their future marketing efforts and business development. New Zealand airports, particularly those of Dunedin, Hamilton and Palmerston North, may find the results of this study to be of significant benefit given that some airports have placed importance on returning international air services to their respective businesses and/or developing those services

(Rankin, 2018). For this purpose, airport management may use the findings to help them develop the optimal plans for reinstating and attracting new or expanding trans-Tasman services (e.g., LCC services).

For aviation stakeholders, it is important to note the significant positive impact of greater airline seat capacity on air passenger numbers on the sampled routes. Given that all airlines used aircraft of a similar size and capacity on the sampled routes historically, the empirical findings highlight the major impact of flight frequency increases on air passenger numbers. Increasing seat capacity by operating smaller aircraft but at a higher frequency may offer travellers more travel choice so that they are less likely to opt to travel from the nearby competing alternative international airports, which in turn would increase passenger numbers on trans-Tasman routes from their origin airports. This approach is particularly important for regional airports that are closer to alternative competing airports, taking into account the effect of travel time to alternative airports on their passenger numbers. A further consideration for airlines is how the presence of FSNCs and flight availability in the winter season of New Zealand may affect the route choices of travellers. Given the negative impact of the presence of FNSCs, perhaps airports and local governments may attract low-cost operator (e.g., the Qantas LCC subsidiary, Jetstar) to serve these smaller New Zealand regional routes to Australian destinations. In addition, airlines may consider adjusting their seasonal flight schedules to increase capacity in the winter months in New Zealand, when New Zealand's inbound and outbound air travel demand is higher.

Two major research limitations are observed in this study. First, it is extremely difficult and costly to collect ticket prices for all the sampled routes. Therefore, information on ticket prices is largely unrepresented in the model. Second, as each New Zealand airport in this study is less than five hours' drive from another international airport, no data are available on how many potential passengers are lost from the sampled routes to alternative competing international airports in New Zealand due to more flight options and cheaper airfares. Having this information is particularly important in the context of the sampled routes in this study, which are primarily leisure-focused routes and have price-sensitive markets. A meaningful extension to this study is to include data on ticket prices on both the sampled routes and the routes of the alternative competing airports (when available) to Australia, which may add more insights this study has provided into the determinants of air passenger demand for New Zealand's regional cities to Australian destinations.

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