On-line Booking and Revenue Management: Evidence from a Low-Cost Airline

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Introduction

- In three influential papers, Dana analysed how revenue management can be effectively used when capacity is costly and firms set prices BEFORE demand is known.
- In all these papers, price dispersion arises as a consequence of the assumptions of the model, and it does not imply a carrier’s intention to price discriminate.
- A crucial assumption is that the airlines have to commit to a pricing schedule and will not update it; i.e., the solutions are not sub-game perfect.

Price Dispersion & Demand uncertainty – Dana (1999, Rand)

- Costly capacity and prices set before the actual realisation of demand is known;
- in practice, the firm has to decide the level of prices and the associated number of seats it will sell for each possible realization of demand.
- For the case of two-states demand (low and high), the firm will set two prices and the corresponding number of tickets available at each price.
- The analysis consider the case in which the firm operates in different market structures.

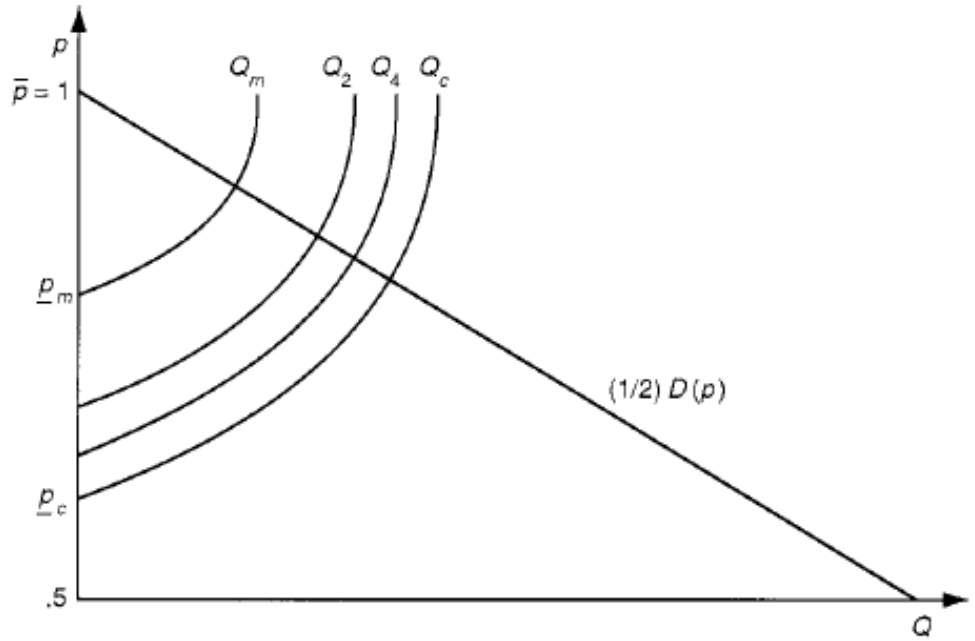
Dana (1999, Rand)

- Dana shows that regardless of the market structure, the firm should determine different ``batches'' of seats, and that fares should increase as fewer batches remain unsold.
- That is, the profile of fare should be an increasing function of the number of sold seats.
- The domain over which this function is distributed should increase with the degree of competition on a route or market
- There is no room for intertemporal price discrimination in Dana’s work.

Eq. Supply Price Distributions

FIGURE 5

CUMULATIVE PRICE DISTRIBUTIONS AND MARKET DEMAND



Price support increases with competition.

Further from Dana (1999)

- Another important feature of the model is the commitment of the firm to the schedule of prices it set before demand is known.
- Such a price rigidity may arise because the firm must incur a very high cost in tracking the evolution of demand for all the flights it operates and adjust fares to reflect demand conditions.
- This appears to run contrary to the current standard practice in the industry.

Literature

- There are no studies that try to link the paid fare for a seat on a flight with the number of available seats on that flight.
- Escobari and Li Gan (2006, NBER) and Puller, Sengupta and Wiggins (2009, NBER) try to obtain this information by merging two different dataset; their analysis is complicated by the complexity of Full Service Carriers' Yield Management, that considers a number of ticket classes that are open all at the same time.
- This work benefits from dealing with the simpler system of a Low Cost Carrier, and allows a more direct test of the implications of Dana's model.

Literature

- Implicitly, this paper studies the effect of (stochastic) peak load pricing on Fare Dispersion;
- Previous literature has mainly looked into the relationship between Price Discrimination and Price Dispersion (Gerardi and Shapiro, JPE 2009; Borenstein and Rose, 1994; Gaggero and Piga, 2010)

A quote from EU CC investigation of the FR and AL takeover

- *The first software type which both companies use is a system that tracks the booking status of each flight, provides forecasts for the further development and makes proposals for the pricing pattern.*
- *This software allows the responsible “yield manager” or “analyst” to verify the booking status for any given Ryanair or Aer Lingus flight.*
- *With the help of the program, the analyst can compare the actual booking status (or “load factor”) of a flight with the booking forecast which is provided by the system.*
- *This booking forecast is based on previous experience with the same route at the relevant dates or on similar routes. The forecasts are adjusted according to forecasted growth and other relevant changes of the factors affecting supply and demand on the route.*

Study objectives

- Derive a pricing curve for Ryanair, a European Low Cost Carrier;
- Test the hypothesis of the relationship between price dispersion and market structure.
- Assess whether and how the adjustment to a “pricing” template are made, i.e., assess whether the commitment story by Dana has important implications

LCA Business Model Characteristics

LCA Business Model Characteristics

1. Simple pricing structures – **one passenger class**; fares only cover basic transport
2. Each leg priced independently;
3. Direct selling - internet bookings, electronic tickets, no seat reservations
4. Point-to-point networks using cheaper, less congested airports
5. Intensive aircraft usage (25-min turnaround times)
6. Multiple role employees (flight attendants-cleaners-gate agents)
7. Highly standardised fleets (Ryanair operates only Boeing 737 with 189 seats each)

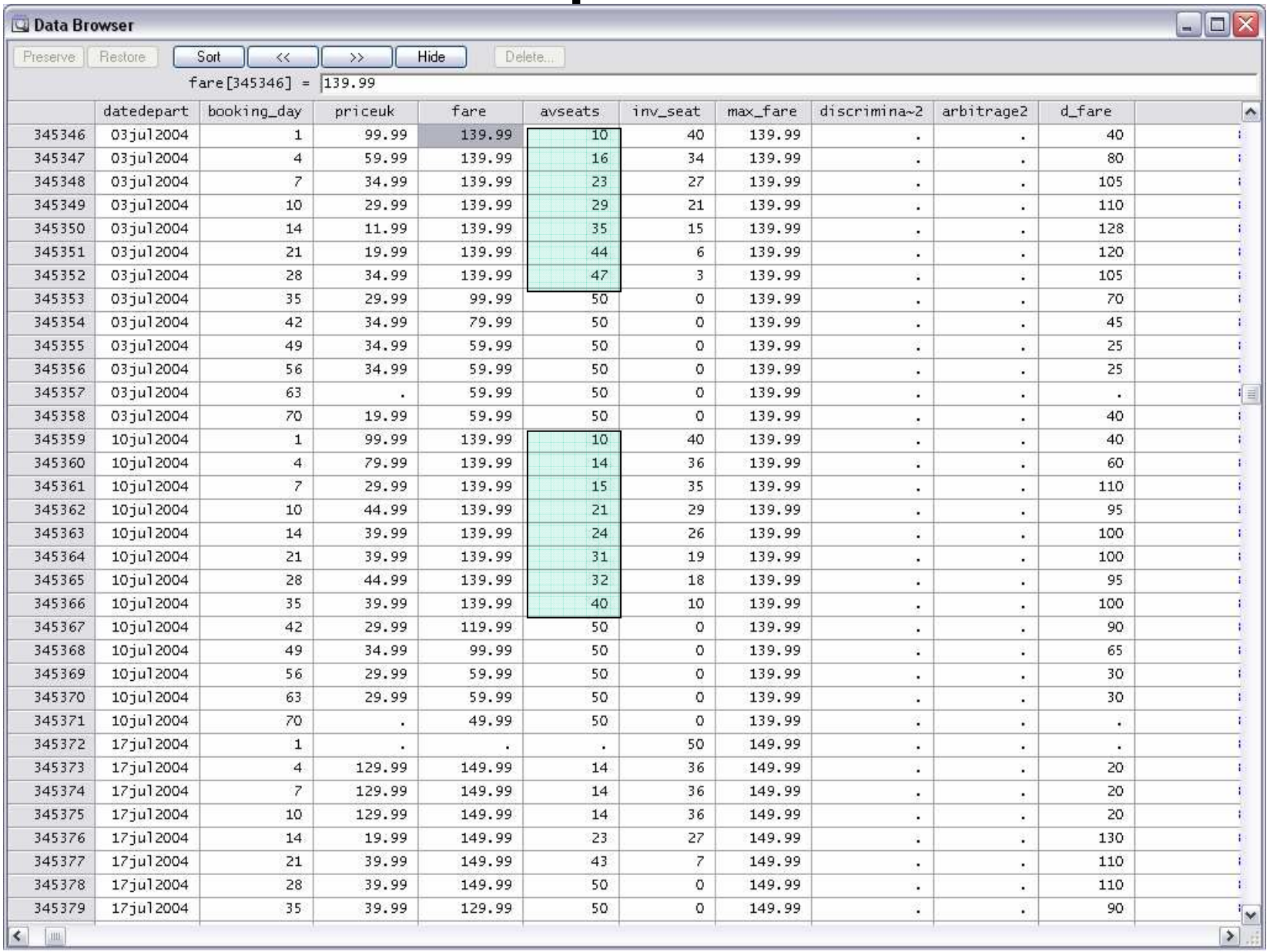
Data Collection #1

- Primary data on posted fares and secondary data on routes' traffic
- posted fares collected using an "electronic spider" from main LCAs (inc, Ryanair, Buzz, Easyjet, GoFly)
- Only for Ryanair, data on seats availability could be obtained for up to 50 seats
- This was possible due to the features of the carrier's on-line reservation system
- Period for this study: 2004-June 2005

Data Collection #2

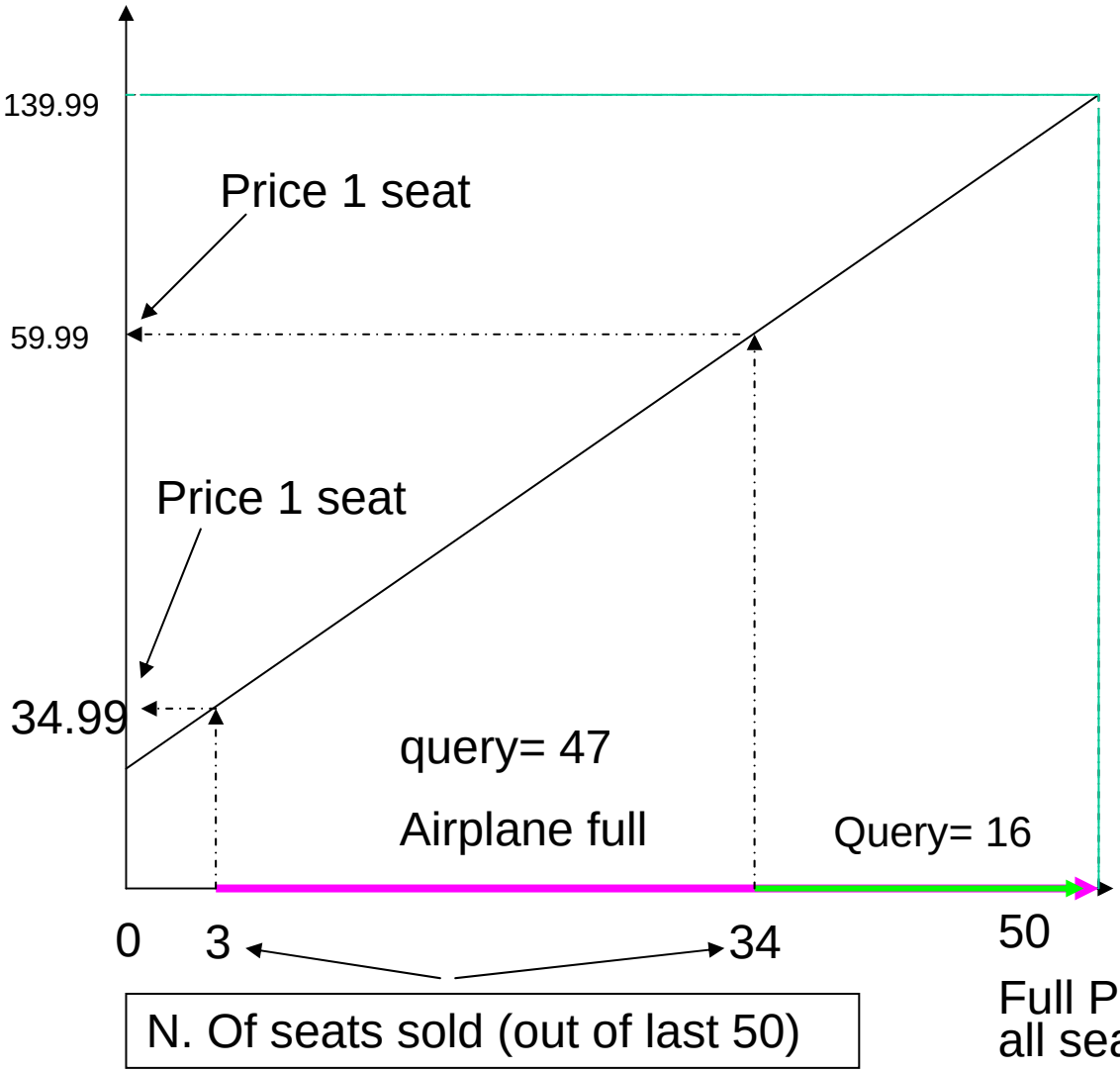
- Fares cover routes from/to UK, inc. domestic and main European destinations
- LCA fares collected for "booking days before departure" at intervals of 1, 4, 7, 10, 14, 21, 28, 35, 42, 49, 56, 63 and 70 days
- Data on routes' traffic (inc load factors) obtained from the CAA

An example of data



	datedepart	booking_day	priceuk	fare	avseats	inv_seat	max_fare	discrimina~2	arbitrage2	d_fare
345346	03jul2004	1	99.99	139.99	10	40	139.99	.	.	40
345347	03jul2004	4	59.99	139.99	16	34	139.99	.	.	80
345348	03jul2004	7	34.99	139.99	23	27	139.99	.	.	105
345349	03jul2004	10	29.99	139.99	29	21	139.99	.	.	110
345350	03jul2004	14	11.99	139.99	35	15	139.99	.	.	128
345351	03jul2004	21	19.99	139.99	44	6	139.99	.	.	120
345352	03jul2004	28	34.99	139.99	47	3	139.99	.	.	105
345353	03jul2004	35	29.99	99.99	50	0	139.99	.	.	70
345354	03jul2004	42	34.99	79.99	50	0	139.99	.	.	45
345355	03jul2004	49	34.99	59.99	50	0	139.99	.	.	25
345356	03jul2004	56	34.99	59.99	50	0	139.99	.	.	25
345357	03jul2004	63	.	59.99	50	0	139.99	.	.	.
345358	03jul2004	70	19.99	59.99	50	0	139.99	.	.	40
345359	10jul2004	1	99.99	139.99	10	40	139.99	.	.	40
345360	10jul2004	4	79.99	139.99	14	36	139.99	.	.	60
345361	10jul2004	7	29.99	139.99	15	35	139.99	.	.	110
345362	10jul2004	10	44.99	139.99	21	29	139.99	.	.	95
345363	10jul2004	14	39.99	139.99	24	26	139.99	.	.	100
345364	10jul2004	21	39.99	139.99	31	19	139.99	.	.	100
345365	10jul2004	28	44.99	139.99	32	18	139.99	.	.	95
345366	10jul2004	35	39.99	139.99	40	10	139.99	.	.	100
345367	10jul2004	42	29.99	119.99	50	0	139.99	.	.	90
345368	10jul2004	49	34.99	99.99	50	0	139.99	.	.	65
345369	10jul2004	56	29.99	59.99	50	0	139.99	.	.	30
345370	10jul2004	63	29.99	59.99	50	0	139.99	.	.	30
345371	10jul2004	70	.	49.99	50	0	139.99	.	.	.
345372	17jul2004	1	.	.	.	50	149.99	.	.	.
345373	17jul2004	4	129.99	149.99	14	36	149.99	.	.	20
345374	17jul2004	7	129.99	149.99	14	36	149.99	.	.	20
345375	17jul2004	10	129.99	149.99	14	36	149.99	.	.	20
345376	17jul2004	14	19.99	149.99	23	27	149.99	.	.	130
345377	17jul2004	21	39.99	149.99	43	7	149.99	.	.	110
345378	17jul2004	28	39.99	149.99	50	0	149.99	.	.	110
345379	17jul2004	35	39.99	129.99	50	0	149.99	.	.	90

Fixed Upper Boundary

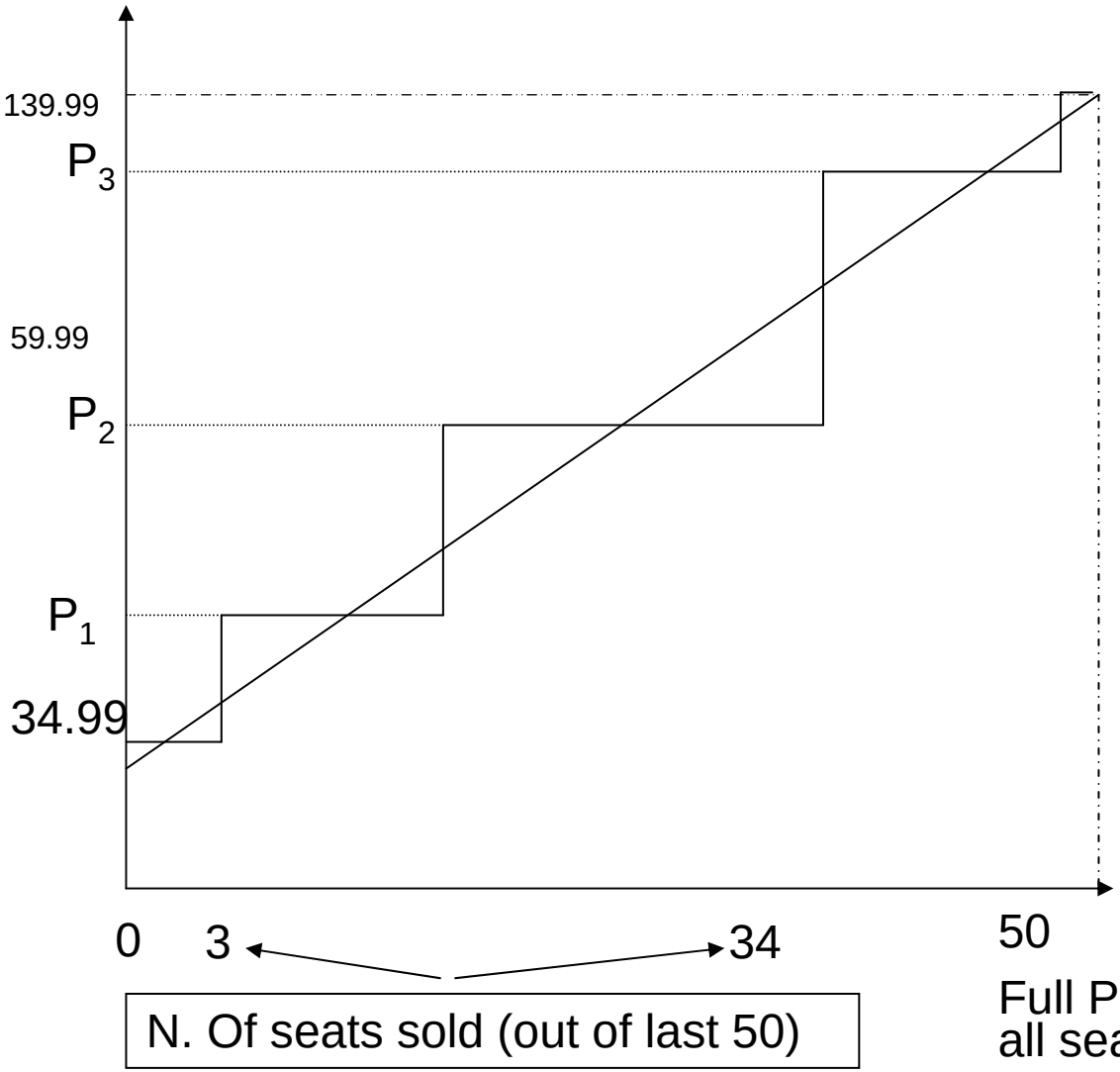


The revenue management software defines a maximum threshold which corresponds to the price of the last seat.

This can be obtained by any query that closes the flight.

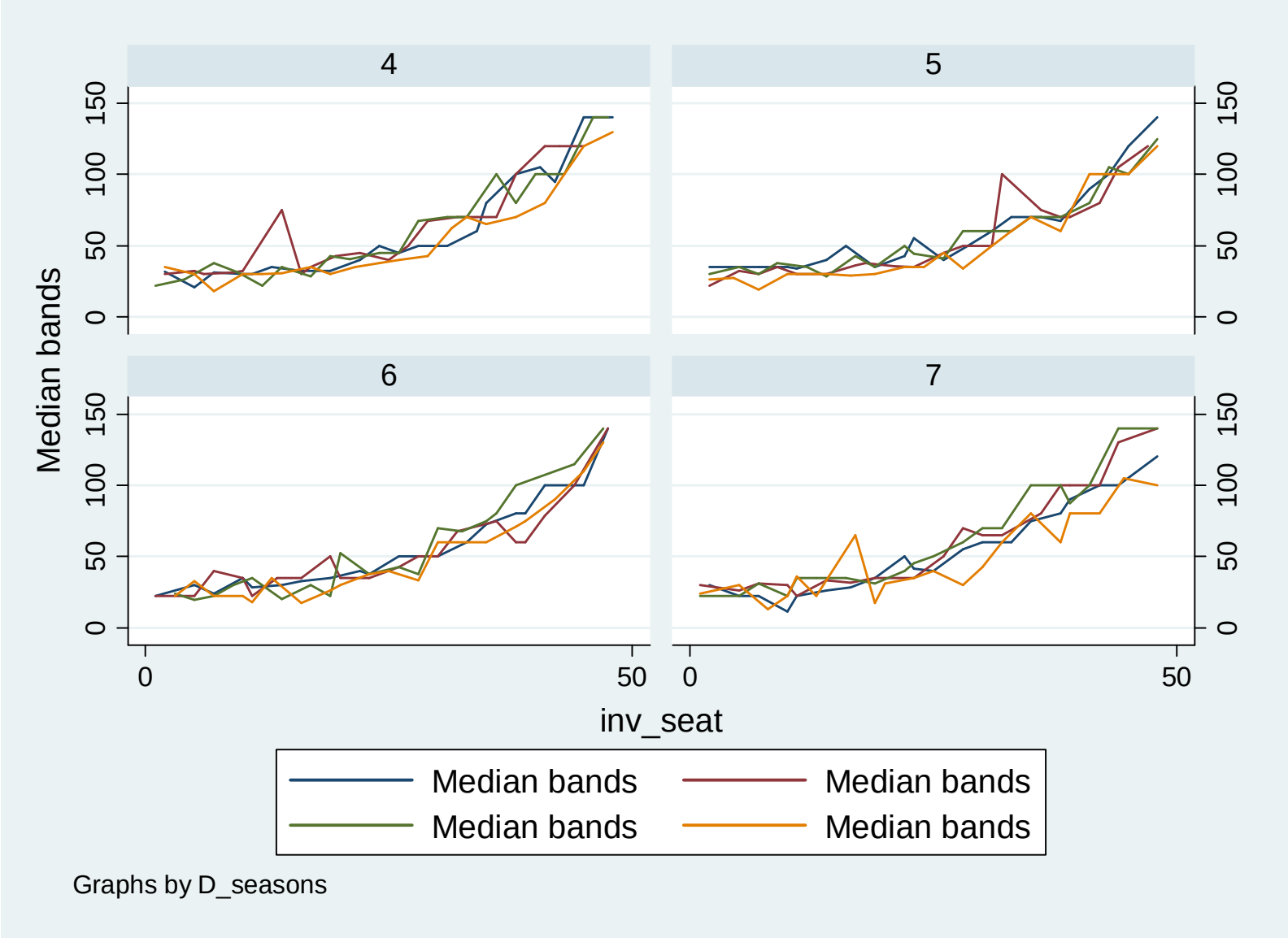
The threshold is independent of the current occupancy rate.

Fixed Upper Boundary

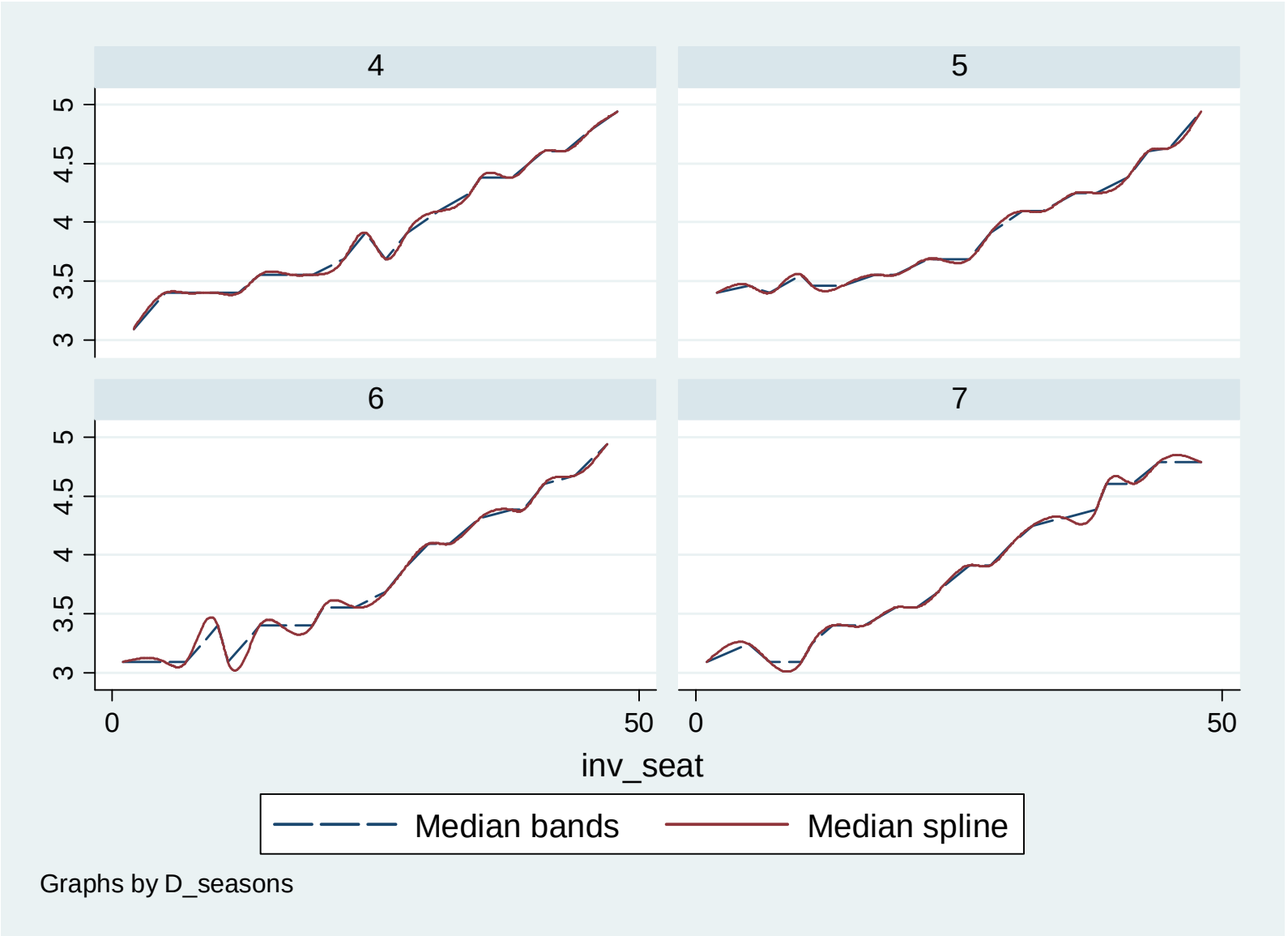


In reality, each pricing profile is a step function, although aggregation over time may produce a smoother profile.

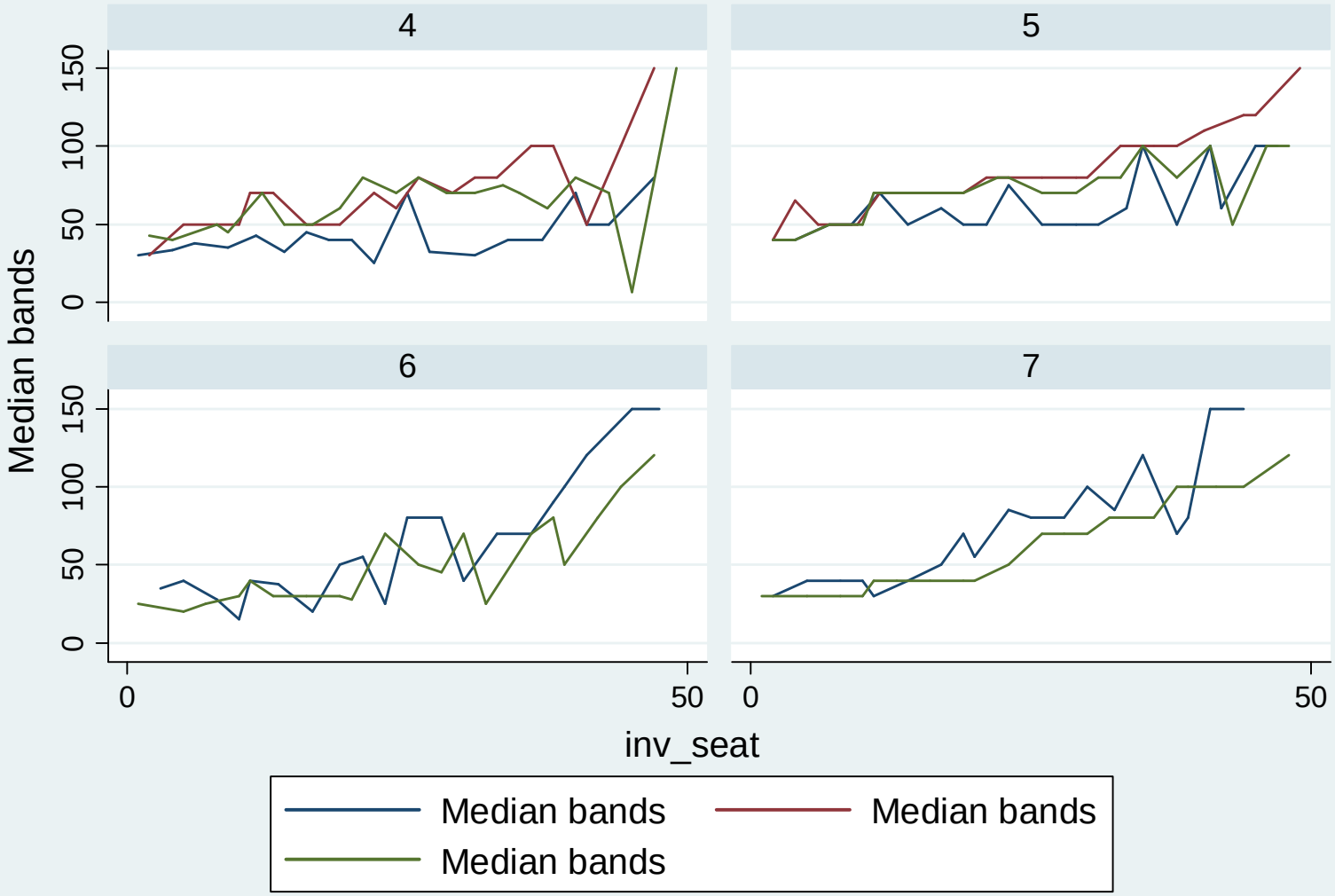
Gatwick - Dublin



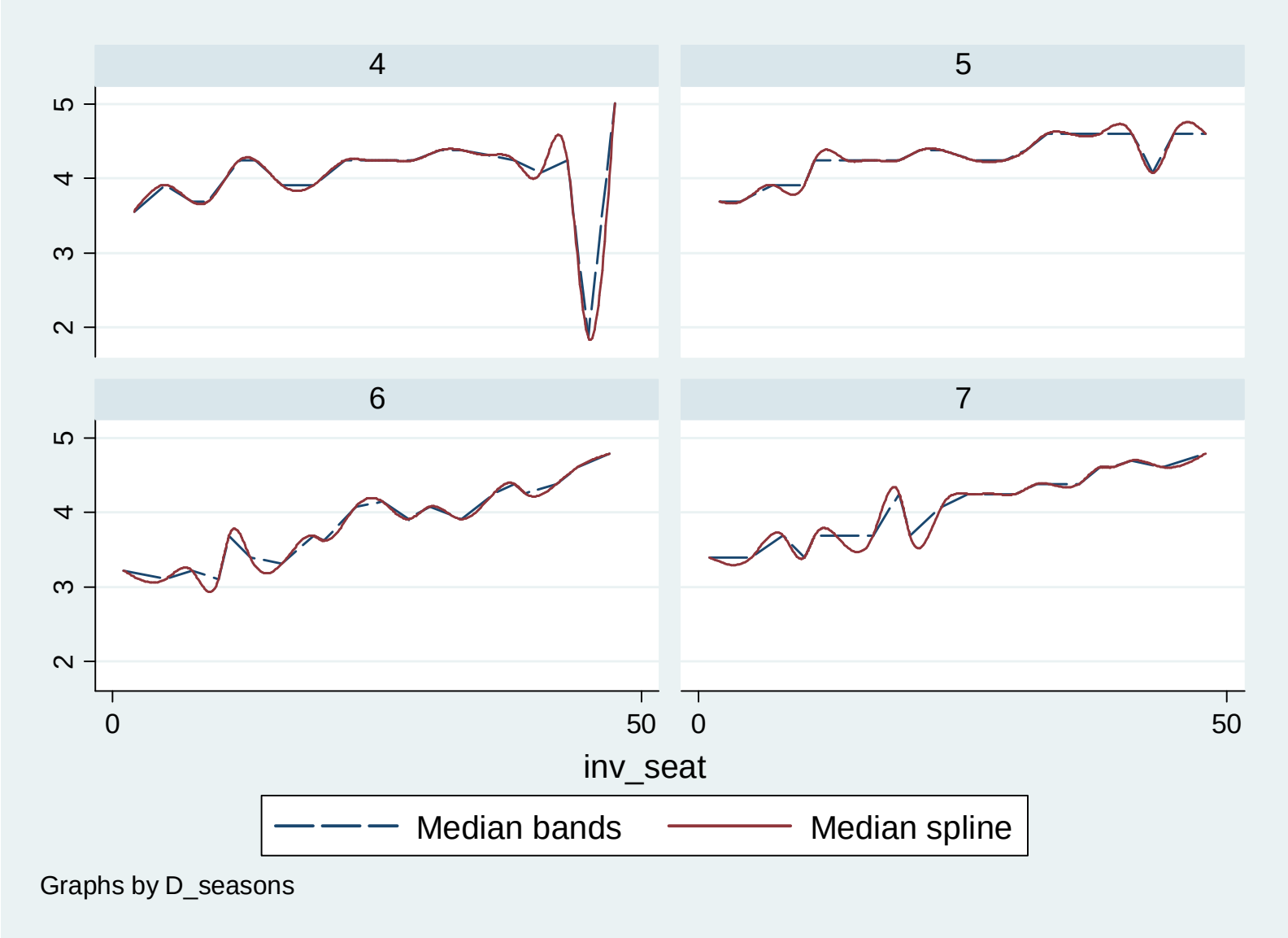
Gatwick – Dublin - Lnprice



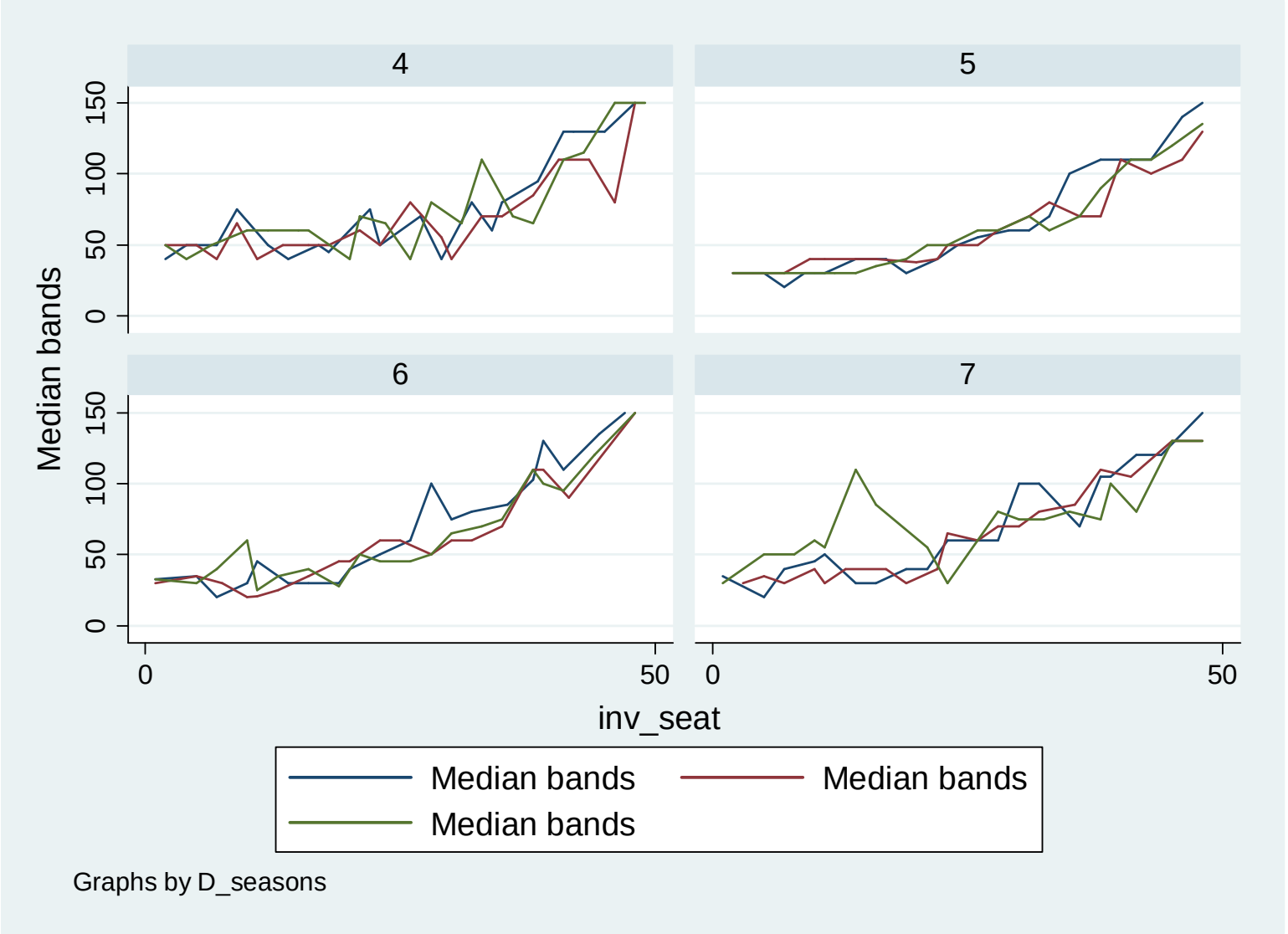
London Stansted-Berlin



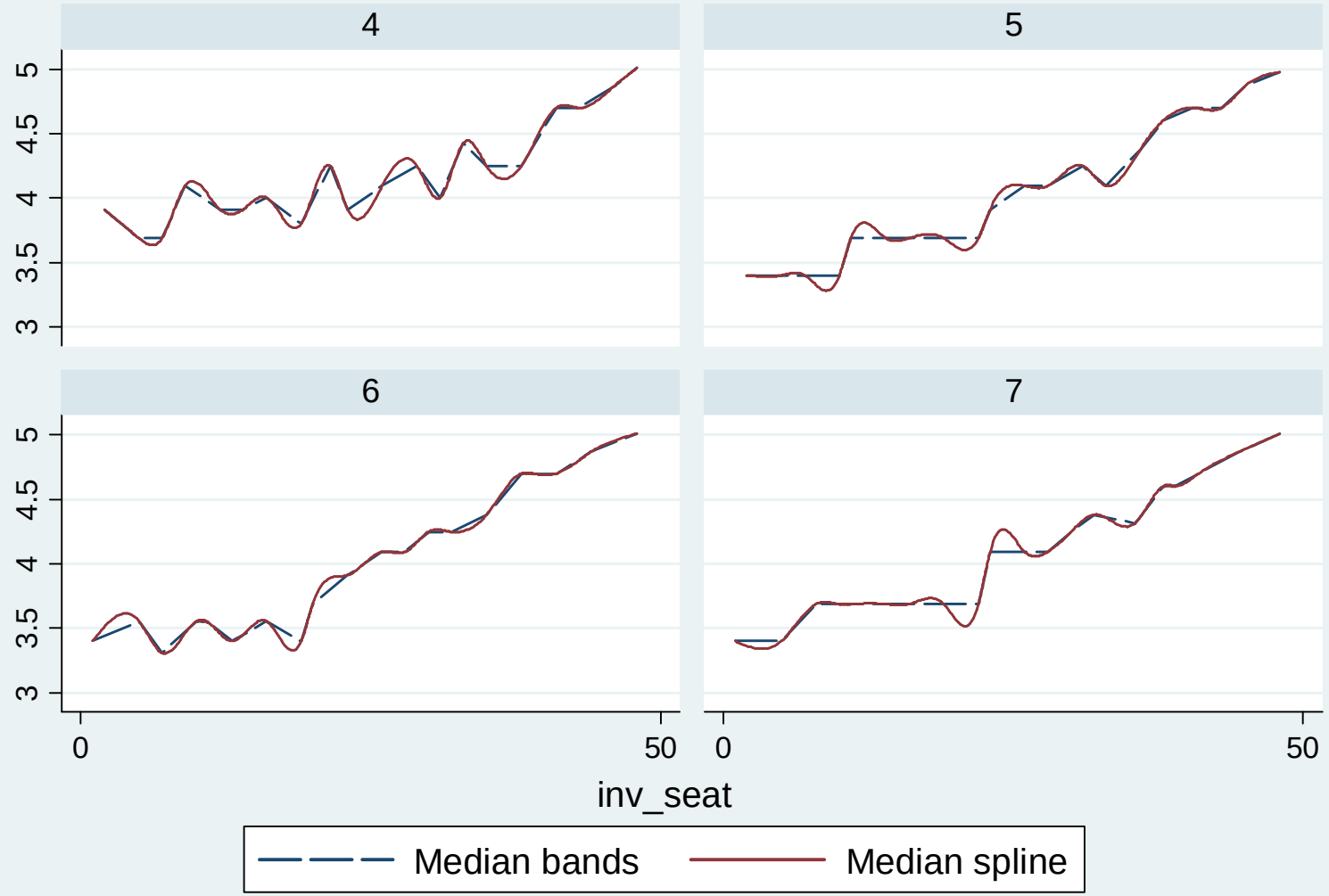
London Stansted-Berlin - lnprice



Bristol - Dublin



Bristol- Dublin - Lnprice



Monotonic Prices? Not always!

Table 1: Percentage of price decreases relative to previous booking day, by booking day and remaining capacity.

Days from Take-off	Available seats				
	1-9	10-19	20-29	30-39	40-49
1	0.04	0.02	0.02	0.01	0.01
4	0.05	0.06	0.05	0.05	0.05
7	0.07	0.10	0.10	0.11	0.11
10	0.09	0.11	0.12	0.12	0.14
14	0.14	0.16	0.18	0.22	0.24
21	0.08	0.13	0.13	0.19	0.21
28	0.09	0.10	0.14	0.18	0.19
35	0.06	0.05	0.12	0.16	0.13
42	0.10	0.13	0.11	0.15	0.15
49	0.04	0.06	0.07	0.13	0.12
56	0.00	0.15	0.07	0.09	0.16
63	0.05	0.06	0.11	0.13	0.21

Note: percentages were calculated only if two consecutive available seats were below the censored value of 50.

Monotonic Prices

Table 2: Percentage of price decreases relative to previous booking day, by booking day and season.

Days from Take-off	Aug03-Oct03	Nov03-Mar04	Apr04-Oct04	Nov04-Mar05	Apr05-Jun05
1	0.04	0.03	0.02	0.02	0.03
4	0.06	0.09	0.04	0.02	0.03
7	0.17	0.12	0.07	0.10	0.07
10	0.16	0.18	0.08	0.10	0.07
14	0.30	0.29	0.20	0.25	0.23
21	0.31	0.30	0.20	0.28	0.27
28	0.35	0.33	0.21	0.30	0.29
35	0.34	0.34	0.20	0.32	0.26
42	0.31	0.33	0.19	0.31	0.21
49	0.28	0.35	0.18	0.31	0.21
56	0.30	0.37	0.18	0.30	0.19
63	0.32	0.36	0.17	0.25	0.18

Note: percentages were calculated without controlling for available seats.

Estimation

- Available seats are measured from 49 to 1
- So av_seat is censored.
- The variable used in the estimation is
- Inv_seat=50 – av_seat (this gives a positive slope).
- Estimates are obtained assuming that inv_seat (or av_seat) is exogenous
- But consider the following:

Panel Fixed Effect

We want to estimate

$$p_{it} = \beta_1 Q_{it} + \beta_2 X_{it} + \delta_i + \varepsilon_{it}$$

i is a flight, *t* identifies booking days. We cannot rule out that Q_{it} and p_{it}, *are both* correlated with $\varepsilon_{it;}$ and that they are jointly determined*; hence we treat* Q_{it} as endogenous.

Following Wooldridge, the instrument used is the *expected value* of av_seat, obtained from a Tobit model that includes as regressors many factors which could be interpreted as demand shifters. These are:
i.booking_day d_base_both d_promo i.day_week shr_fli_city_subp ln_dist d_deptime ///
n_route_comp_in_city n_flights_tot_route n_flights_tot_city n_flights_comp_city n_flights_comp_route

Any correlation with δ_i is taken care of by the fixed effect estimator.

Basic Model – FE
Dependent: Ln(Price)

	xtreg1	xtiv1	xtreg2	xtiv2	xtreg3	xtiv3
inv_seat	0.044a	0.043a	0.036a	0.042a	0.030a	0.040a
book_day1			0.232a	0	0.360a	0
book_day4			-0.026	-0.230a	0.085	-0.233a
book_day7			-0.228a	-0.399a	-0.118b	-0.384a
book_day10			-0.222a	-0.362a	-0.130b	-0.349a
book_day14			-0.369a	-0.474a	-0.214a	-0.380a
book_day21			-0.277a	-0.337a	-0.167a	-0.261a
book_day28			-0.180a	-0.207a	-0.120b	-0.164a
book_day35			-0.104b	-0.110a	-0.076	-0.085a
book_day42			-0.064	-0.061	-0.029	-0.025
book_day49			-0.025	-0.017	0.01	0.022
book_day56			0.031	0.045	0.035	0.056c
book_day63			-0.017	-0.019	-0.007	-0.01
d_promo1					-4.625a	-4.563a
Constant	2.850a	2.871a	3.172a	3.164a	3.240a	3.228a
R-2w	0.42	0.42	0.47	0.46	0.72	0.71
r2_o	0.220705	0.220705	0.278009	0.272155	0.563943	0.545522

Does Ryanair update? Maybe yes

	xtreg4	xtiv4	xtreg5	xtiv5	xtreg6	xtiv6	
inv_seat	0.030a	0.041a	0.029a	0.038a	0.028a	0.037a	
book_day1	0.274a	0	0.261a	0	0.264a	0	
book_day4	-0.003	-0.231a	-0.022	-0.241a	-0.021	-0.248a	
book_day7	-0.208a	-0.379a	-0.232a	-0.402a	-0.235a	-0.416a	
book_day10	-0.221a	-0.341a	-0.251a	-0.376a	-0.259a	-0.398a	
book_day14	-0.317a	-0.397a	-0.342a	-0.431a	-0.337a	-0.440a	
book_day21	-0.277a	-0.316a	-0.278a	-0.330a	-0.257a	-0.319a	
book_day28	-0.187a	-0.194a	-0.189a	-0.209a	-0.175a	-0.203a	
book_day35	-0.073	-0.088a	-0.079c	-0.090a	-0.084c	-0.093a	
book_day42	-0.021	-0.021	-0.026	-0.024	-0.03	-0.027	
book_day49	0.018	0.024	0.016	0.023	0.013	0.022	
book_day56	0.042	0.061c	0.043	0.059c	0.039	0.056c	
book_day63	-0.005	-0.009	-0.005	-0.01	-0.006	-0.009	
d_promo1	-4.630a	-4.578a	-4.628a	-4.578a	-4.634a	-4.582a	
uncert21_30	0.171a	0.185a					
uncert14_30	0.034c	0.005					
uncert10_30	-0.044b	-0.146a					
uncert21_25			0.132a	0.152a			
uncert14_25			0.088a	0.070a			
uncert10_25			0.014	-0.072a			
uncert21_20					0.082a	0.107a	
uncert14_20					0.076a	0.065a	
uncert10_20					0.117a	0.049a	
Constant		3.314a	3.252a	3.336a	3.289a	3.342a	3.308a
R-2w	0.72	0.71	0.72	0.71	0.72	0.71	
r2_o	0.58	0.55	0.58	0.56	0.58	0.56	

Maybe No

	xtreg4	xtiv4	xtreg5	xtiv5	xtreg6	xtiv6
inv_seat	0.044a	0.047a	0.042a	0.044a	0.041a	0.041a
d_promo1	-4.638a	-4.603a	-4.637a	-4.614a	-4.640a	-4.629a
uncert21_30	0.046c	0.057a				
uncert14_30	-0.137a	-0.147a				
uncert10_30	-0.150a	-0.222a				
uncert21_25			0.027	0.033b		
uncert14_25			-0.087a	-0.092a		
uncert10_25			-0.113a	-0.157a		
uncert21_20					0.008	0.011
uncert14_20					-0.092a	-0.094a
uncert10_20					-0.016	-0.034a
Constant	2.989a	2.937a	2.985a	2.950a	2.995a	2.979a
R2w	0.68	0.68	0.68	0.68	0.67	0.67
r2_o	0.50	0.50	0.50	0.50	0.50	0.50

Market Structure? Maybe no

	Monopoly		Duo-Triopoly	
	xtreg3	xtiv3	xtreg4	xtiv4
inv_seat	0.029a	0.040a	0.035a	0.039a
book_day1	0.400a	0	0.175c	0
book_day4	0.122c	-0.230a	-0.094	-0.248a
book_day7	-0.077	-0.373a	-0.303a	-0.431a
book_day10	-0.087	-0.330a	-0.322a	-0.430a
book_day14	-0.164b	-0.347a	-0.430a	-0.513a
book_day21	-0.114c	-0.218a	-0.383a	-0.430a
book_day28	-0.08	-0.128a	-0.285a	-0.309a
book_day35	-0.064	-0.070b	-0.145b	-0.156a
book_day42	-0.026	-0.019	-0.051	-0.052
book_day49	0.017	0.034	-0.031	-0.032
book_day56	0.047	0.077b	-0.039	-0.04
book_day63	0.017	0.017	-0.131b	-0.141c
d_promo1	-4.687a	-4.617a	-4.391a	-4.362a
Constant	3.251a	3.231a	3.235a	3.240a
R-2w	0.71	0.7	0.75	0.75
r2_o	0.55	0.53	0.63	0.62

Market Structure? Maybe yes

	Monopoly		Duo-Triopoly	
	xtreg3	xtiv3	xtreg4	xtiv4
inv_seat	0.038a	0.039a	0.044a	0.042a
d_promo1	-4.707a	-4.700a	-4.435a	-4.463a
Constant	3.057a	3.047a	2.818a	2.854a
R-2w	0.66	0.66	0.71	0.71
r2_o	0.5	0.5	0.56	0.56

FULL SAMPLE

	xtreg1	xtiv1	xtreg2	xtiv2	xtreg3	xtiv3
inv_seat	**0.046a**	**0.084a**	**0.004a**	**0.083a**	**0.012a**	**0.061a**
book_day1			2.158a	0	1.370a	0
book_day4			1.724a	0.245a	1.009a	0.065a
book_day7			1.052a	-0.175a	0.555a	-0.225a
book_day10			0.952a	-0.047a	0.491a	-0.147a
book_day14			0.184a	-0.540a	0.170a	-0.282a
book_day21			0.003	-0.370a	0.101a	-0.129a
book_day28			-0.074b	-0.257a	0.051a	-0.059a
book_day35			-0.070a	-0.159a	0.038b	-0.014c
book_day42			-0.048b	-0.099a	0.042a	0.012c
book_day49			-0.113a	-0.156a	-0.003	-0.026a
book_day56			-0.130a	-0.161a	-0.033a	-0.050a
book_day63			-0.079a	-0.105a	-0.020a	-0.035a
d_promo1					-3.909a	-4.028a
Constant	2.265a	2.012a	2.145a	2.164a	2.695a	2.724a
R-2w	0.14	0.05	0.28	0.07	0.7	0.62
r2_o	0.16	0.16	0.16	0.18	0.72	0.69

Full Sample & Market Structure

	Monopoly		Duo-Triopoly	
	xtiv1	xtiv2	xtiv3	xtiv4
inv_seat	**0.058a**	**0.063a**	**0.053a**	**0.055a**
d_promo1	-4.099a	-4.066a	-3.865a	-3.841a
book_day1		0		0
book_day4		0.070a		0.045a
book_day7		-0.235a		-0.165a
book_day10		-0.150a		-0.121a
book_day14		-0.281a		-0.276a
book_day21		-0.124a		-0.150a
book_day28		-0.053a		-0.087a
book_day35		-0.011		-0.027
book_day42		0.016c		-0.005
book_day49		-0.027a		-0.024
book_day56		-0.043a		-0.079a
book_day63		-0.027a		-0.072a
Constant	2.710a	2.738a	2.597a	2.648a
R-2w	0.62	0.61	0.68	0.67
r2_o	0.69	0.69	0.72	0.71

Using a monopoly dummy

	Censored		Full Sample	
	xtiv1	xtiv2	xtiv3	xtiv4
inv_seat	**0.043a**	**0.042a**	**0.055a**	**0.051a**
inv_seat_mono	**-0.003a**	**-0.004a**	**0.008a**	**0.007a**
book_day1	0		0	
book_day4	-0.233a		0.066a	
book_day7	-0.384a		-0.224a	
book_day10	-0.349a		-0.146a	
book_day14	-0.379a		-0.281a	
book_day21	-0.259a		-0.129a	
book_day28	-0.162a		-0.059a	
book_day35	-0.085a		-0.014c	
book_day42	-0.026		0.012c	
book_day49	0.022		-0.026a	
book_day56	0.056c		-0.049a	
book_day63	-0.011		-0.035a	
d_promo1	-4.562a	-4.648a	-4.029a	-4.061a
Constant	3.229a	3.006a	2.723a	2.691a
R-2w	0.71	0.67	0.62	0.63
r2_o	0.54	0.50	0.69	0.70