Entry: Applications

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1. Ciliberto and Tamer (2009)
2. Ciliberto and Zhang (2017)
3. Ciliberto, Murry, and Tamer (2021)

Section 1

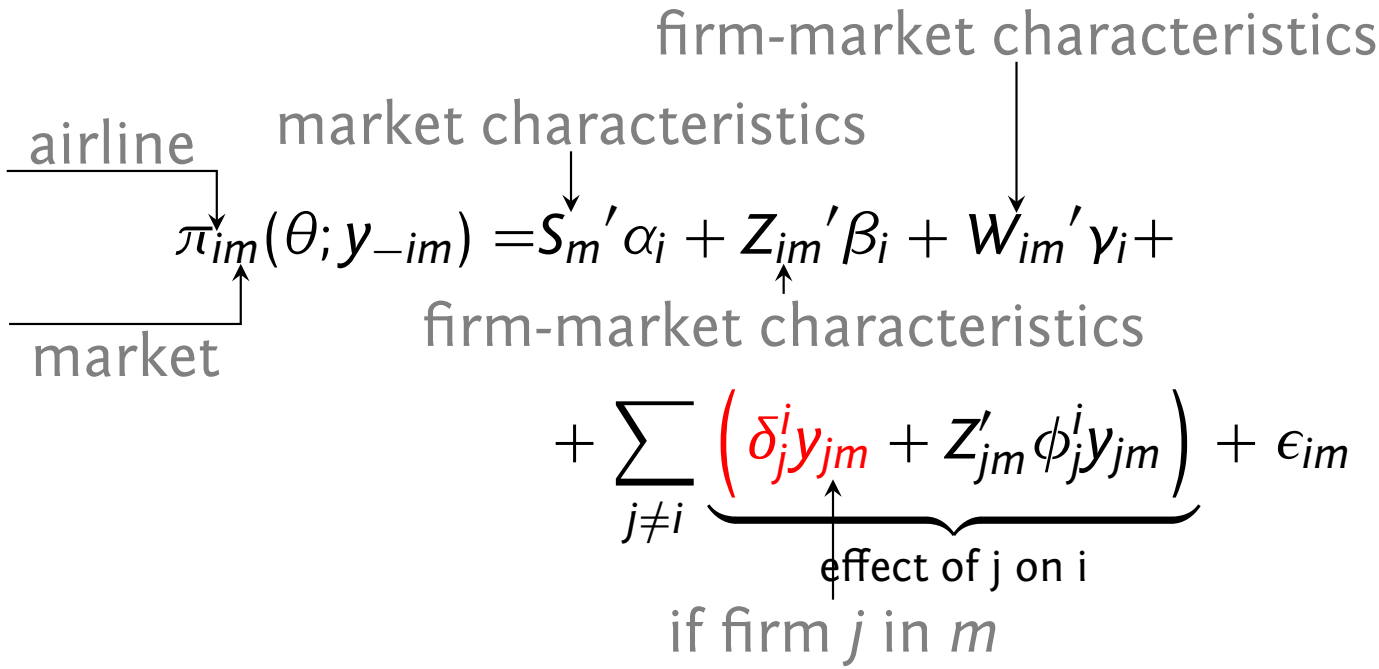
Ciliberto and Tamer (2009)

Ciliberto and Tamer (2009)

"Market structure and multiple equilibria in airline markets"

- **Flexible** entry model of airlines
  - Heterogeneity
  - Equilibrium selection
  - ⇒ Partial identification
- Results:
  - Heterogeneity in profit functions
    - Large legacy carriers vs low-cost carriers
    - Airport presence
  - Effect of repealing Wright amendment

Profits of firm if present in market:



- Coefficients heterogeneous
- Complete information (all firms know all ϵ_{im})

Multiple Equilibria

- Simplified 2 player model:

$$y_{1m} = 1\{\alpha_1' X_{1m} + \delta_2^1 y_{2m} + \epsilon_{1m} \geq 0\}$$
$$y_{2m} = 1\{\alpha_2' X_{2m} + \delta_1^2 y_{1m} + \epsilon_{2m} \geq 0\}$$

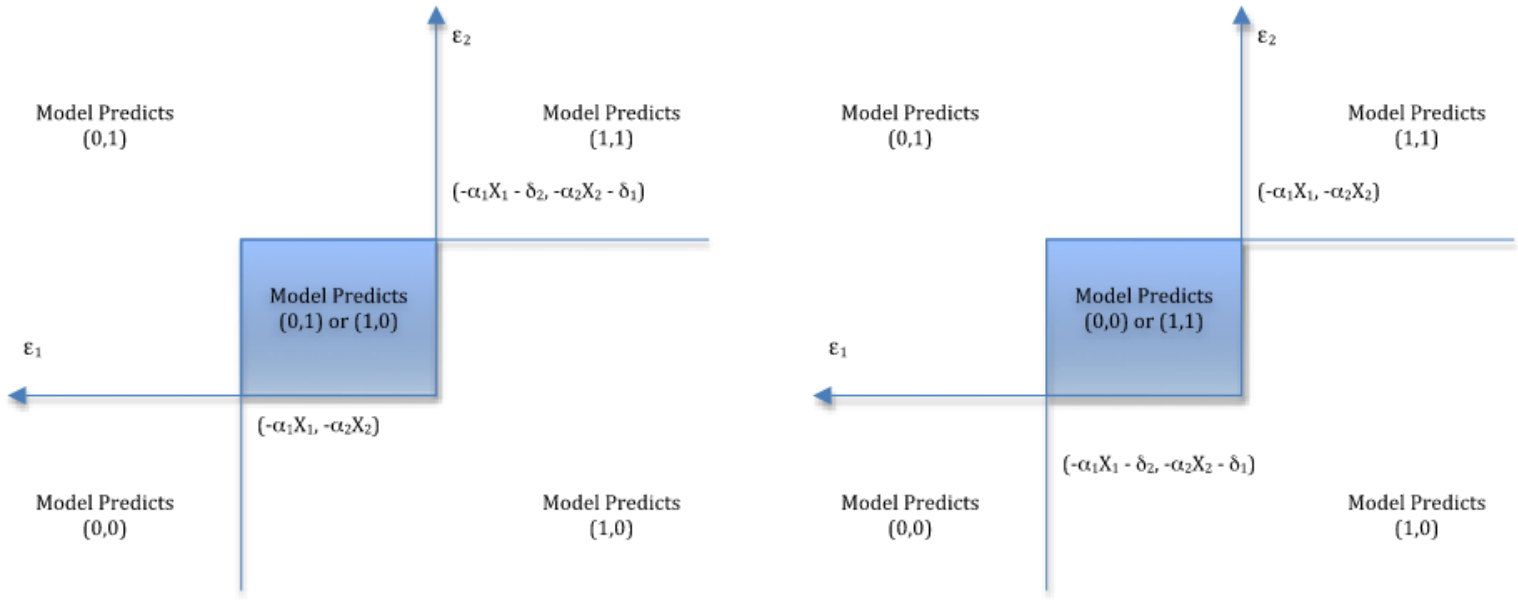


FIGURE 1.—Regions for multiple equilibria: LHP, $\delta_1, \delta_2 < 0$; RHP, $\delta_1, \delta_2 > 0$.

Probability Bounds

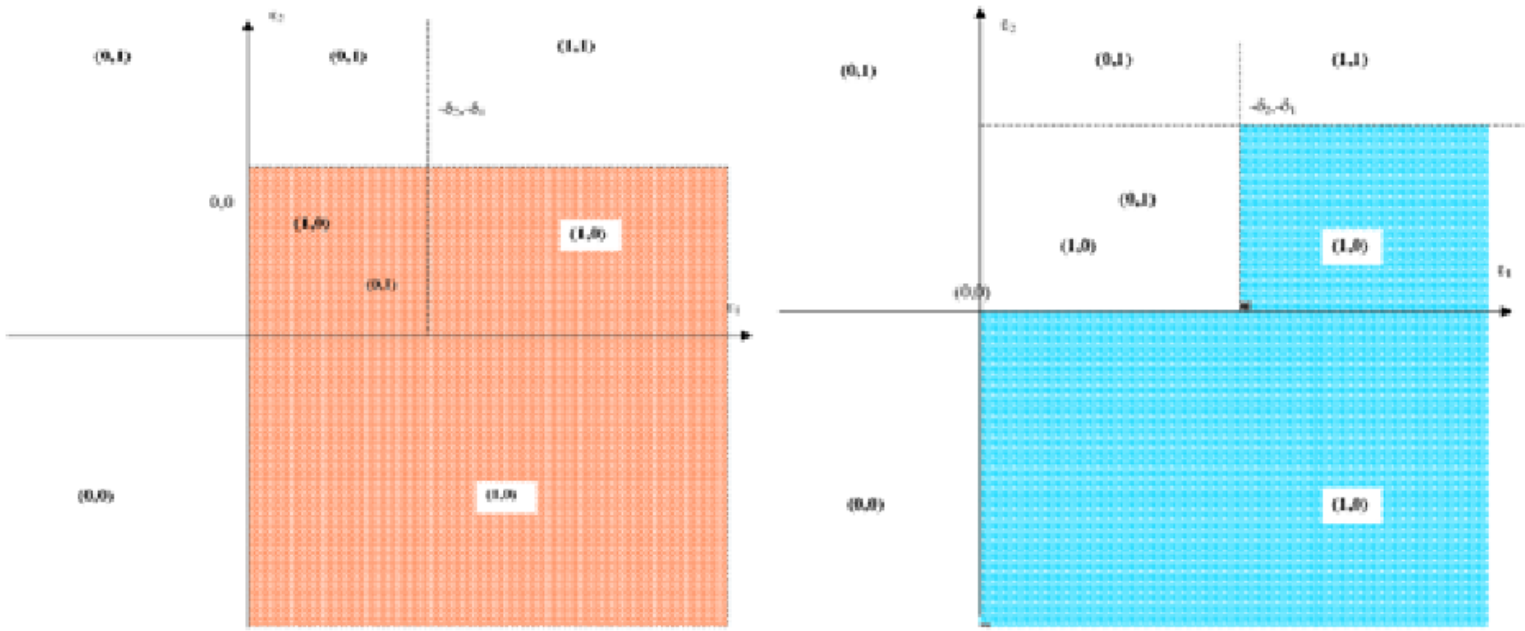


FIGURE 2.—Upper and lower probability bounds on the Pr(1, 0). The shaded area in the graph on the right hand side represents the region for $(\varepsilon_1, \varepsilon_2)$ that would predict the outcome (1, 0) uniquely. The shaded region in the graph on the left hand side represents the region where (1, 0) would be predicted if we *always* select (1, 0) to be the equilibrium in the region of multiplicity. The probability of the epsilons falling in the respective regions provides an upper and a lower bound on the probability of observing (1, 0).

Estimation

- Model implies conditional moment inequalities

$$H_1(\theta, X) \leq P(y|X) \leq H_2(\theta, X)$$

- Population objective function

$$Q(\theta) = \int \left\| (P(X) - H_1(X, \theta))_- \right\| + \left\| (P(X) - H_2(X, \theta))_+ \right\| dF_x$$

- Sample objective function

$$Q_n(\theta) = \frac{1}{n} \sum_i \left\| (P_n(X_i) - H_1(X_i, \theta))_- \right\| + \left\| (P_n(X_i) - H_2(X_i, \theta))_+ \right\|$$

- Estimate: $\hat{\Theta} = \{\theta : nQ_n(\theta) \leq \log n\}$

Data

- Second quarter of the 2001 Airline Origin and Destination Survey
- Market = trip between any two of top 100 MSAs
- Airlines: American (AA), Delta (DL), United (UA), SouthWest (WN), medium airlines (MA, includes America West, Continental, Northwest, USAir), low cost carriers (LCC)
- "Cost" = (distance of shortest connecting flight through hub − distance of direct flight) / (distance of direct flight)

TABLE I

SUMMARY STATISTICS

%	AA	DL	UA	MA	LCC	WN
Airline (%)	0.426 (0.494)	0.551 (0.497)	0.275 (0.447)	0.548 (0.498)	0.162 (0.369)	0.247 (0.431)
Airport presence (%)	0.422 (0.167)	0.540 (0.180)	0.265 (0.153)	0.376 (0.135)	0.098 (0.077)	0.242 (0.176)
Cost (%)	0.736 (1.609)	0.420 (1.322)	0.784 (1.476)	0.229 (0.615)	0.043 (0.174)	0.302 (0.860)
Market level variables						
Wright amendment (0/1)			0.029 (0.169)			
Dallas airport (0/1)			0.070 (0.255)			
Market size (population)			2,258,760 (1,846,149)			
Per capita income ($)			32,402.29 (3911.667)			
Income growth rate (% $*$ 100)			5.195 (0.566)			
Market distance (miles)			1084.532 (624.289)			
Closest airport (miles)			34.623 (20.502)			
U.S. center distance (miles)			1570.614 (593.798)			
Number of markets			2742			

TABLE II

DISTRIBUTION OF THE NUMBER OF CARRIERS BY MARKET SIZE[a]

Number of Firms	Large	Medium	Small	Total
0	7.07	7.31	7.73	7.29
1	41.51	22.86	20.91	30.63
2	29.03	24.30	22.14	25.93
3	12.23	19.67	16.34	15.72
4	8.07	15.14	14.59	11.93
5	1.66	9.58	16.17	7.48
6	0.42	1.13	2.11	1.02
Number	1202	971	569	2742

[a]Cross-tabulation of the percentage of firms serving a market by the market size, which is here measured by the geometric mean of the populations at the market endpoints.

TABLE III

EMPIRICAL RESULTS[a]

	Berry (1992)	Heterogeneous Interaction	Heterogeneous Control	Firm-to-Firm Interaction
Competitive fixed effect	[−14.151, −10.581]			
AA		[−10.914, −8.822]	[−9.510, −8.460]	
DL		[−10.037, −8.631]	[−9.138, −8.279]	
UA		[−10.101, −4.938]	[−9.951, −5.285]	
MA		[−11.489, −9.414]	[−9.539, −8.713]	
LCC		[−19.623, −14.578]	[−19.385, −13.833]	
WN		[−12.912, −10.969]	[−10.751, −9.29]	
LAR on LAR				
LAR: AA, DL, UA, MA				[−9.086, −8.389]
LAR on LCC				[−20.929, −14.321]
LAR on WN				[−10.294, −9.025]
LCC on LAR				[−22.842, −9.547]
WN on LAR				[−9.093, −7.887]
LCC on WN				[−13.738, −7.848]
WN on LCC				[−15.950, −11.608]
Airport presence	[3.052, 5.087]	[11.262, 14.296]	[10.925, 12.541]	[9.215, 10.436]
Cost	[−0.714, 0.024]	[−1.197, −0.333]	[−1.036, −0.373]	[−1.060, −0.508]
Wright	[−20.526, −8.612]	[−14.738, −12.556]	[−12.211, −10.503]	[−12.092, −10.602]
Dallas	[−6.890, −1.087]	[−1.186, 0.421]	[−1.014, 0.324]	[−0.975, 0.224]
Market size	[0.972, 2.247]	[0.532, 1.245]	[0.372, 0.960]	[0.044, 0.310]
WN			[0.358, 0.958]	
LCC			[0.215, 1.509]	

(*Continues*)

TABLE III—*Continued*

	Berry (1992)	Heterogeneous Interaction	Heterogeneous Control	Firm-to-Firm Interaction
Market distance	[4.356, 7.046]	[0.106, 1.002]	[0.062, 0.627]	[−0.057, 0.486]
WN			[−2.441, −1.121]	
LCC			[−0.714, 1.858]	
Close airport	[4.022, 9.831]	[−0.769, 2.070]	[−0.289, 1.363]	[−1.399,−0.196]
WN			[1.751, 3.897]	
LCC			[0.392, 5.351]	
U.S. center distance	[1.452, 3.330]	[−0.932, −0.062]	[−0.275, 0.356]	[−0.606, 0.242]
WN			[−0.357, 0.860]	
LCC			[−1.022, 0.673]	
Per capita income	[0.568, 2.623]	[−0.080, 1.010]	[0.286, 0.829]	[0.272, 1.073]
Income growth rate	[0.370, 1.003]	[0.078, 0.360]	[0.086, 0.331]	[0.094, 0.342]
Constant	[−13.840, −7.796]	[−1.362, 2.431]	[−1.067, −0.191]	[0.381, 2.712]
MA			[−0.016, 0.852]	
LCC			[−2.967, −0.352]	
WN			[−0.448, 1.073]	
Function value	1756.2	1644.1	1627	1658.3
Multiple in identity	0.837	0.951	0.943	0.969
Multiple in number	0	0.523	0.532	0.536
Correctly predicted	0.328	0.326	0.325	0.308

[a] These set estimates contain the set of parameters that cannot be rejected at the 95% confidencet level. See Chernozhukov, Hong, and Tamer (2007) and the Supplemental Material for more details on constructing these confidence regions.

VARIABLE COMPETITIVE EFFECTS

	Independent Unobs	Variance–Covariance	Only Costs
Fixed effect			
AA	[−9.433, −8.485]	[−8.817, −8.212]	[−11.351, −9.686]
DL	[−10.216, −9.255]	[−9.056, −8.643]	[−12.472, −11.085]
UA	[−6.349, −3.723]	[−4.580, −3.813]	[−10.671, −8.386]
MA	[−9.998, −8.770]	[−7.476, −6.922]	[−11.906, −10.423]
LCC	[−28.911, −20.255]	[−14.952, −14.232]	[−11.466, −8.917]
WN	[−9.351, −7.876]	[−6.570, −5.970]	[−12.484, −10.614]
Variable effect			
AA	[−5.792, −4.545]	[−4.675, −3.854]	
DL	[−3.812, −2.757]	[−3.628, −3.030]	
UA	[−10.726, −5.645]	[−8.219, −7.932]	
MA	[−6.861, −4.898]	[−7.639, −6.557]	
LCC	[−9.214, 13.344]		
WN	[−10.319, −8.256]	[−11.345, −10.566]	
Airport presence	[14.578, 16.145]	[10.665, 11.260]	
Cost	[−1.249, −0.501]	[−0.387, −0.119]	
AA			[−0.791, 0.024]
DL			[−1.236, 0.069]
UA			[−1.396, −0.117]
MA			[−1.712, 0.072]
LCC			[−17.786, 1.045]
WN			[−0.802, 0.169]
Wright	[−17.800, −16.346]	[−16.781, −15.357]	[−14.284, −10.479]
Dallas	[0.368, 1.323]	[0.839, 1.132]	[−5.517, −2.095]
Market size	[0.230, 0.535]	[0.953, 1.159]	[1.946, 2.435]
WN	[0.260, 0.612]	[0.823, 1.068]	
LCC	[−0.432, 0.507]		
Market distance	[0.009, 0.645]	[0.316, 0.724]	[−0.039, 1.406]
WN	[−3.091, −1.819]	[−2.036, −1.395]	

TABLE V

MARGINAL EFFECTS[a]

	AA	DL	UA	MA	LCC	WN	No Firms
Market size							
Positive	*0.1188*	*0.1136*	*0.0571*	*0.1188*	*0.0849*	*0.1118*	−0.0033
Negative	−0.0494	−0.0720	−0.0001	−0.0442	*−0.1483*	−0.0300	−0.0033
Market distance							
Positive	0.0177	0.0165	0.0106	0.0177	0.0099	0.0000	0.0006
Negative	*−0.0354*	*−0.0377*	*−0.0110*	*−0.0360*	*−0.0128*	*−0.0377*	0.0006
Close airport							
Positive	*0.1178*	*0.1122*	*0.0312*	*0.1048*	0.0662	*0.1178*	−0.0033
Negative	−0.0375	−0.0518	−0.0004	−0.0318	*-0.0911*	−0.0175	−0.0033
Change income							
Positive	*0.0283*	*0.0265*	*0.0149*	*0.0283*	0.0171	*0.0277*	−0.0007
Negative	−0.0140	−0.0193	−0.0001	−0.0120	*−0.0339*	−0.0086	−0.0007
Per capita income							
Positive	*0.0576*	*0.0546*	*0.0291*	*0.0576*	0.0364	*0.0573*	−0.0015
Negative	−0.0270	−0.0377	−0.0002	−0.0237	*−0.0699*	−0.0160	−0.0015
U.S. center distance							
Positive	*0.0177*	*0.0181*	*0.0052*	*0.0171*	0.0038	*0.0181*	−0.0004
Negative	−0.0044	−0.0055	−0.0001	−0.0033	*−0.0076*	−0.0011	−0.0004
Airport presence	0.0673	0.0498	0.1888	0.0734	0.0599	0.1040	
Cost	−0.0102	−0.0068	−0.0117	−0.0120	−0.0054	−0.0125	
AA	···	−0.3606	−0.2556	−0.4108	−0.0704	−0.2143	
DL	−0.3336	···	−0.2658	−0.3908	−0.0335	−0.2126	
UA	−0.2486	−0.2630	···	−0.2696	−0.0675	−0.2015	
MA	−0.3877	−0.3941	−0.2717	···	−0.0989	−0.2766	
LCC	−0.0998	−0.1579	−0.0721	−0.1415	···	−0.0411	

TABLE VI

VARIANCE–COVARIANCE MATRIX

	AA	DL	UA	MA	LCC	WN
AA	1	[0.043, 0.761]	[−0.110, 0.442]	[0.103, 0.626]	[−0.217, 0.752]	[0.055, 0.355]
DL		[5.052, 6.895]	[−0.200, 0.190]	[0.629, 0.949]	[−0.128, 0.656]	[0.218, 0.834]
UA			[2.048, 3.340]	[−0.173, 0.309]	[−0.213, 0.652]	[0.192, 0.797]
MA				[2.396, 5.558]	[−0.094, 0.313]	[0.093, 0.862]
LCC					[2.026, 6.705]	[0.093, 0.764]
WN						[2.063, 2.331]

TABLE VII

PREDICTED PROBABILITIES FOR POLICY ANALYSIS: MARKETS OUT OF DALLAS LOVE

Airline	Variance–Covariance	Independent Obs	Only Costs
No firms	[−0.6514, −0.6384, −0.6215]	[−0.7362, −0.6862, −0.6741]	[−0.6281, −0.6162, −0.5713]
AA	[0.4448, 0.4634, 0.4711]	[0.2067, 0.3013, 0.3280]	[0.3129, 0.3782, 0.4095]
DL	[[0.4768, 0.4988, 0.5056]	0.2733, 0.3774, 0.4033]	[0.3843, 0.4315, 0.4499]
UA	[0.1377, 0.1467, 0.1519]	[0.1061, 0.1218, 0.2095]	[0.2537, 0.3315, 0.3753]
MA	[0.4768, 0.4988, 0.5056]	[0.2733, 0.3774, 0.4033]	[0.3656, 0.4143, 0.4342]
LCC	[0.3590, 0.3848, 0.4156]	[0.8369, 0.8453, 0.8700]	[0.2839, 0.3771, 0.3933]
WN	[0.4480, 0.4744, 0.4847]	[0.2482, 0.2697, 0.3367]	[0.3726, 0.4228, 0.4431]

Conclusions

- ...

Section 2

Ciliberto and Zhang (2017)

"Multiple Equilibria and Deterrence in Airline Markets"

Section 3

Ciliberto, Murry, and Tamer (2021)

"Market Structure and Competition in Airline Markets"

Ciliberto, F. and E. Tamer. 2009. "Market structure and multiple equilibria in airline markets." *Econometrica* 77 (6):1791–1828. URL http://onlinelibrary.wiley.com/doi/10.3982/ECTA5368/abstract.

Ciliberto, Federico, Charles Murry, and Elie Tamer. 2021. "Market Structure and Competition in Airline Markets." *Journal of Political Economy* 129 (11):2995–3038. URL https://doi.org/10.1086/715848.

Ciliberto, Federico and Zhou Zhang. 2017. "Multiple Equilibria and Deterrence in Airline Markets." *Economic Inquiry* 55 (1):319–338. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/ecin.12381.