Pricing dynamics in the Australian airline market

Nicolas de Roos* Sydney University
Gordon Mills Sydney University
Stephen Whelan Sydney University

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Abstract

We harness a unique dataset of airfares to examine price discrimination in the Australian air travel market. Price discrimination is achieved by restricting the menu of available fares, and through variation in fares with the day of booking. Our fixed effects estimator allows us to characterise both of these mechanisms. Price discrimination by booking day is particularly dramatic, with fares rising rapidly in the week before travel. We also find an ambiguous relationship between market structure and price discrimination. We find the greatest discrimination on routes involving competition between the two main airlines, Qantas and Virgin. However, we find greater discrimination on monopoly routes than routes pitting Virgin with Qantas' subsidiary, Jetstar.
JEL Classification: L13, L93

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1 Introduction

Airline tickets are sold to individuals and generally are not transferable. The short-run marginal cost of carrying an extra passenger is well below the average total cost. For these reasons, it is not surprising that airlines practice extensive price discrimination, including differentiation by cabin class, route, and ticket conditions on transferability and cancellation. In this paper, we use an extensive self-collected data set of airfares to examine the nature of price discrimination in the Australian domestic aviation market. Given the detailed nature of our data, we are able to focus on how fares vary according to the number of days between booking time and travel. The panel nature of our data set permits us to control for individual route characteristics, isolating the impact of booking time on airfares.

At least since Borenstein and Rose (1994), the relationship between price discrimination and the competitive environment has been recognised as an empirical question.

*School of Economics and Political Science, Merewether Building H04, University of Sydney, NSW 2006, Australia, e-mail: n.deroos@econ.usyd.edu.au, phone: +61 (2) 9351 7079, fax: +61 (2) 9351 4341.

We use detailed information on market structure to characterise the nature of price discrimination both for different airlines, and for different competitive settings. This paper contributes to the literature in two ways. First, we identify one dimension of price discriminating behaviour by considering how prices vary as the flight date approaches. We argue that such an approach is valid in the domestic Australian air market where only small differences are observed in the nature of offered tickets. The econometric evidence we present indicates that the fares increase substantially as the travel date approaches. The increase in fares we observe is particularly pronounced in the days immediately prior to travel.

Our secondary goal is to examine the impact of competition on airfares. Ideally, our analysis would take into account the endogenous nature of the relationship between price and the competitive characteristics of markets. In the absence of valid instruments that may be exploited for this purpose, however, the approach in this paper is to undertake empirical analysis that places a bound on the effect of competition on pricing behaviour. Controlling for the competitive nature of the route in question provides insight into the relationship between pricing behaviour and competition. We find, for example, that greater variation in prices is observed on routes in which the two largest airlines compete directly.

The Australian domestic aviation market is of particular interest for our research questions for several reasons. First, due to the small number of domestic airlines, it is feasible to collect fares with booking time variation for all airlines on a large set of routes. Second, the recent history of competition in Australia provides an interesting setting. Virgin Blue, one of the two major airlines, has only recently entered, affording us a rare glimple of a competitive environment that has not matured. Third, many of the complications of other aviation markets are absent. A very large proportion of air journeys in Australia involve direct travel, removing the necessity of considering a complicated hub and spoke network.

1.1 Related literature

The literature has long been interested in the relationship between competition and price discrimination. Air travel markets have been a fertile area for study due to the existence of substantial observable variation in competitive conditions across routes. Borenstein and Rose (1994) find that price dispersion is more pronounced in markets with a greater number of carriers. Stavins (2001) finds that ticket restrictions are an important tool for price discrimination. Substantial discounts are associated with Saturday night stayover requirements and advance purchase requirements. Further, the extent of price discrimination linked to these restrictions is greater for less concentrated markets.

While the restrictions examined by Stavins (2001) result in product differentiation, their motivation is clearly for price discrimination. In the Australian context, the restrictions between most fare classes are extremely minor. For example, of the five fare classes commonly offered by Qantas, only the top two classes offer substantive differences. Consequently, we can confidently attribute most of the dispersion in the lowest available fares on an airline to price discrimination rather than product differentiation.

There have been several recent case studies examining airline pricing behaviour following the entry of low-cost carriers. For example, Pels and Rietveld (2004) examine the variation in prices by booking date for a single return flight between London and Paris. Pitfield (2005a, 2005b) examines the behaviour of competing low-cost carriers on five European routes originating in the United Kingdom. The present paper also addresses the price competition between airlines as we approach the day of travel, but harnesses a dataset of a substantially larger scale. Our dataset comprises a total of 365181 flight $\times$ booking day observations and 1369247 observations for all fare types, across a variety of different routes, travel times, and competitive settings, allowing us to make much more general inferences.

The yield management literature has also considered issues related to price discrimination in aviation markets. The problem of managing demand for a perishable commodity of fixed capacity, such as seats on an airline route, is considered extensively by this literature.[1] However, the underlying motivations for yield management are often not explicitly distinguished. For the purposes of discussion, suppose that demand arrives at a rate given by the function $\lambda(p_t, \epsilon_t, t; \gamma)$, where p_t is the market price at time t, ϵ_t is an unobservable shock reflecting demand uncertainty, and the demand function is parameterised through γ. The term t makes the time-dependence of demand explicit. If demand is time-invariant, there is no demand uncertainty and the parameters, γ, are known to the firm, then the firm's optimal policy is to set a constant price over time.[2] We can then consider the variation in the optimal pricing policy induced by uncertainty (the term ϵ_t) as arising from *inventory management* concerns. Intuitively, the firm optimally varies price over time in response to fluctuation in the option value of remaining inventory as sales are made and time passes. We attribute the variation in price due to time-variation in demand as *price discrimination*. Finally, if the demand parameters, λ, are unknown to the firm, the firm's optimal price will adjust over time due to *learning*.

For the remainder of the paper, we will refer to variation in price over booking days as price discrimination, although the above motivations will also be evident. This characterisation is guided by two observations. First, in simulation exercises, the revenue gains from pure inventory management cannot explain the extent of profitability of computer reservation systems. For example, in a model of optimal pricing of limited seat capacity, Gallego and van Ryzin (1994) argue that the potential revenue gains from dynamic (as opposed to fixed) pricing are modest in the absence of time-varying demand. Second, casual observation of our data suggests that it is routine for airlines to raise their lowest offered fare substantially over the last few days before travel. Price discrimination presents an obvious rationale. Leisure budget travellers will not book this late; these late bookers are likely travelling for business or for other very pressing reasons, and hence demand is very inelastic. An inventory management rationale would imply both more uniform upward movements in lowest offered fares as the booking date approaches, and substantial variation in the pattern of last minute fare rises across flights with variation in the volume of unfilled seats.

The remainder of the paper is structured as follows. We discuss the data and industry setting in section 2. In section 3, we outline our empirical model. Results are contained in section 4, and concluding remarks are offered in section 5.

[1] See, for example, Talluri and van Ryzin (2004) for a recent text treatment.
[2] See, for example, Gallego and van Ryzin (1994).

2 Data and industry background

2.1 The Australian airline context

For many years, the Australian government's infamous two-airline policy (applying to all but local routes) resulted in a duopoly with parallel pricing and very little by way of fare discounting. After deregulation in 1989, a further 11 years elapsed before there was effective competition from a well-managed and financially robust entrant, Virgin Blue. Soon after Virgin's entry, one of the long-established incumbents went out of business, leaving Virgin to compete with Qantas. After Virgin had won about 30% of the market, Qantas set up its own low-cost airline, Jetstar, and gradually handed to that subsidiary entire routes (mainly to tourist destinations), and certain departure times on routes still served by Qantas itself. Throughout, it has been a case of multi-market contact. Indeed, Virgin now faces competition from Qantas and/or Jetstar on every route that it serves. Qantas has a monopoly on one major route, and on a number of minor routes.

2.2 Data

We employ a self-collected dataset of airfares advertised online by the major domestic Australian airlines. A unique feature of the dataset is that it contains the price charged for a variety of flights conditional on the day the flight was booked. As we shall see, the day of booking explains a great deal of the variation in airfares. An observation then consists of information about the fare offered, the fare class, the identity of the airline, the date of booking, and the details of the flight (origin, destination, time and date of travel, and aircraft type).

Because our dataset is collected through direct queries to airline websites, it is a necessarily selective sample. We have selected routes and times with the goal of capturing much of the variation in nature of Australian air travel. We have sought a selection of routes of different character. We have included high volume routes, such as Melbourne-Sydney, predominantly leisure routes such as Sydney-Hamilton Island, and predominantly business routes such as Sydney-Canberra. Further, we have attempted to control for observable variation in several dimensions. For each travel route, we have collected fares for both directions of travel, for travel that falls both in and out of school holiday periods, for travel on different days of the week, for travel at peak and non-peak times, and for travel in different seasons.

For each flight in our dataset, we have information on the offered fare for all available classes of travel. There are two mechanisms that airlines use for intertemporal price discrimination. First, fares within a fare class may rise as the travel date approaches. Second, cheaper fare classes may become unavailable as the travel date approaches. To capture both of these mechanisms in a single measure, we focus most of our analysis on the lowest available fare offered for a flight. Differences in fares between fare classes on a given flight will reflect both product differentiation and price discrimination. However, the extent of product differentiation between the lowest fare classes is extremely minor, allowing us to attribute most of the variation in lowest available fares to price discrimination.

The dataset contains only observations on direct flights. In Australia, most air travel can be completed through a direct flight. Indirect flights represent an inferior product. Moreover, because individual legs are typically priced separately in Australia, indirect flights often cannot compete with direct flights without compromising profitability on the constituent legs. Therefore, our restriction to direct flights should not greatly affect our results.

Our dataset consists of fares on a total of 118 different routes, where we distinguish between different directions of travel. For the majority of flights, we have collected fares for at least the five weeks preceeding travel. Our dataset spans the period September 2003 to April 2006, with the majority of observations collected after September 2004. Table 1 contains summary statistics for our dataset, restricting attention to lowest available fares. The majority of routes exhibit competition between Qantas and Virgin, with a substantial minority of monopoly routes.

Table 1: Descriptive statistics - lowest available fares

Variable	Mean	Std Dev.	Min	Max
Fare (A$)	162.060	84.401	28	1533
Days until travel	25.607	17.659	1	151
Jet fuel prices	150.719	26.216	74.76	189.761
Flight operated by				
Jetstar	0.056	0.230	0	1
Qantas	0.633	0.482	0	1
Virgin	0.310	0.463	0	1
Potential competition[a]				
Monopoly	0.237	0.425	0	1
Jetstar and Virgin	0.020	0.140	0	1
Qantas and Virgin	0.658	0.474	0	1
All Airlines	0.086	0.280	0	1
Temporal competition[b]				
Monopoly	0.377	0.485	0	1
Jetstar and Virgin	0.015	0.122	0	1
Qantas and Virgin	0.585	0.493	0	1
All Airlines	0.021	0.142	0	1
Flight characteristics				
Non-peak period	0.674	0.469	0	1
School holiday	0.111	0.314	0	1
Leisure route	0.370	0.483	0	1
Business route	0.569	0.495	0	1
Route distance (km)	984.722	782.671	236	3615

Notes: Restricting attention to lowest available fares, an observation is a flight × booking day combination. There are a total of 365,181 such observations.

[a] Potential competition for a flight is defined as the set of airlines who operate on the same route on the same day of travel.

[b] Temporal competition for a flight is defined as the set of airlines who operate on the same route within 90 minutes of travel.

3 Empirical model

Our aim is to characterise the nature of price discrimination and fare setting generally in the Australian domestic aviation market. We break this empirical task into two related exercises. First, we adopt a fixed effects model, controlling for route-specific characteristics. By removing unobservable heterogeneity across routes, this allows us to focus attention on price discrimination, using our entire dataset. However, our fixed effects model does not allow inference on the determination of fares across routes. Our second specification dispenses with the route-specific controls, permitting us to examine the association between airfares and characteristics of individual routes.

3.1 A fixed effects model

Our first exercise is to characterise the nature of price dispersion. Controlling for individual characteristics of each route allows us to isolate the effect on the fare of the airline operating the route, the time of booking, and the travel time and date. We consider the following empirical specification:

$$p_{ijkn} = \alpha_i + \delta_{jk} + \gamma_n + \theta t + X'\beta + \epsilon_{ijkn}, \tag{1}$$

where p_{ijkn} is the minimum available price in Australian dollars (A\$) offered by airline i operating on the route linking origin j and destination k, with n days until travel. Further, t represents a time trend, and X is a vector of (predominantly dummy) variables that are not specific to the route. Hence, α is an airline dummy, δ is a route-specific dummy (with $\delta_{jk} \neq \delta_{kj}$), and γ contains a vector of dummy variables representing the number of days until travel at the time a booking was made.

The inclusion of the route specific dummy variable, δ_{jk}, allows us to control for (fixed) individual characteristics of each route. The vector X contains cost and demand information that varies across flights within a route. We include jet fuel prices as a cost shifter. There is a set of variables with information to distinguish whether the flight operates in a peak period. Indicator variables are included for the time of the day and the day of the week of the flight. We also include an indicator for the presence of school holidays. A flight was deemed to have occurred in a school holiday if the more populous of the origin and destination was in a school holiday period. We also consider interaction terms between our explanatory variables.

In addition, we consider a set of variables designed to measure the extent of competition on the route. Our first candidate is an indicator variable containing the identities of the airlines operating within 90 minutes of the flight (before or after). This is a proxy for the extent of direct competition faced by the airline on a particular flight. Our second candidate is an indicator variable containing the identities of the airlines operating on the route on the same day as the flight. By describing which airlines have already set up operations on this route, but may not operate flights in direct temporal competition, this measures the extent of potential competition on the route.

We might reasonably expect the nature of competition on a route and the level of fares set on the route to be jointly determined by intrinsic characteristics of the route. Our fixed effects specification removes unobserved heterogeneity, allowing us to examine the effect of competition on price discrimination. The cost of this empirical strategy is that the impact of competition is necessarily identified through variation in competition *within* a route, rather than variation *across* routes.

3.2 The effect of route characteristics

In (1) the route specific dummy variable, δ_{jk}, allows us to control for fixed characteristics of individual routes. However, it permits no insight into the determination of prices on individual routes. To this end we replace δ_{jk} by characteristics of individual flights.

$$p_{ijkn} = \alpha_i + \gamma_n + \theta t + X'\beta + W'\phi + \epsilon_{ijkn}, \tag{2}$$

The cost, demand and competition information embodied in X is included as before. In the vector W, we consider route- or flight-specific characteristics relating to costs and demand. The length of the route is included as a cost shifter. We also include an interaction term with jet fuel prices. We classify routes as mainly business, mainly leisure, or mixed, according to the predominant purpose of the route. We also include demographic information related to the origin and destination airports.

As we alluded to above, our primary concern in interpreting (2) is the joint determination of airfares and competitive conditions. Two common solutions to this problem are fixed effects estimation and instrumental variables. The limitation of fixed effects estimation is that it does not permit identification based on variation across routes. The challenge for instrumental variables estimation is to find a set of variables that are correlated with the competitive conditions in a market, but unrelated to the unobservable determinants of airfares. In the absence of convincing instruments, our estimates place a lower bound on the true impact of competition on fares.

4 Results

4.1 Fixed effects model

Lowest available fares

Our fixed effects model examines price discrimination, controlling for route-specific characteristics. To abstract from price dispersion due to product differentiation, we first restrict our attention to the lowest fare made available for each flight. Because of the large number of explanatory variables, we employ a combination of tables and figures to present the results of several specifications of (1).

The number of days until travel at the time of booking is an important instrument for price discrimination. Models 1-4 of table 2 all contain estimates of (1), but differ in the treatment of the number of days until travel. In Model 1, we incorporate indicator variables for the number of days until travel. This tells us explicitly the relationship between booking time and air fares. In Model 2, we interact these indicator variables with indicators of the airline operating the flight. This allows air fare variation over booking time to differ between airlines. In Model 3 and 4, we interact the indicator variables with indicators of the nature of competition. We return to these last two specifications shortly.

Figures 1, 2 and 3 contain the parameter estimates for these indicator variables; table 2 contains the remaining parameter estimates.

Table 2: Price dispersion

	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]	
	Coeff	Std err	Coeff	Std err	Coeff	Std err	Coeff	Std err
Constant	95.913	(1.195)	103.083	(1.197)	102.347	(1.272)	98.682	(1.223)
Jetstar	-27.947	(0.476)			-28.001	(0.480)	-26.915	(0.492)
Qantas	49.343	(0.196)			49.154	(0.196)	48.828	(0.198)
Tues am Peak	40.211	(0.706)	40.390	(0.697)	40.296	(0.703)	40.372	(0.705)
Tues pm Peak	24.708	(0.617)	24.897	(0.603)	24.839	(0.613)	24.901	(0.616)
Wednesday	6.884	(0.376)	6.932	(0.373)	6.790	(0.375)	6.872	(0.376)
Wed am Peak	22.503	(0.669)	22.705	(0.657)	22.555	(0.667)	22.552	(0.669)
Wed pm Peak	39.420	(0.796)	39.455	(0.785)	39.321	(0.792)	39.734	(0.794)
Thursday	20.055	(0.407)	19.917	(0.405)	20.195	(0.406)	20.152	(0.406)
Thur am Peak	5.125	(0.687)	5.446	(0.681)	5.181	(0.685)	5.265	(0.685)
Thur pm Peak	46.094	(1.014)	46.237	(1.010)	46.065	(1.011)	46.393	(1.015)
Friday	38.928	(0.402)	38.995	(0.401)	38.967	(0.401)	38.992	(0.402)
Fri am Peak	-26.048	(0.515)	-25.793	(0.511)	-25.950	(0.514)	-26.009	(0.514)
Fri pm Peak	71.682	(0.962)	71.803	(0.957)	71.719	(0.959)	71.947	(0.964)
Saturday	6.010	(0.379)	5.961	(0.376)	5.942	(0.378)	5.994	(0.379)
Sat am Peak	8.400	(0.533)	8.427	(0.529)	8.409	(0.532)	8.470	(0.534)
Sunday	17.498	(0.377)	17.638	(0.376)	17.603	(0.377)	17.542	(0.377)
Sun pm Peak	20.540	(0.495)	20.602	(0.494)	20.535	(0.495)	20.749	(0.495)
Monday	17.467	(0.419)	17.573	(0.417)	17.311	(0.419)	17.445	(0.418)
Mon am Peak	28.165	(0.892)	28.559	(0.883)	28.133	(0.890)	28.288	(0.890)
Mon pm Peak	2.212	(0.738)	2.260	(0.734)	2.111	(0.739)	2.660	(0.738)
Jetfuel price	-0.027	(0.007)	-0.028	(0.007)	-0.042	(0.007)	-0.031	(0.007)
School hols	10.317	(0.328)	10.202	(0.324)	9.872	(0.331)	10.046	(0.328)
Time	0.019	(0.001)	0.019	(0.001)	0.022	(0.001)	0.019	(0.001)
Observations	356181							
R^2	0.566		0.572		0.568		0.567	

Notes: All coefficients are in A$. We restrict attention to lowest available fares. Route-specific indicator variables are included in the specification, but omitted above. All standard errors are heteroskedasticity adjusted. Alternative clustering methods were considered, but did not qualitatively affect the results.

[a] Model 1 contains indicator variables for the number of days between booking and travel.

[b] Model 2 contains indicator variables for the number of days between booking and travel, interacted with the airline operating the flight.

[c] Model 3 contains indicator variables for the number of days between booking and travel, interacted with the nature of competition on the route on the day of travel.

[d] Model 4 contains indicator variables for the number of days between booking and travel, interacted with the nature of competition on the route within 90 minutes of travel.

First, turning to table 2, it is clear that, for all specifications, airfares are sensitive to travel time, with an average premium for Friday night travel of around A$110 relative to a Tuesday non-peak flight (the numeraire). There is also a premium for school holiday travel. Relative to a flight on Virgin, fares are on average higher on Qantas, and lower on Jetstar. There is an apparently spurious negative relationship between fares and jet fuel prices. This presumably reflects a non-linear rise in airfares over time.

Figure 1: Fares and booking day

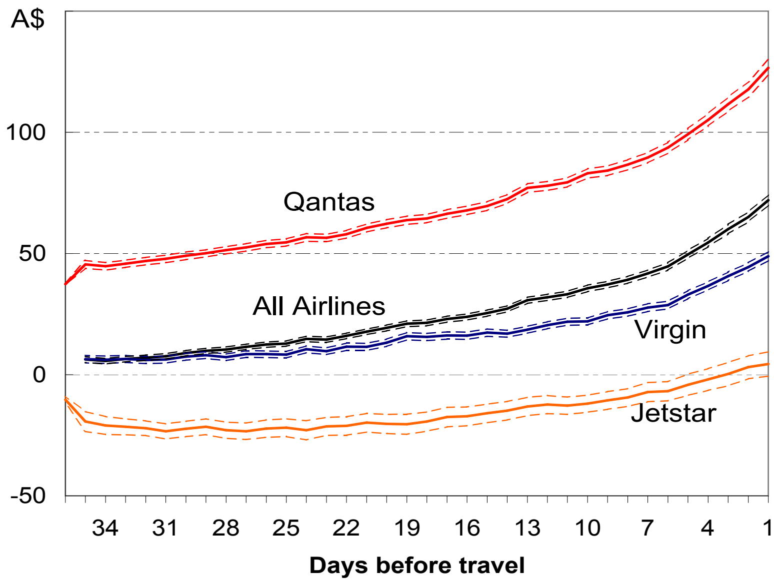


Figure 1 contains results for Models 1 and 2, illustrating a dramatic relationship between airfares and booking time. Solid lines represent point estimates, and dashed lines indicate 95% confidence intervals. The line for "All Airlines" is the coefficient on the number of days until travel at the time of booking for Model 1. The numeraire is a flight booked more than five weeks before departure. The average premium for booking a flight the day before travel is more than A$70, with the premium rising most precipitously in the last week before travel. The airline-specific lines are from Model 2. The numeraire is a Virgin flight booked more than five weeks before departure. We again see a premium for travel on Qantas, and a discount on Jetstar. The rise in fares as we approach the departure date is most dramatic for Qantas flights, and mildest for Jetstar.

The marked variation in fares as we approach the date of travel is suggestive of substantial price discrimination. Our next goal is to ascertain the relationship between this apparent price discrimination and the competitive environment. We achieve this by incorporating into (1) dummy variables indicating the nature of competition. Model 3 includes indicators for the identities of the airlines operating each route on the day of travel. Again, we stress that, because we control for route-specific effects in (1), we identify the effect of competition only through variation in the set of airlines operating on different days of travel *for a given route*. We cannot use variation in the nature of competition *between different routes* to identify the effect of competition. Model 4 includes indicators for the identities of the airlines offering service within 90 minutes of the flight. In this case, we identify the effect of competition through variation in the identities of the temporal competitors, for a given route.

Figure 2: Daily competition and price discrimination

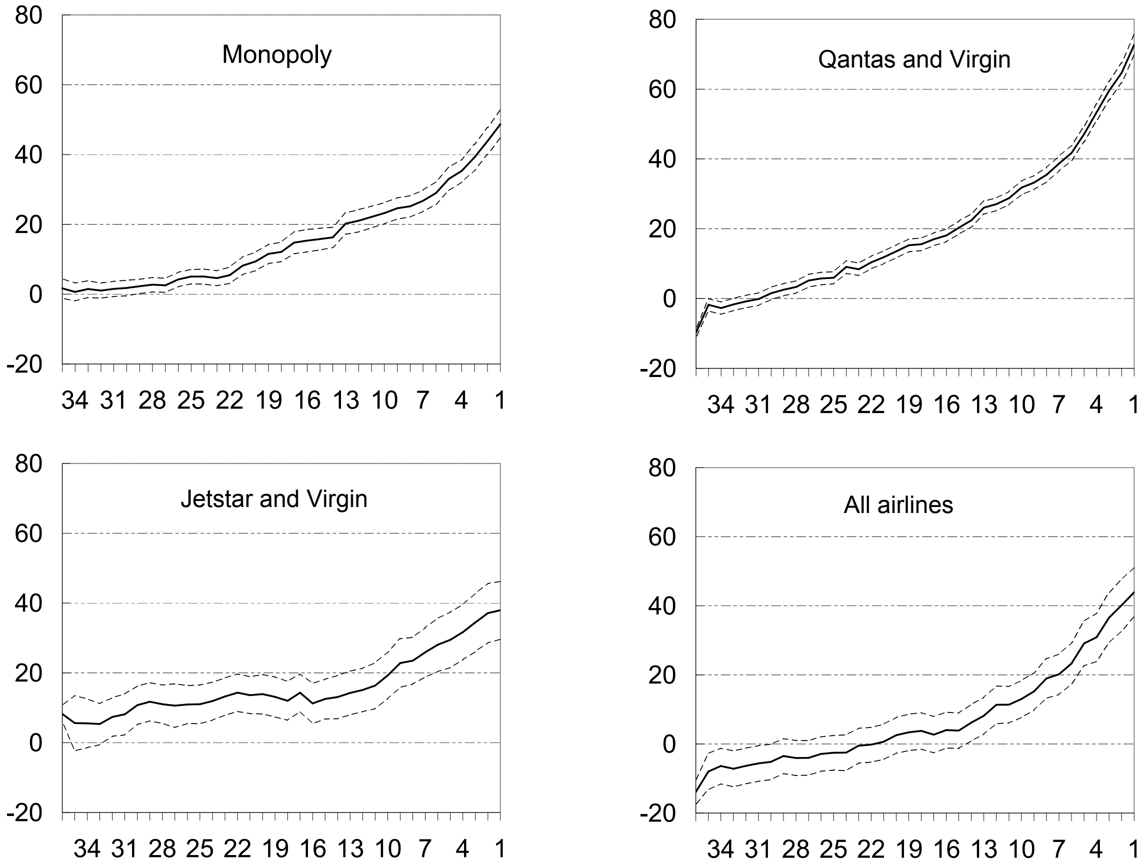
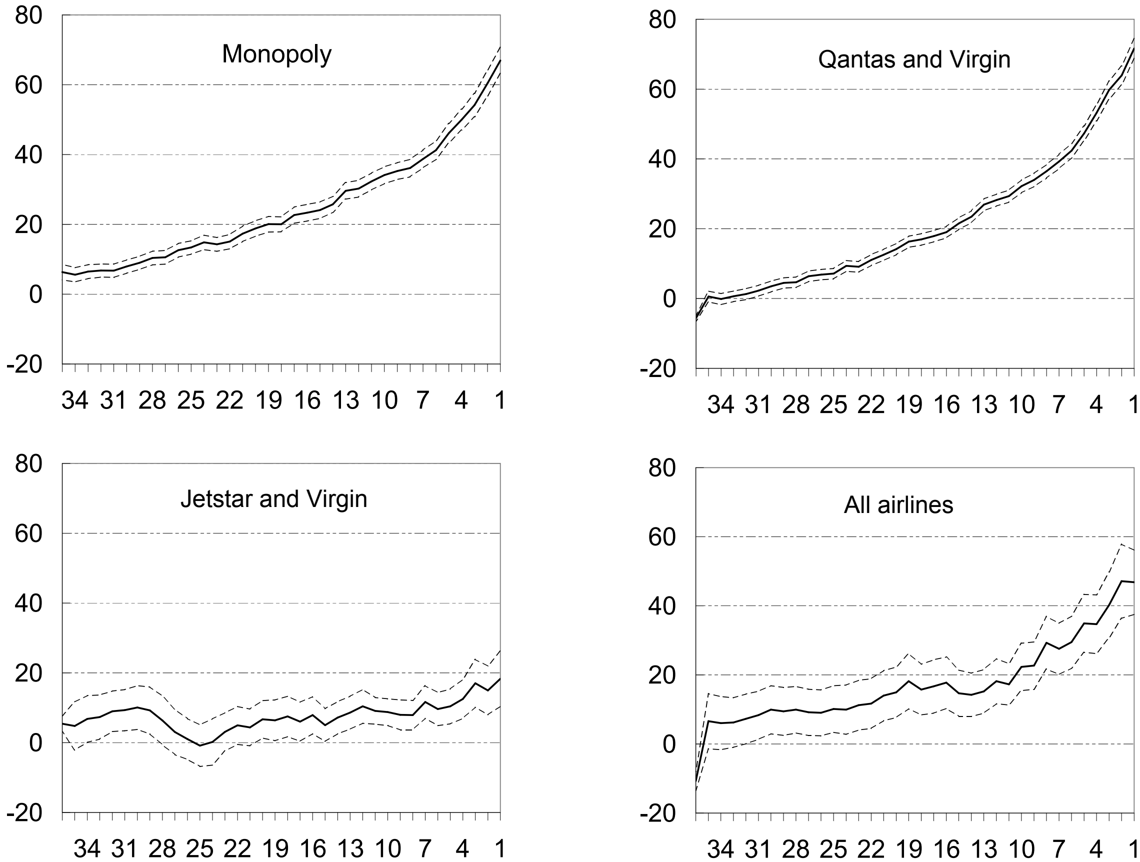


Figure 2 contains the results of Model 3. Each panel corresponds to a different market structure, and contains the coefficients on an indicator of that market structure interacted with indicators of the number of days until travel. The numeraire is a monopoly flight booked more than five weeks before travel. Solid lines indicate point estimates and dashed lines 95% confidence intervals. The effect of the nature of competition on the day of travel on the extent of price discrimination by booking date is ambiguous. Considerable price discrimination is evident in the A$50 discount available for early booking on monopoly flights. A similar discount is apparent for routes in which all airlines offer flights on the same day. The discount rises to more than A$80 for routes in which Qantas and Virgin offer flights on the same day, but falls to around A$30 for routes involving competition between Jetstar and Virgin.

Figure 3 contains results for Model 4. There is again an ambiguous relationship between the extent of price discrimination and the nature of competition. Price discrimination is most dramatic for flights involving temporal competition between Qantas and Virgin. The extent of price discrimination is also substantial for monopoly flights. Price discrimination is less marked in competition between all airlines. Finally, there is very little discrimination evident in flights involving competition between Virgin and Jetstar.

Figure 3: Within-day competition and price discrimination



All available fares

Table 3 contains estimates of (1) using our full dataset, which incorporates observations for all available fare classes. In Model 5, we include indicators for the number of days until travel (not reported) and the class of fare. In Model 6, we include indicators for the number of days until travel interacted with fare class. These are separately reported in figure 4. Relative to our earlier results, the effect of the time and day of travel has an apparently muted relationship with fares. This reflects the reduced sensitivity of premium fare classes to the time and day of travel.

As we would expect, premium fare classes are clearly associated with higher average fares. This is especially pronounced for Qantas flights. After controlling for route and flight characteristics, a business class seat costs on average A$480 more than the lowest class of Qantas fare. The difference is less dramatic on Virgin and Jetstar flights, with the highest class of fare attracting an average premium of around $200. We should note that this difference reflects both cross-sectional and time-series variation. First, at a given time, a customer chooses amongst a set of fare classes for a flight. The difference in prices across fare classes reflects a combination of product differentiation and price discrimination. Second, one method of intertemporal price discrimination is to reduce the set of available fare classes as we approach the date of travel. The cheapest fare classes

Table 3: Price dispersion - all fare classes

	Model 5[a]		Model 6[b]	
	Coeff	Std err	Coeff	Std err
Constant	150.423	(1.352)	147.407	(1.387)
Tue am Peak	22.371	(0.510)	22.723	(0.505)
Tue pm Peak	13.333	(0.536)	13.715	(0.530)
Wednesday	3.400	(0.320)	2.930	(0.316)
Wed am Peak	11.098	(0.511)	11.229	(0.506)
Wed pm Peak	19.033	(0.539)	19.857	(0.534)
Thursday	13.326	(0.326)	13.305	(0.323)
Thu am Peak	2.347	(0.564)	2.285	(0.558)
Thu pm Peak	22.552	(0.592)	22.652	(0.585)
Friday	16.784	(0.317)	16.296	(0.313)
Fri am Peak	-10.919	(0.542)	-10.770	(0.536)
Fri pm Peak	34.836	(0.548)	35.355	(0.542)
Saturday	1.311	(0.316)	1.635	(0.312)
Sat am peak	3.352	(0.450)	3.088	(0.445)
Sunday	9.151	(0.327)	8.720	(0.324)
Sun pm Peak	7.473	(0.434)	7.769	(0.429)
Monday	3.601	(0.332)	3.430	(0.328)
Mon am Peak	14.075	(0.598)	14.490	(0.592)
Mon pm Peak	0.518	(0.615)	0.951	(0.608)
School hols	12.032	(0.317)	11.418	(0.314)
Time	0.035	(0.001)	0.041	(0.001)
Virgin flights				
Class 2	136.346	(0.371)		
Class 3	186.240	(0.371)		
Class 4	193.985	(0.439)		
Qantas flights				
Class 1	74.092	(0.317)		
Class 2	96.048	(0.320)		
Class 3	216.337	(0.334)		
Class 4	298.532	(0.335)		
Class 5	554.548	(0.349)		
Jetstar flights				
Class 1	-40.932	(0.800)		
Class 2	157.071	(0.800)		
Observations	1369247			
R^2	0.840		0.844	

Notes: All standard errors are heteroskedasticity adjusted. Alternative clustering methods were considered, but did not qualitatively affect the results.

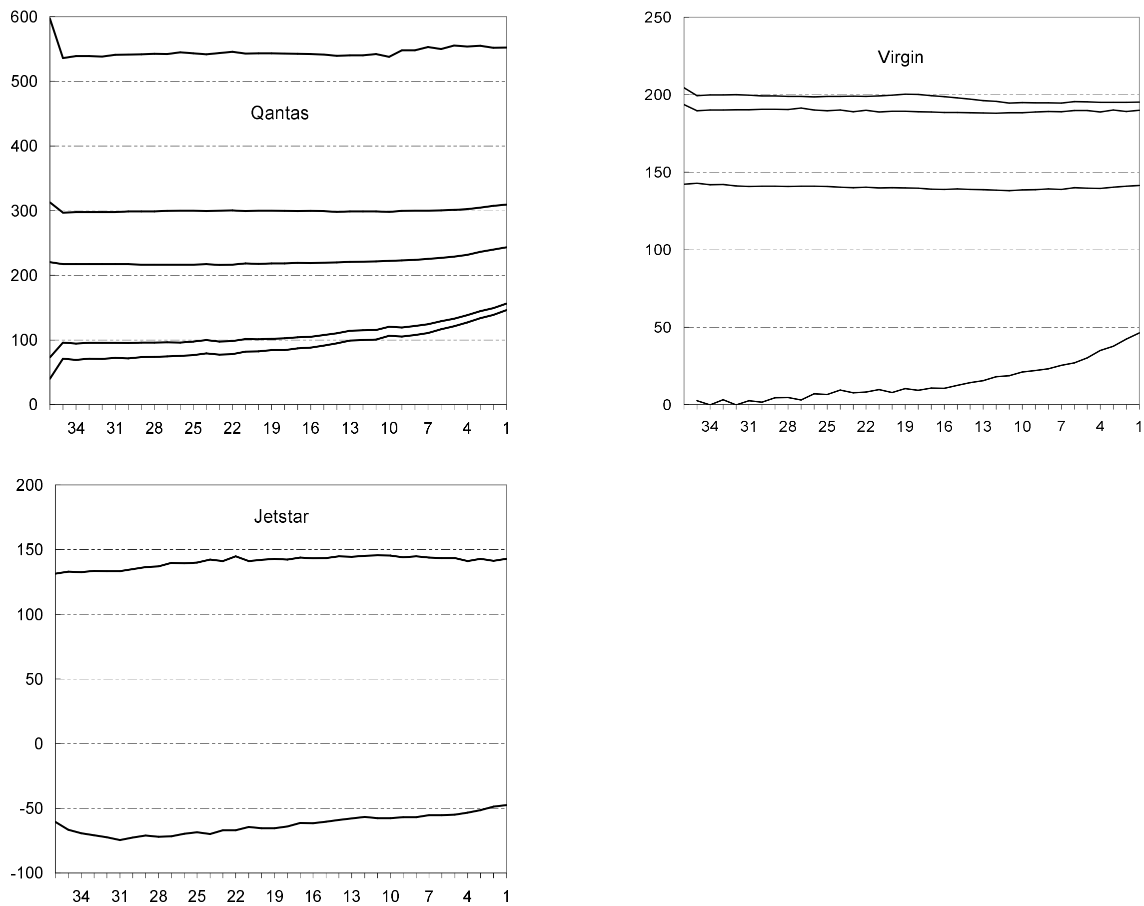
[a] Model 5 contains indicator variables for the route and number of days until travel.

[b] Model 6 contains indicator variables for the route and also for the number of days until travel interacted with the class of fare.

are commonly no longer offered as the travel date becomes close. This selection effect also contributes to higher average fares on higher fare classes.

The behaviour of fares of different classes as we approach the travel date is captured in figure 4. Each panel of the figure depicts the coefficients on the interaction terms between the number of days until travel and fare class for a particular airline. Confidence intervals are extremely tight and are omitted. Only the cheapest fare classes rise in price as we approach the travel date.[3] This suggests that there is little intertemporal price discrimination for premium fare classes. Price discrimination on other fare classes is achieved by a combination of fare changes within the fare class, and restrictions placed on the availability of fare classes.

Figure 4: Fare classes and booking day



4.2 The effect of route characteristics

Our fixed effects model allowed us to examine the relationship between airfares and the time between booking and travel, after controlling for route characteristics. To examine the effect of specific route and flight characteristics on airfares, we now turn to table 4 which contains estimates of (2) based on our lowest available fares dataset. We are

[3]The apparent drop in Business class and Fully Flexible Qantas fares (the top two lines in the Qantas panel of Figure 4) 35 days before travel reflects a selection effect. Only a subset of our data contains these fare classes more than 5 weeks before travel. There is no apparent drop in fares over time in these fare classes.

particularly interested in the relationship between competitive conditions and average fares. Again, we stress that, owing to the joint determination of market structure and fares, our estimates will understate the effect of competition on fares.

Models 7-10 differ only in their treatment of our competition variables. In all models, on average, relative to a Virgin flight, there is again a premium for travel on Qantas flights, and a discount for Jetstar travel. As we might expect, longer routes are associated with higher fares. However, rising fuel prices have had no obvious positive impact on fares, with a negative relationship evident between fares and fuel prices for short routes. Fares are lower linking origins and destinations with higher populations. Presumably this reflects a saving of station costs as more flights are offered for centres with greater population density. There is also a mild premium for travel on routes we have designated as either predominantly business or predominantly leisure.

Model 7 includes indicator variables for the identities of the airlines operating on the route on the day of the flight. The numeraire is a single operator on the day of travel. As we might expect, greater competition on the day of travel is associated with lower average fares, with the lowest fares observed for routes on which all airlines operated on the day. Model 8 instead includes indicator variables for the airlines operating within 90 minutes of the flight. This is designed to capture the effect of more immediate temporal competition. The results are similar, with lower fares associated with a greater number of operators. Model 9 includes both sets of competition variables. The results suggest that, once we have controlled for the airlines operating on a given day, the affect of direct temporal competition is significantly muted.

Model 10 includes interaction terms between the identities of the airlines operating on the day, and the airline operating the current flight. For Qantas flights, the effect of competition is apparently the greatest. Substantially lower fares are evident in the presence of competition. For Jetstar flights, there is still a marked negative association between competition and fares. However, for Virgin flights, the effect is substantially muted. In fact, competition with Qantas appears to be associated with higher fares. This result highlights the joint determination of fares and market structure. The routes for which Virgin is the sole operator on a given day are likely to be the least attractive routes for an airline. Consequently, we tend to see lower fares on these routes, even in the absence of competition.

4.3 Discussion

Most of the results we observe in tables 2 - 4 are consistent with a priori expectations. For example, premiums are observed on high demand periods including school holidays and peak times, such as Friday evenings. Intuitively, demand is likely to be more inelastic during these periods.

Our most interesting results relate to price discrimination. The results paint a dramatic and complex picture of price discrimination in the Australian domestic aviation market. Two primary mechanisms are deployed to impart a substantial degree of price discrimination. First, the extent of price variation between different fare classes appears exaggerated given the relatively minor substantive differences between the conditions applying to different fare classes. Second, we have seen that fares rise rapidly as the time

Table 4: Competition and fares

	Model 7		Model 8		Model 9		Model 10	
	Coeff	Std err	Coeff	Std err	Coeff	Std err	Coeff	Std err
Constant	89.435	(1.685)	69.438	(1.502)	90.572	(1.677)	61.460	(1.602)
Jetstar	-29.641	(0.507)	-27.783	(0.505)	-30.445	(0.525)	-7.898	(0.795)
Qantas	51.895	(0.198)	52.812	(0.210)	51.456	(0.204)	86.406	(0.602)
Distance	0.044	(0.001)	0.046	(0.001)	0.044	(0.001)	0.043	(0.001)
Fuel	-0.212	(0.009)	-0.223	(0.009)	-0.215	(0.009)	-0.217	(0.009)
Fuel * Distance	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
School Hols	8.313	(0.349)	7.436	(0.345)	8.190	(0.348)	8.605	(0.348)
Time	0.023	(0.001)	0.032	(0.001)	0.022	(0.001)	0.020	(0.001)
Business	4.733	(0.495)	6.083	(0.495)	5.161	(0.495)	4.741	(0.496)
Leisure	13.090	(0.768)	10.256	(0.782)	12.330	(0.794)	16.426	(0.813)
Popn at Dest	-0.009	(0.000)	-0.008	(0.000)	-0.009	(0.000)	-0.009	(0.000)
Popn at Origin	-0.010	(0.000)	-0.009	(0.000)	-0.011	(0.000)	-0.011	(0.000)
Popn Dest*Origin	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Potential competition[a] on this route between								
Jetstar & Virgin	-23.808	(0.767)			-23.488	(0.786)		
Qantas & Virgin	-19.690	(0.356)			-17.140	(0.432)		
All airlines	-31.681	(0.510)			-27.848	(0.642)		
Temporal competition[b] for this flight between								
Jetstar & Virgin			-16.717	(0.578)	1.350	(0.733)		
Qantas & Virgin			-13.552	(0.296)	-4.530	(0.361)		
All airlines			-27.083	(0.724)	-10.543	(0.811)		
Jetstar & Qantas			-22.539	(3.334)	-5.520	(3.365)		
Qantas flights involving potential competition[a] with								
Virgin & Jetstar							-36.105	(0.836)
Virgin							-26.303	(0.439)
Virgin flights involving potential competition[a] with								
Qantas & Jetstar							-5.009	(0.616)
Qantas							12.362	(0.466)
Jetstar							-1.072	(0.938)
Jetstar flights involving potential competition[a] with								
Virgin & Qantas							-17.359	(0.823)
Virgin							-10.242	(1.088)
Observations	356181							
R^2	0.504		0.499		0.504		0.507	

Notes: We restrict attention to lowest available fares. Indicator variables for day and time of flight and number of days until travel are included in all specifications, but omitted here. All standard errors are heteroskedasticity adjusted. Alternative clustering methods were considered, but did not qualitatively affect the results.

[a] Potential competition on a route is defined as the set of airlines who operate on that route on the day of travel.

[b] Temporal competition on a route is defined as the set of airlines who operate on that route within 90 minutes of travel.

between booking and travel closes. This latter feature has also been observed in markets in the United Kingdom and Europe (Pitfield (2005a, 2005b)).

The ambiguous relationship between price discrimination and competition suggests that further work is needed in this area. We found the mildest price discrimination in markets in which the two low cost airlines, Virgin and Jetstar, compete head to head.[4] A greater degree of price discrimination was evident in monopoly routes. However, the most extreme form of price discrimination was found in routes pitting Qantas and Virgin. An explanation might be sought in the different cost structures of the airlines, or in the different industry and firm-specific demand elasticities evident on the different routes.

A further question that we have not addressed is the nature of the strategic interaction between the airlines. Interesting dynamics are indeed evident on individual routes in our dataset, but these dynamics are masked by the aggregative nature of our analysis. This question is particularly interesting given the formative nature of competition in the market, and the ownership structure of the market, with two of the main airlines owned by a single firm.

5 Concluding remarks

In this paper, we exploit a unique self-collected database of airfares to characterise the nature of price discrimination in the Australian domestic aviation market. The detailed nature of our dataset allows us to adopt a fixed effects estimator to uncover the primary mechanisms used for price discrimination.

We find dramatic variation in airfares offered, both across fare classes for a given booking day, and across booking days. Variation in airfares with booking day is a particularly important source of price discrimination, with fares rising precipitously, particularly in the week before travel. Price discrimination by booking day is evident for economy fares, but not premium fares, and is the most dramatic for Qantas. We find the relationship between competition and price discrimination to be ambiguous. The greatest variation in prices is observed on flights involving competition between the two main airlines, Qantas and Virgin. However, compared with monopoly routes, less variation is evident on flights with competition between Virgin and Qantas' subsidiary, Jetstar.

References

[1] Borenstein, S. and Rose, N. L., 1994, Competition and price dispersion in the US airline industry, Journal of Political Economy 102, 653-683.

[2] Gallego, G. and van Ryzin, G., 1994, Optimal dynamil pricing of inventories with stochastic demand over finite horizons, Management Science 40, 999,1020.

[3] Pels, E. and Rietveld, P., 2004, Airline pricing behaviour in the London-Paris market, Journal of Air Transport Management 10, 279-283.

[4] Pitfield, D. E., 2005a, Some speculations and empirical evidence on the oligopolistic behaviour of competing low-cost airlines, Journal of Transport Economics and Policy 39, 379-390.

[4] While Jetstar is a subsidiary of Qantas, Jetstar is marketed as a no-frills low cost alternative, and efforts are made by Qantas to separate important aspects of its operations.

[5] Pitfield, D. E., 2005b, A time series analysis of the pricing behaviour of directly competitive 'low-cost' airlines, International Journal of Transport Economics 32(1), 15-39.

[6] Stavins, J., 2001, Price discrimination in the airline market: the effect of market concentration, Review of Economics and Statistics 83, 200-202.

[7] Talluri, K. and van Ryzin, G., 2004, Theory and practice of revenue management (New York, NY, Springer).