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Air Transport Services in Regional Australia – Demand pattern, frequency choice and airport entry

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ABSTRACT: This study investigates the development of the aviation market at Australia's top 50 regional airports during 2005-2013. Demand estimation results suggest that a higher commodity price increases traffic volume in markets where the local economy heavily relies on mineral resources and that an appreciation of the Australian dollar decreases passenger flows in tourism-dependent areas. The presence of leading airlines and low-cost carriers, and the availability of international services all contribute positively to market growth. Airport entry analysis reveals that major carriers engage in clear strategic interactions. The Qantas airline group has used Jetstar as a fighting brand, thus that Jetstar flies to a destination if and only if the regional airport is also served by Virgin Australia, the group's major competitor. Unlike routes connected to major airports, demands in regional airports are not sensitive to flight frequency, but seem to be positively influenced by national fare levels. Our empirical results support a consistent aviation policy across Australia, especially for issues related to airline competition and demand stimulation. However, special considerations need be made for regional airports to help them to deal with economic shocks and cover fixed costs.

KEY WORDS: ***Regional Australia; regional airports; airline entry; flight frequency***

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1. Introduction

Air transport is an input into many economic activities such as tourism, trade and investment and is thus important to the economy and residents of the region it serves. Air service to distant and small markets is particularly important, as there is no close substitute for this travel mode due to the tyranny of distance. In some parts of the world, air transport is the only viable means of transportation for both goods and people due to geographic or climate constraints (Pagliari 2010).

Bråthen, Johansen and Lian (2006) examine the economic effects of air transport and grouped them into four categories: direct, indirect, induced, and catalytic effects. Direct effects refer to the operation of an airport itself and also include non-airside activities like shops and car rentals (Halpern and Bråthen 2010). Indirect effects relate to the operations of suppliers in the surrounding area. Induced effects relate to the activity generated by direct and indirect operations. The effects of air transport on the performance of other industries are known as catalytic effects, which represent the most important function of an airport (York Aviation 2004). These effects include the contribution made by air transport to regional access and social and economic development (Halpern and Bråthen 2010). The magnitude of the multiplier determines the size of the induced and catalytic effects. In general, as the multiplier is larger in less developed and therefore remote regions, these regions may experience the largest catalytic effects, especially when they are export oriented (Hooper 1998, Bråthen 2011).

Airport privatization for major Australian airports commenced in 1997 with the sales of the Melbourne, Brisbane and Perth Airports (Hooper et al. 2000). By 2003, all other major airports were privatized and formal price regulation had been replaced by a "light-handed regulation" (Forsyth 2002, 2003). The benefits of Australian airport privatization have been well recognized. LeighFisher (2011) notes that the overall cost levels at Australian airports are clearly lower than those in North America and Europe. Assaf (2010) examines the cost efficiency of major Australian airports using data from 2002 to 2007 and concludes that the cost efficiency of Australian airports increased over time, reaching a high value of 90.08% in 2007. Forsyth (2004, 2008) reaches similar conclusions. The overall effects of light-handed regulation are also positive (Littlechild 2012, Yang and Fu 2015). Despite the good performance of major airports, local governments and councils own the overwhelming majority of Australia's regional airports. Many of them are poorly resourced to provide maintenance and infrastructure upgrade services and to attract qualified and skilled personnel (Donehue and Baker 2012). A small number of regional airports are owned or operated by the private sector, predominantly for the purposes of resource extraction (AAA 2012). The Australian Airports Association estimates that up to 50% of regional airports are operating at a loss each year and heavily rely on cross-subsidization from their local government owners.

In 2014, passenger movement (the sum of passenger arrivals and departures) at Australian regional airports reached 24.3 million, an increase of 45% from 16.8 million in 2005. The total passenger movement in the domestic market was 115 million in 2014, an increase of 42.5% from 80.7 million in 2005. The top 50 regional airports handled 22.8 million passengers in 2014, accounting for 94% of the total passenger movement at regional airports (BITRE 2015). According to the Bureau of Infrastructure, Transport and Regional Economics (BITRE), the annual growth in passenger traffic at regional airports has been consistently higher than that at airports in major cities in the last 10 years.

Many studies have examined the determinants of air traffic volume in metropolitan areas. Liu *et al*. (2006) contend that the likelihood of a major air passenger market is primarily determined by metropolitan population size and employment activity in the professional/scientific/technical service and management fields. Discazeaux and Polese (2007) examine the determinants of air traffic volume for the 89 largest urban areas in the U.S. and Canada. They confirm that urban size and local industry structure remain the primary determinants. Dobruszkes et al. (2011) report that gross domestic product (GDP), the level of economic decision-power, tourism functions, and distance from a major air market are the most important factors influencing air traffic flows in Europe. On the other hand, efficient and competitive aviation services stimulate traffic volumes, offering positive feedback to demand generation. As increased flight frequency generally reduces passengers' schedule delay (Douglas and Miller 1974), consumers' willingness-to-pay and travel demands usually increase with flight frequency (Richard 2003, Fu et al. 2014). Sharp airline competition often leads to lower prices and improved service quality, which increase traffic volume substantially (Windle and Dresner 1996, 1999, Dresner et al. 1996, Fu et al. 2011).

In comparison, much less attention has been dedicated to aviation markets at regional airports. Humphreys and Francis (2002) note a worldwide traffic concentration at large airports and underused capacity at regional airports. Graham and Guyer (2000) argue that the U.K. aviation policy has largely focused on capacity shortages at large airports in southeast England and the privatization and commercialization of the country's airports. Issues affecting regional airports, such as sustainability and pro-competition policy, should be given more consideration. Humphreys and Francis (2002) examine the U.K. aviation market and conclude that regional airport performance depended greatly on the decisions of airlines. It is thus important to balance the interests of all stakeholders in airport planning and regulatory policies. Forsyth (2006) simulates the costs and benefits of regional airport subsidies using a computable general equilibrium model. He argues that although it is possible for a region to enjoy economic gains as a result of an airport subsidy, the effect on nationwide welfare can be uncertain. Adler et al. (2013) study the efficiency of 85 European regional airports via data envelopment analysis and second-stage regressions. They conclude that regional airports had been inefficient in exploring business opportunities and daily operations and missed the opportunity to break even with small traffic volumes. Although these studies offer rich insights into regional aviation issues, they did not directly analyze the market development patterns at regional airports. Airline service and traffic volume are critically important to the management of an airport. Together, they directly determine capacity usage, operational costs and airport revenue and indirectly determine regulatory policy and regional economic development. It is thus important to examine the demand pattern and market dynamics before appropriate recommendations can be made for regional airports.

This study aims to fill this gap in the research by empirically examining the market development pattern in Australia's top 50 regional airports during 2005-2013. It is organized as follows. Section 2 reviews Australia's air transport policy and aviation activities at regional airports. Section 3 explains the data and methods used to analyze the demand pattern, frequency choice and airport entry. The final section summarizes the key findings and discusses their policy implications and possible directions for future studies.

2. Australia's air transport policy and aviation activity at regional airports

The Australian aviation industry was deregulated in 1990, ending the "Two-Airline Policy" established under the 1957 Civil Aviation Agreement. Air transport liberalization in the 1990s resulted in the removal of capacity, airfare and market entry constraints and eventually the limits on foreign ownership of Australian domestic airlines. Interstate regional services have since been completely deregulated and subject only to the competition laws that apply to other industry sectors. Although the state and territory governments have the power to regulate intra-state air services, intra-state air services in Victoria, Tasmania, Northern Territory and the Australian Capital Territory have been completely deregulated. Some low-volume routes in New South Wales, Queensland, South Australia and West Australia are still subject to regulation. Low-volume routes are licensed on a one-route, one-license basis. Competition is encouraged on higher-volume routes where licensing is not required.

The Department of Infrastructure and Regional Development of Australian Government defines regional aviation as scheduled commercial airline activity between regional areas or between regional areas and capital cities. Avstas (1999) defines regional airlines as those that provide scheduled regular public transport (RPT) services within Australia and link smaller rural centers with principal cities. The strict definition states that an aircraft contains 38 seats or fewer or has a payload of 4,200 kilograms or less. However, some airlines that use larger aircraft with 60-70 seats are still called regional airlines. Some regional areas are even serviced by jet aircraft from major domestic airlines.

The definitions of metropolitan and regional areas are based on the Australian Standard Geographical Classification (ASGC) Remoteness Structure, which broadly divides the country into five regions: major cities, inner regional Australia, outer regional Australia, remote Australia and very remote Australia. The last four classes are collectively designated as the “regional area”, a designation used in this study.

Table 1 shows that the number of regional airports across all regions, from inner regional Australia to very remote Australia, began declining in 1985 until 2009, when there was a rise in the number of airports with RPT air services in very remote Australia. Although some regional airports have lost RPT air services in the last few years, more new services have been added to regional airports, resulting in an increase in the number of regional airports served. This sudden increase might have been caused by a data collection problem, as the number of regional airports in the very remote area served by West Wing was not available before 2009 (BITRE 2012).

Table 1: Number of regional airports served, by the Australian Statistical Geographic Classification (ASGC) Remoteness Classification

Airports by ASGC Remoteness Classification	**1985**	**1990**	**1995**	**2000**	**2005**	**2008**	**2009**	**2010**	**2011**	**2012**
Inner regional Australia	43	38	40	37	29	24	25	25	27	26
Outer regional Australia	47	43	36	36	31	27	28	27	27	28
Remote Australia	38	32	31	22	21	19	17	15	15	16
Very remote Australia	136	95	100	86	88	67	82	81	82	101
Total	264	208	207	181	169	137	152	148	151	171

Source: Adapted from BITRE (2013)

Many of the regional airports in Australia often compete to attract airlines. The number of airlines serving regional airports decreased from 33 in 2005 to 28 in 2010, and more than 60% of the regional airports were served by only one airline (AAA2012). BITRE (2011) reports that between 2008 and 2010, 7% of regional airports lost all RPT services and 30% lost some services, and from 2005 to 2008 the two figures were 25% and 21%, respectively. However, more than 40% of regional airports have received additional services in the last 10 years.

BITRE (2013) suggests that air travel between major cities and regional areas accounted for more than 90% of the entire regional aviation market. However, the number of routes between regional airports (300) was much higher than the number of routes (176) between major cities and regional airports in 2012. Given that the Australian population is concentrated in a few large capital cities, 40% of the regional air routes had less than 1,000 passengers each year and the frequency on 60% of the regional routes was less than 3.

To support the low volumes and new routes to small and remote communities, the Australian government introduced the Airservices Australia Enroute Charges Payment Scheme, which subsidies air operators that provide aeromedical services to regional and remote areas. Since September 2014, airlines operating commercial services to regional and remote areas have been able to apply for assistance under this scheme. In addition, the Australian government uses the Regional Aviation Access Program to provide assistance for air transport access and safety upgrades in remote areas where air services are not commercially viable. However, the government assistance provided to this industry has significantly decreased in the last two decades, and part of the assistance goes toward supporting new routes to regional communities that did not have air transport services. Most of the current regional airlines and airport air services must rely on new technologies and efficiency improvements to contain costs and offer better services to increase revenue. Therefore, it is important to understand the market development pattern in regional Australia, so that to assist the decision-making in business strategy and public policy.

3. Market analysis at Australian regional airports

To investigate the market development pattern in the Australian regional markets, we first estimate reduced-form equations of travel demand and flight frequency jointly. Our empirical findings allow us to identify the key macroeconomic determinants of market outcomes at regional airports and the dynamic patterns of flight frequency and aircraft choice. As airport performance is significantly influenced by the operations of major airlines, we study airport entry for the major airlines in the Australian regional markets, including Qantas and its low-cost subsidiary Jetstar along with Virgin Australia. In the following sections, we first describe the data used and subsequently explain the methodology and results obtained for each research module.

3.1. Data description

Two groups of factors, namely geo-economic and service-related factors, have been identified as the main drivers of air traffic demand (Jorge-Calderón 1997, Wang and Song 2010). Geo-economic factors consist of economic variables such as income and population and locational factors including distance and other geographical characteristics of the area in which transportation takes place. Service-related factors include the quality and airfare components of aviation services (Wang and Song 2010). Previous investigations have found that flight frequency is a key determinant of consumer surplus and airline market share, often based on pooled national data or routes out of metropolitan regions (see, for example, Windle and Dresner 1995, 1999, Drenser et al. 1996, Richard 2003, Fu et al. 2011, Homsombat 2014, Fu et al. 2015a). Few studies have validated such a pattern in regional markets. In this study, we focus on the market performance of the top 50 regional airports in Australia using data taken from the 2005-2013 period. We collect a wide range of control variables, including macroeconomic variables such as local population and income, jet fuel, and aggregate airfare level; service attributes such as flight frequency and aircraft size; and market-specific variables such as the number of destinations connected to an airport, and the market shares of major airlines at airport level. Table 2 lists the dependent and independent variables in addition to the data sources. Table 3 provides the summary statistics.

Table 2: Explanation of the variables and data sources

Variable	Notation	Explanation	Data source
Passenger traffic	$Traffic_{it}$	The sum of passenger arrivals and departures at a regional airport for the period 2005-2013. The sample contains top 50 regional airports in terms of passenger movements in 2014.	Airport Traffic data reported by the Bureau of Infrastructure, Transport and Regional Economics (BITRE), the Department of Infrastructure and Regional Development of Australian Government.
Flight frequency	$Flight_{it}$	The aggregate airport total scheduled flight frequency for domestic flights, including outbound and inbound	The Official Airline Guide (OAG)
Aircraft Size	$AircraftSize_{it}$	The average aircraft size of the airport, calculated by dividing airport aggregate seats by the aggregate flight frequency	OAG
Population	Pop_{it}	Resident population by local government area (LGA) where the airport locates.	Australian Bureau of Statistics (ABS): Regional Population Growth (cat no. 3218.0), Australia, March 2015.
Income	$Income_{it}$	Average wage and salary income of the LGA where the airport locates	ABS: The Wage and Salary Earner Statistics for Small Areas, Time Series, 2005-06 to 2010-11 (cat no. 5673.0.55.003 2005-06) 2013. The data for 2011-2013 were estimated by the author based on the growth rate of wage and salary income between 2005 and 2010.
Distance	$Dist_{it}$	The distance from the regional airport to the capital city of the state.	Australian air distances published by the Bureau of Infrastructure, Transport and Regional Economics (BITRE), the Department of Infrastructure and Regional Development of Australian Government.
Tourism	$Tourism_i$	A dummy variable indicating whether or not tourism is a major industry in an airport's catchment area.	Local government's websites

Mining	$Mining_i$	A dummy variable indicating whether or not mining is a major industry in an airport's catchment area.	Local government's websites
International	$International_i$	A dummy variable denoting whether or not there is a presence of international flights at an airport	Airport website
Exchange rate	$Exchange_{it}$	The real effective exchange rate (REER) that measures the real value of a country's currency against the basket of the trading partners of the country.	World Bank's Global Economic Monitor.
Commodity price	$Commodity_{it}$	Index of commodity prices which is a weighted average of recent changes in commodity prices, where the weight given to each commodity reflects its importance in total commodity export values in a base period	Reserve Bank of Australia (RBA)
Jet fuel	$Jetfuel_{it}$	US Gulf Coast kerosene-type jet fuel spot price FOB	US Energy Information Administration
Air fare	$Fare_{it}$	BITRE's domestic air fare index. Fares are collected for the top 70 routes in the Australian domestic network.	Compiled by BITRE, the Department of Infrastructure and Regional Development of Australian Government.
Qantas Share	$QantasShare_{it}$	The share of scheduled seats of Qantas in each regional airport	Calculated by authors using the OAG data
LCC Share	$LCCShare_{it}$	The share of scheduled seats of all LCCs in each regional airport	Calculated by authors using the OAG data. LCC classification from CAPA is used.
No. of Destination	$NoDest_{it}$	The number of destinations served by this regional airport.	Calculated by authors using the OAG data
No. of Airlines	$NoAirline_{it}$	The number of airlines operating in this regional airport	Calculated by authors using the OAG data
Qantas / Virgin /Jetstar	$Qantas_{it}$ $/Virgin_{it}$ $/Jetstar_{it}$	The dummy variable equals to 1 if the airline Qantas / Virgin/ Jetstar airline operates in this airport	OAG
Others		The number of other regional/ charter airlines operating in this regional airport	OAG
Radius	$Radius_{it}$	The average distance (Kms) of the routes served out of this regional airport. The weight is based on the route scheduled seats	Calculated by authors using the OAG data

Table 3. Summary Statistics of the Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Traffic	450	401,635	643,125	5,417	4,200,000
Flight	450	6,196	6,189	302	39,458
Seats	450	543,928	758,960	11,430	5,033,602
Aircraft Size	450	76	39	14	166
Population	450	40,766	35,491	500	189,017
Income	450	49,829	13,880	29,827	106,914
Distance	450	827	633	1	3,214
Tourism	450	0.30	0.459	0	1
Mining	450	0.30	0.459	0	1
International	450	0.04	0.196	0	1
Exchange rate	450	96.22	8.79	86.30	109.80
Commodity price	450	94.43	16.16	64.40	120.10
Jet fuel	450	2.39	0.55	1.66	3.06
Fare index	450	74.84	12.55	58.10	92.30
Qantas Share	450	0.49	0.38	0	1
LCC Share	450	0.21	0.31	0	1
No. of destination	450	4.48	4.41	1	28
No. of airlines	450	2.587	1.611	1	8
Qantas	450	0.762	0.426	0	1
Jetstar	450	0.224	0.418	0	1
Virgin	450	0.407	0.492	0	1
Others	450	1.138	0.989	0	5
Radius	450	730	456	230	2,399

The exchange rate and commodity price variables are included because many regional Australian airports are close to famous tourism resorts or lie in mining-dependent areas. Tourism tends to react strongly to fluctuations in the real exchange rate, regardless of the bilateral or multilateral indicators used (Culiuc 2014). The real effective exchange rate (REER), which measures the real value of a country's currency against a basket of its trading partners' currency, may affect the travel decisions of both overseas tourists and Australian residents. As a domestic tourism destination may be a potential substitute for an overseas destination, exchange rate may influence visitor volumes at regional tourism cities. An interaction between the tourism destination dummy and the REER is considered in the demand equation. The commodity price index serves as an indicator of the prices received by Australian commodity exporters. Australia's mining boom in the last decade is expected to affect passenger traffic flows in resource-dependent areas. Therefore, an interaction term between the mining variable and commodity price is also included in the demand equation.

The airfare index is constructed based on the fares collected monthly for the top 70 routes in the Australian domestic market by BITRE. We use the annual average index constructed by the lowest available economy class fare in our estimation. In theory, the use of this variable may cause an endogeneity problem. However, this fare index mainly captures fare changes on the busiest routes between major cities, as passenger volumes are used as weights when constructing the index. Therefore, any endogeneity bias should be minimal.

Airport-specific variables such as the number of destinations, number of airlines and average distance of the routes served out of an airport describe the network connectivity and service level at an airport. They are used in all of the empirical estimations described in the following sections. Airline/airport-specific variables such as the market shares of leading airlines and/or a presence dummy at an airport are used to capture the possible effects of airline market power and traffic feeder operations. These variables may also cause endogeneity problems. However, as airline entry and competition mostly occur at the route level, and these variables are calculated at the airport level in our study, any endogeneity bias should be minimal.

The names and airport codes for the top 50 airports used in our analysis are reported in the Appendix.

3.2. Demand determinants and flight frequency

Using an approach similar to those adopted by Schipper *et al.* (2002), Pitfield *et al.* (2010), and Wang *et al.* (2014), we simultaneously estimate demand and flight frequency equations to improve estimation efficiency and control for the endogeneity between travel demand and flight frequency. The system of equations is specified as follows.

$$(1.1)\quad \ln Traffic_{it}=\alpha_0+\beta_1\ln Flight_{it}+\delta_1\ln Pop_{it}+\alpha_1\ln Income_{it}+\delta_2\ln Dist_{it}+\alpha_2 Tourism_i+ \alpha_3 Mining_i+\alpha_4 International_i+\delta_3 Exchange_{it}+\delta_4 Tourism_i{*}Exchange_{it}+ \delta_5\ln Commodity_{it}+\delta_6 Mining_i{*}\ln Commodity_{it}+\alpha_5\ln Fare_{it}+\alpha_6 QantasShare_{it}+ \alpha_7 LCCShare_{it}+\alpha_8 NoDest_{it}+\alpha_9\ln Year_t+\eta_{1i}+\varepsilon_{1it}$$

$$(1.2)\quad \ln Flight_{it}=\omega_0+\beta_2\ln Traffic_{it}+\beta_3\ln AircraftSize_{it}+\omega_1\ln Income_{it}+\omega_2 Tourism_i+\omega_3 Mining_i +\omega_4 International_i+\lambda_1\ln Jetfuel_{it}+\omega_5\ln Fare_{it}+\omega_6 QantasShare_{it} +\omega_7 LCCShare_{it}+\lambda_2 NoAirline_{it}+\omega_8 NoDest_{it}+\omega_9\ln Year_t+\eta_{2i}+\varepsilon_{2it}$$

The preceding system of equations is rewritten in the following expressions.

(2.1) $\ln Traffic_{it}=\beta_1 \ln Flight_{it}+\boldsymbol{X_{1it}\alpha}+\boldsymbol{Z_{1it}\delta}+\eta_{1i}+\varepsilon_{1it}$

(2.2) $\ln Flight_{it}=\beta_2 \ln Traffic_{it}+\beta_3 \ln AircraftSize_{it}+\boldsymbol{X_{2it}\omega}+\boldsymbol{Z_{2it}\lambda}+\eta_{2i}+\varepsilon_{2it}$

The two equations can be denoted in matrix form, as shown in Eq. (3).

(3) $$\begin{bmatrix} 1 & -\beta_1 & 0 \\ -\beta_2 & 1 & -\beta_3 \end{bmatrix} \begin{bmatrix} \ln Traffic_{it} \\ \ln Flight_{it} \\ \ln AircraftSize_{it} \end{bmatrix} = \begin{bmatrix} \boldsymbol{\alpha} & \boldsymbol{\delta} \\ \boldsymbol{\omega} & \boldsymbol{\lambda} \end{bmatrix} \begin{bmatrix} \boldsymbol{X_{1it}} & \boldsymbol{X_{2it}} \\ \boldsymbol{Z_{1it}} & \boldsymbol{Z_{2it}} \end{bmatrix} + \begin{bmatrix} \eta_{1i}+\varepsilon_{1it} \\ \eta_{2i}+\varepsilon_{2it} \end{bmatrix},$$

Variables [$\ln Traffic_{it}$, $\ln Flight_{it}$, $\ln Aircraft_{it}$]' are endogenous given their simultaneity relationship. $\boldsymbol{X_{it}}$=[$\boldsymbol{X_{1it}}$,$\boldsymbol{X_{2it}}$,$\boldsymbol{Z_{1it}}$, $\boldsymbol{Z_{2it}}$]′ are exogenous variables that satisfy the mean independence condition $\mathrm{E}[\boldsymbol{X_{it}\varepsilon_{it}}] = 0$, $\boldsymbol{\varepsilon_{it}} = [\varepsilon_{1it}, \varepsilon_{2it}]'$. We do not assume mean independence between $\boldsymbol{X_{it}}$ and $\boldsymbol{\eta_i}$, as we use a fixed effect (FE) model to deal with the potential endogeneity problem in the case $\mathrm{E}[\boldsymbol{X_{it}\eta_i}] \neq 0$.

In the demand equation, the aircraft size variable (i.e., $AircraftSize_{it}$) is not included because the comfort offered by large aircraft is minor in short regional markets. We use the flight frequency variable $\ln Flight_{it}$ to control for passenger schedule delay. The exogenous variables $\boldsymbol{X_{1it}}$ include $\ln Income_{it}$, $\ln Dist_{it}$, $Tourism_i$, $Mining_i$, $International_i$, $\ln Fare_{it}$, $QantasShare_{it}$, $LCCShare_{it}$, and $\ln NoDest_{it}$ as explained previously. We use $\ln Year_t$ to control for any time trend during the sample period. $\boldsymbol{Z_{1it}}$ comprises exogenous variables affecting travel demand but not flight frequency and include variables such as $\ln Pop_{it}$, $\ln Dist_{it}$, $Exchange_{it}$, $Tourism_i * Exchange_{it}$, and $Mining * \ln Commodity_{it}$.

We include endogenous variables $\ln Traffic_{it}$ and $\ln Aircraft_{it}$ in the flight frequency equation because airlines accommodate changes in passenger volume by adjusting flight frequency and there is a negative relationship between flight frequency and aircraft size. Exogenous variables $\boldsymbol{X_{2it}}$ include factors influencing flight frequency such as $\ln Income_{it}$, $Tourism_i$, $Mining_i$, $International_i$, $\ln Fare_{it}$, $QantasShare_{it}$, $LCCShare_{it}$, $\ln NoDest_{it}$, and $\ln Year_t$. $\boldsymbol{Z_{2it}}$ includes flight frequency determinants that do not directly shift travel demand. Jet fuel price (i.e., variable $Jetfuel_{it}$) should affect flight frequency through airline fuel costs. The number of airlines serving the airport (i.e., $NoAirline_{it}$) should have a positive effect on the airport's aggregate flight frequencies. However, the presence of more airlines at an airport does not necessarily indicate a higher traffic volume, because travel demand is largely influenced by airline competition at the route level.

The order condition of identification clearly holds for the specifications in Eq. (3), and an equation-by-equation estimation method is used. In the demand equation estimation, the exogenous variables in

$\boldsymbol{Z_{2it}}$ serve as instrumental variables for the endogenous variable $\ln Flight_{it}$. In the frequency equation, the exogenous variables in $\boldsymbol{Z_{1it}}$ serve as instrumental variables for endogenous variables $\ln Traffic_{it}$ and $\ln Aircraft_{it}$. An fixed effect (FE) approach is used to control for potential endogeneity by allowing $\boldsymbol{X_{it}}$ to correlate with the airport-specific time-invariant unobservable $\boldsymbol{\eta_i}$. We demean the equations as follows.

(4.1) $$\ln Traffic_{it}-\overline{\ln Traffic_i}=\beta_1(\ln Flight_{it}-\overline{\ln Flight_i})+(\boldsymbol{X_{1it}}-\boldsymbol{\bar{X}_{1i}})\boldsymbol{\alpha}+(\boldsymbol{Z_{1it}}-\boldsymbol{\bar{Z}_{1i}})\boldsymbol{\delta}+(\varepsilon_{1it}-\bar{\varepsilon}_{1i})$$

(4.2) $$\ln Flight_{it}-\overline{\ln Flight_i}=\beta_2(\ln Traffic_{it}-\overline{\ln Traffic_i})+\beta_3(\ln Aircraftsize_{it}-\overline{\ln Aircraftsize_i}$$
$$+(\boldsymbol{X_{2it}}-\boldsymbol{\bar{X}_{2it}})\boldsymbol{\omega}+(\boldsymbol{Z_{2it}}-\boldsymbol{\bar{Z}_{2it}})\boldsymbol{\lambda}+(\varepsilon_{2it}-\bar{\varepsilon}_{2i})$$

We subsequently use $\boldsymbol{Z_{2it}}-\boldsymbol{\bar{Z}_{2it}}$ as instrumental variables to identify parameters β_1, $\boldsymbol{\alpha}$ and $\boldsymbol{\delta}$ in the demand equation and use $\boldsymbol{Z_{1it}}-\boldsymbol{\bar{Z}_{1i}}$ as instrumental variables to identify parameters β_2, β_3, $\boldsymbol{\omega}$ and $\boldsymbol{\lambda}$ in the frequency equation, both through a two-stage least squares estimation (2SLS). In addition to the FE model, a random effect (RE) specification is also used with the assumption of $E[\boldsymbol{X_{it}\eta_i}]=0$. If this assumption holds, then the RE model is more efficient than the FE estimation. Table 4 reports the estimation results from both models.

Table 4. Estimation of the Demand and Flight Frequency Equations

Demand equation	**2SLS FE**		**2SLS RE**	
lnTraffic	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
lnFlight	0.195	0.312	0.208	0.261
lnPop	0.885	0.583	0.267***	0.092
lnIncome	0.855**	0.390	1.655***	0.363
lnDist	-3.157	7.875	-0.006	0.036
Tourism			1.312***	0.261
Mining			-2.702**	1.126
International			1.285***	0.284
exchangerate	0.003	0.002	-0.0007	0.002
tourism*exchangerate	-0.010***	0.002	-0.010***	0.002
lncommodity	0.124	0.131	0.236	0.148
mining*lncommodity	0.563***	0.195	0.488**	0.221
lnfare	0.336***	0.131	0.390***	0.129
Qantas Share	0.545***	0.075	0.627***	0.07
LCC Share	1.141***	0.238	1.567***	0.161
NoDest	-0.020	0.023	-0.0007	0.022
lnYear	-0.041	0.072	-0.140**	0.06
constant	8.945	49.825	-13.213***	3.115
Frequency equation	**2sls FE**		**2sls RE**	
lnFlight	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
lnTraffic	0.905***	0.059	0.860***	0.039
lnAircraftSize	-1.044***	0.073	-1.019***	0.045
lnIncome	0.229	0.161	0.208**	0.086
International			-0.441***	0.094
Tourism			-0.028	0.035
Minimg			0.0007	0.045
lnjetfuel	-0.021	0.033	-0.010	0.031
lnfare	-0.042	0.069	-0.046	0.061
Qantas Share	-0.070	0.052	-0.057	0.038
LCC Share	0.082	0.107	-0.024	0.075
NoAirline	0.017*	0.010	0.024**	0.009
NoDest	0.031***	0.005	0.027***	0.004
lnYear	-0.034	0.025	-0.024	0.019
constant	-0.629	1.675	0.069	0.949
No. of Obs	450		450	

***significant at 1%; **significant at 5%; *significant at 10%.

Consistent with previous studies, local population and income have positive signs. The “population” variable is significant in the RE estimation, and the “income” variable is significant in both the FE and RE models. The interaction terms in both the FE and RE models are statistically significant. Higher commodity prices led mining-dependent areas to experience higher passenger movements during the sample period. In comparison, a higher exchange rate deterred overseas visitors from visiting Australian resorts and encouraged Australian residents to visit international destinations.

The domestic airfare index is significantly positive in both the FE and RE models. As mentioned earlier, this index mainly captures price changes on routes between major cities. Since regional aviation often serve as traffic feeder to network carriers' hub-and-spoke network, it is possible that higher yields on trunk routes allowed major airlines to cross-subsidize regional services or to jointly-price services at trunk and regional segments to explore network effects. Meanwhile, competition between Qantas and Virgin Australia, the two largest airlines in the domestic market, has been strong in the last few years. Therefore, it is also possible that the fare increase on trunk routes was caused by a general rise in aviation demand instead of airline market power. As air transport is a derived demand, the nationwide fare index may be interpreted as a proxy for unobserved demand drivers in our analysis. If airline-specific fares can be obtained for all domestic routes, an in-depth analysis on this issue may lead to fresh insights.

The demand equation estimates also suggest that Qantas and other low-cost carriers (LCCs) are important to boosting air travel in regional markets. Qantas has a well-developed network and a large fleet of regional/narrow-body aircraft. This allows the carrier to feed traffic to its network with efficient operations or to offer cost-effective services on a large scale. The cost advantage of LCCs enables them to offer competitive prices. As a result, they drive up traffic volumes at regional Australian airports. The RE model reports that regional airports with international flights had higher passenger flows during the sample period. This was also the case for airports in tourism-rich areas. Mining towns usually have lower traffic movement, as most are located in sparsely populated areas. The number of destinations connected to a regional airport has insignificant effects in both models. This seems to suggest that only flights to hub airports mattered, as routes to additional destinations did not attract significantly more travellers. Passenger itinerary data are required for more detailed investigation.

It is somewhat surprising to observe that higher flight frequency did not significantly increase the air passenger volume at regional airports. In comparison, the demand elasticity to flight frequency has been estimated to be 0.79 for interstate European routes by Schipper *et al*. (2002); 1.021 for north Atlantic markets by Pitfield *et al*. (2010); and 0.945 in major Chinese routes by Wang *et al*. (2014). These estimates, which were mostly based on trunk route data, suggest that higher frequency stimulates demand. Our findings for the regional markets suggest that travel demand is insensitive to frequency. The estimation results of the frequency equation suggest that the elasticity of flight frequency to airport traffic is 0.905. This implies that, *ceteris paribus*, most airport traffic changes are accommodated by flight frequency increases and slightly larger aircraft. Such a pattern can be identified in Figures 1 and 2, which depict the distribution of frequency and aircraft size at the sample airports. Over the sample period, there were moderate increases in total frequency and aircraft size.

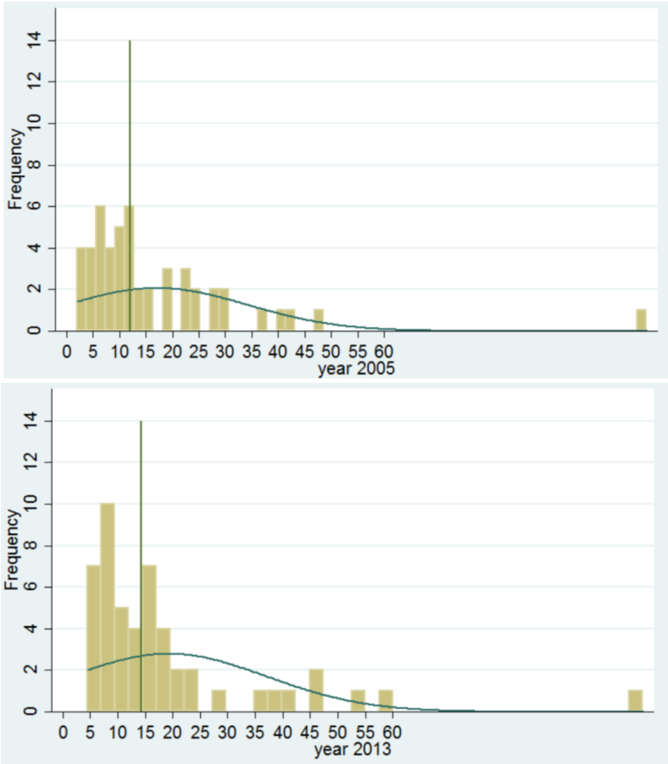

Figure 1. Distribution of average daily flight frequency at sample regional airports
*Note: the vertical line is the Median; the curve is the fitted continuous ***density***

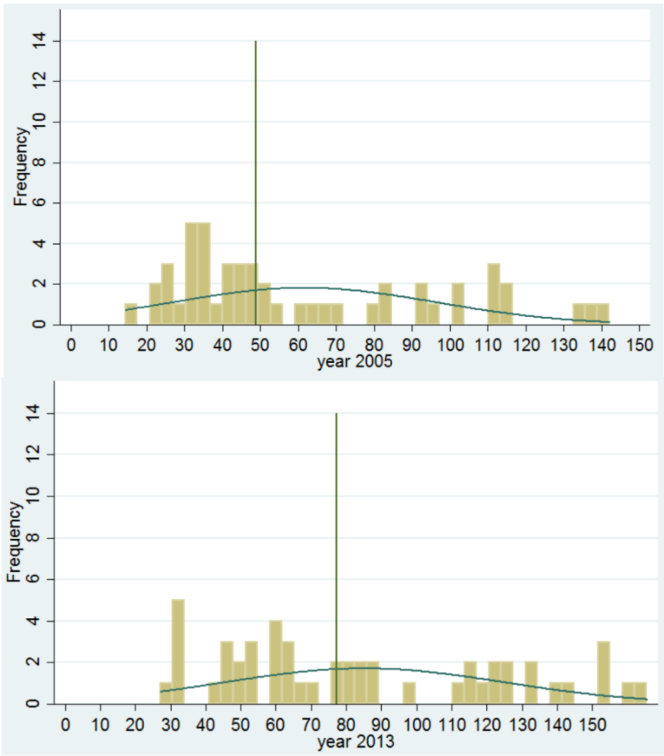

Figure 2. Distribution of average aircraft size at sample regional airports
*Note: the vertical line is the Median; the curve is the fitted continuous density

As shown in Figure 3, among the major airlines serving regional airports, Jetstar (JQ) used the largest aircrafts on average, most of which comprised its A320 series narrow-body fleet. In comparison, although Virgin Australia (VA) used a similar aircraft mix in the early days, the carrier's average fleet size decreased slightly over time. Qantas (QF) used mostly small regional aircraft owned by its regional aviation arm, QantasLink. As shown in Figure 4, Virgin's market share increased from less than 10% to about 20% over the sample period, and the combined market share of Qantas and Jetstar also increased slightly. This allowed the aggregate share of the top three airlines to increase from 60% to 76% at the expense of other niche competitors. Therefore, the increase in average aircraft size at Australian regional airports can largely be attributed to higher market penetration by Virgin, Jetstar and Qantas. The operations and airport choices of these three airlines play critical roles in shaping the market outcomes at regional airports.

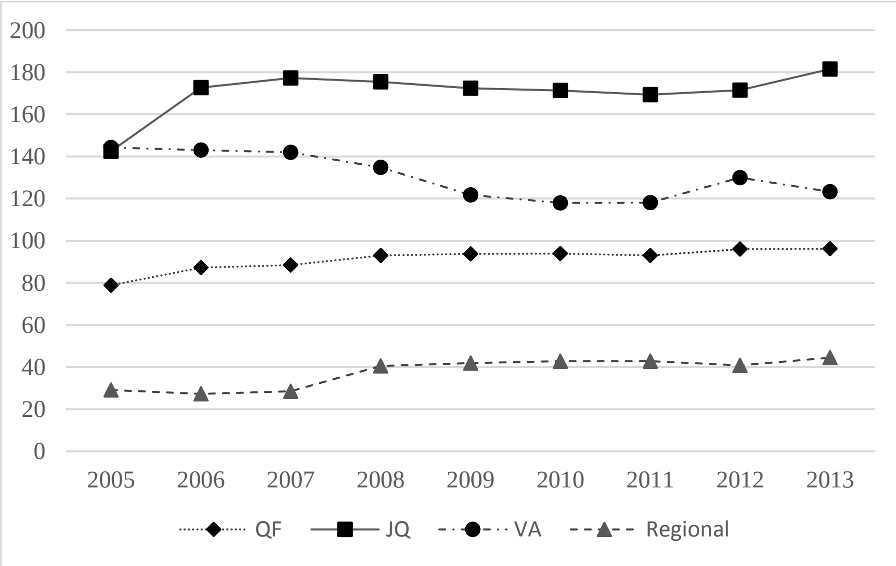

Figure 3. Average aircraft size of major airlines in the sample regional airports
Source: calculated from OAG data

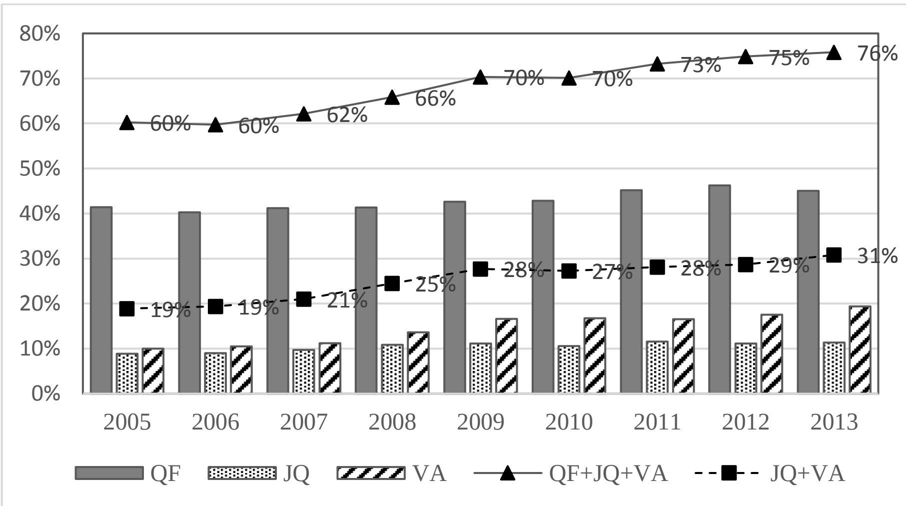

Figure 4. Share of total scheduled flights in the sample regional airports
Source: Calculated from OAG data

3.3. Entry patterns of airlines at regional airports

As the operations of major airlines significantly affect the overall performance of an airport, this section investigates the airport entry patterns of the three leading carriers in the Australian regional market, including those of Qantas (QF), Jetstar (JQ) and Virgin Australia (VA). Table 5 reports the summary statistics of the airport entry pattern of these carriers during the sample period. According to Table 5(a), in every year of the sample period, Jetstar served a regional airport if and only if Virgin Australia also served that airport. Homsombat *et al.* (2014) investigated airline pricing and route entry patterns in the Australian domestic markets during 2009-2011. They concluded that Qantas used Jetstar as a fighting brand against other LCCs. Our analysis confirms that such a strategy has been consistently applied for extended periods in the regional markets.

Table 5. Airport entry by major airlines in the sample regional airports during 2005 to 2013

(a) Jetstar vs. Virgin

Jetstar \ **Virgin**	0	1	Total
0	267	82	349
1	0	101	101
Total	267	183	450

(b) Qantas vs. Jetstar

Qantas \ **Jetstar**	0	1	Total
0	89	18	107
1	260	83	343
Total	349	101	450

(c) Qantas vs. Virgin

Qantas \ **Virgin**	0	1	Total
0	87	20	107
1	180	163	343
Total	267	183	450

Note: 0 stands for no service at the airport (no airport entry); 1 stands service at the airport
Source: compiled by authors using OAG data

To systematically investigate the airport choice patterns of airlines in regional markets, we estimate a probit model for Qantas, Jetstar and Virgin Australia, respectively. Qantas and Jetstar both belong to the Qantas airline group and have inter-connected loyalty programs. Their main competitor is Virgin Australia, a carrier that started as an LCC but has progressively switched to a full-service carrier.[1] The probit model specification is similar to those used by Homsombat *et al.* (2014) and Fu *et al.* (2015) to analyze route entry decision of airlines, except that we are primarily interested in airport choice in this study. For example, Eq. (5) is estimated for Qantas as follows.

$$(5) \quad Qantas_{it}=\varphi_0+\varphi_1 \ln Pop_{it-1}+\varphi_2 \ln Income_{it-1}+\varphi_3 Tourism_i+\varphi_4 Mining_i +\varphi_5 \ln Fare_{it-1}+\varphi_6 Virgin_{it-1}+\varphi_7 Jetstar_{it-1}+\varphi_8 Others_{it-1} +\varphi_9 \ln Year_t+\xi_{it}$$

To avoid a potential endogeneity problem, we adopt one-year lag variables on the right-hand side of the probit model. Table 6 collates the estimation results for all three of the airlines. Due to the entry pattern observed in Figure 5(a), the effect of Virgin's presence on Jetstar's entry decision cannot be statistically identified.

Table 6. Probit estimation of major airlines' entry patterns at regional airports (Qantas, Jetstar and Virgin)

	Qantas		**Jetstar**		**Virgin**	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
$\ln Pop_{it-1}$	0.347***	0.094	1.210***	0.240	0.687***	0.095
$\ln Income_{it-1}$	3.924***	0.642	3.748***	2.07	3.094***	0.648
$Tourism_i$	0.481**	0.191	0.439**	0.192	0.466***	0.175
$Mining_i$	-0.043	0.247	-1.642***	0.387	-1.018***	0.283
$\ln Fare_{it-1}$	-0.063	0.895	1.128	0.980	0.847	0.828
$Qantas_{it-1}$			-0.645***	0.244	0.341*	0.195
$Virgin_{it-1}$	5.234	130.84				
$Jetstar_{it-1}$	-5.035	130.84				
$Others_{it-1}$	-0.174*	0.096	0.013	0.092	0.100	0.085
$\ln Year_t$	-0.917***	0.337	-0.718*	0.383	0.144	0.320
Constant	-43.175***	8.477	-56.782***	11.684	-44.671***	8.558
No. of Obs	400		400		400	
LR Chi2	112.69		146.43		147.86	
Pseudo R2	0.257		0.3433		0.2720	

[1] In 2013, Virgin purchased a 60% share of Tiger Airways, another major LCC in Australia. In 2014, Tiger Airways became a fully owned LCC subsidiary of Virgin and changed its name to Tiger Australia.

It is clear that all three airlines preferred to serve airports with strong aviation demands, as evidenced by the significantly positive coefficients of population, income and tourism destinations. Both Jetstar and Virgin avoided mining destinations, probably because the fleets of these LCCs were composed of mostly narrow-body aircraft that were not sufficiently cost-effective to serve such small destinations. The regional arm of Qantas, QantasLink, had more regional aircraft that were ideal for thin routes. The estimation results also reveal some strategic airport choice behavior. The Qantas airline group (Qantas + Jetstar) clearly used Jetstar as a fighting brand to compete with LCCs. The presence of Qantas decreased the likelihood of Jetstar service at the same airport to avoid service overlap (consider the significantly negative coefficient of variable *Qantas* in Jetstar's airport entry estimation), as Jetstar provided service at all of the airports served by Virgin Australia in all of the sample years. Controlling for more than half of the domestic market, the Qantas airline group was the clear market leader. This probably explains why the presence of other airlines had negative effects on the entry decisions of Qantas and Jetstar yet no influence on Virgin Australia.

4. Summary and conclusions

Regional Australia accounts for one third of Australia's population and contributes significantly to the national economy. In the last decade or so, many regional areas in Australia have become increasingly dependent on the tourism and mining industries, making efficient and reliable air transport services indispensible. Although many studies have discussed the economic and policy implications of regional aviation, the market development patterns at regional airports remain under-examined. This study aims to fill this research gap by empirically investigating the Australian domestic market using data from the top 50 regional airports during 2005-2013.

The estimation results of our demand and frequency equations suggest that, similar to the aviation markets in major cities, local population and income are two important drivers of travel demand. An increase in commodity price leads to a rise in passenger movement at regional airports where the local economy relies heavily on mineral resources. An appreciation of the Australian dollar leads to a decrease in passenger flows in tourism-dependent areas. The presence of leading airlines such as Qantas, the growth of LCC services and direct international services contribute positively to the expansion of local markets. Meanwhile, our airport entry analysis reveals that major carriers engage in clear strategic interactions. The Qantas airline group has used Jetstar as a fighting brand, having it serve an airport if and only if that airport was also served by Virgin Australia. Competition from other niche airlines had a negative effect on the airport entry decisions of the market leader (i.e., the Qantas airline group), but no significant effects on the market follower Virgin Australia. All of these findings are broadly consistent with the patterns observed in major airports.

Our analysis also reveals preliminary evidence of some of the distinctive features of Australia's regional market. In particular, local demand is not sensitive to flight frequency, although traffic volume growth is mostly served by flight frequency increase. Overall, individual airlines do not use significantly larger aircraft. The moderate growth in average aircraft size observed during the sample period was mainly a result of higher LCC market shares. In addition, higher national fare levels appear to have a positive effect on regional aviation, due perhaps to an airline network effect, a cross-subsidization by major airlines or factors not identified in our investigation. In-depth analysis based on airline-route specific data is required to precisely identify the cause.

Our study may lead to some important policy debates. The similar patterns observed in regional airports and metropolitan areas suggest that consistent aviation policy can be developed across Australia, especially for issues related to airline competition and demand stimulation. However, some special considerations must be made for regional airports, as they can be vulnerable to economic shocks such as commodity price and exchange rate volatility. In addition, regional services can be sensitive to the performance of major routes, probably due to the network effects or inter-firm competition of airlines. In addition, as flight frequency does not seem to play an important role in the regional market, government subsidies may be paid out as lump sums where justified instead of on a per-flight basis to offset fixed costs.

Although our analysis produces rich results, reduced-form equations have a relatively weak power to identify causal effects. If more detailed airline-route specific data are available, structure models should be developed to validate our preliminary findings. This would be a valuable extension of the current research, albeit one beyond the objectives of this study.

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Appendix. The 50 largest Australian regional airports included in our study

Airport	Airport Code
ALBURY	ABX
ALBANY	ALH
ARMIDALE	ARM
ALICE SPRINGS	ASP
AYERS ROCK	AYQ
BUNDABERG	BDB
BROKEN HILL	BHQ
BROOME	BME
BALLINA	BNK
BURNIE	BWT
COFFS HARBOUR	CFS
CAIRNS	CNS
DUBBO	DBO
DEVONPORT	DPO
DARWIN	DRW
EMERALD	EMD
GERALDTON	GET
GRIFFITH	GFF
GLADSTONE	GLT
GOVE	GOV
HOBART	HBA
THURSDAY ISLAND	HID
HAMILTON ISLAND	HTI
HERVEY BAY	HVB
MOUNT ISA	ISA
KALGOORLIE	KGI
KUNUNURRA	KNX
KARRATHA	KTA
LEARMONTH	LEA
LAUNCESTON	LST
MOUNT GAMBIER	MGB
MERIMBULA	MIM
MACKAY	MKY
MORANBAH	MOV
MILDURA	MQL
WILLIAMTOWN	NTL
OLYMPIC DAM	OLP
PARABURDOO	PBO
PORT HEDLAND	PHE
PORT LINCOLN	PLO
PROSERPINE	PPP
PORT MACQUARIE	PQQ
ROMA	RMA

ROCKHAMPTON	ROK
TAMWORTH	TMW
TOWNSVILLE	TSV
WHYALLA	WAY
WEIPA	WEI
WAGGA WAGGA	WGA
NEWMAN	ZNE