Simulating the Dynamic Effects of Horizontal Mergers: U.S. Airlines

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Research Question

U.S. Airline Industry

Background:

- Deregulated in 1978
- Several “distressed firm” mergers in mid-1980s
- No mergers for a long while
- Distressed firm mergers: ValuJet-AirTran 97; AA-TWA 01
- United-USAir, 2000 (blocked)
- Recent merger wave
  - USAir-America West 2005
  - Delta-Northwest 2008
  - United-Continental 2010
  - Southwest-Air Tran 2011
  - American-USAir 2013

Introduction

Static merger evaluation: Hold industry structure fixed and estimate short run price effect

- DOJ/FTC Merger guidelines: HHI's, Diversion Ratios
- Differentiated Products Models
  Berry and Pakes (1993), Berry, Levinson, and Pakes (1995), Nevo (2000), Hausman (various), etc

Introduction

Conclusions from static analysis: by most historical standards these mergers would look pretty bad

Table : Top 5 Routes by HHI Increase, Passengers Enplaned, 2008

CSA1	CSA2	# Top 10 Carriers Pre-Merger	HHI Passengers Pre	HHI Passengers Post	HHI Passengers Chng
DL-NW					
CVG	MSP	2	5066	9996	4930
CVG	DTW	2	4918	9830	4912
ATL	FLL, MIA	2	5230	9993	4763
MSP	SLC	2	3526	6558	3032
BUR, LAX, ONT, SNA	HNL	5	3520	6292	2772
UA-US					
CSA1	CSA2	# Top 10 Carriers Pre-Merger	Pre	Post	Chng
OAK, SFO, SJC	PHL	2	5348	9999	4651
CLT	DEN	2	5893	10000	4107
BUR, LAX, ONT, SNA	PHL	2	6155	9989	3834
CLT	MDW, ORD	3	4250	7690	3440
BWI, DCA, IAD	MSY	3	3617	6876	3259
UA-CO					
CSA1	CSA2	# Top 10 Carriers Pre-Merger	Pre	Post	Chng
CLE	DEN	2	5414	9988	4574
DEN	HOU,IAH	3	3500	5889	2389
DEN	EWR, JFK, LGA	4	3443	5223	1780
BWI, DCA, IAD	CLE	3	3784	5058	1274
HOU,IAH	MDW,ORD	4	3053	4296	1243

Introduction

What about dynamics?

Many possibilities:

- Offsetting entry by other existing carriers
- Or smaller carriers get crowded out by more powerful merged carrier
- How will merged carrier behave?
  - More efficient: might enter formerly unserved routes, prices could fall
  - Alternatively, merger might create redudancies/cause exit
- Secondary concerns:
  - Quality of service
  - On-time performance

Can we use past data to inform us about which of these might happen?

Introduction

Question of paper: Dynamic merger evaluation

At the time merger is proposed, what can we learn from the data about potential longer term effects?

Specifically, how will the world look different in 10 years?

- Empirical literature sparse on longer run effects
- Hope to generate methods useful in other markets too
- Potentially very complex problem

Method

General Framework

Notation/Framework: Imagine a dynamic game with Markov properties: (EP(1995)/BBL)

- States: $\mathbf{s}_t \in S \subset \mathbb{R}^G$, commonly known
- Actions: $a_{it} \in A_i$, simultaneously chosen
- Private Information: $\nu_{it} \sim iid\ G(\cdot|\mathbf{s}_t)$

MPE strategies: $a_i = \sigma_i(\mathbf{s}, \nu_i)$

Note: *iid* assumption not great.

Airline Model

E.g., Model of airline route segment presence:

- Air transport network with K cities.
- Nonstop flight "segment": $j \in \{1, ..., J\}$ where $J = K(K-1)/2$
- Fixed number, A, of airlines (no new airline entry)
- Network for airline i: $n_{it} \in \{0,1\}^J$ (no extent/quality of service)
- "Route Network": N_t, $J \times A$ matrix
- List of profit shifters for every route segment: Z_t
- Shocks to cost (ω_{it}) and demand (ϵ_{it})

Model

In the airline model:

- Commonly known state variable ($\mathbf{s}_t$) is current route network for everyone, and vector of profit shifters: (N_t, Z_t)
- Action a_{it} for airline i is 1770-vector of route segment entry decisions: n_{it}
- Private shocks are $(\omega_{it}, \epsilon_{it})$
- MPE strategy functions:

$$n_i^{t+1} = \sigma_i(N_t, Z_t, \omega_{it}, \epsilon_{it}).$$

- Underlying is potentially rich dynamic model with primitives for static demand/costs (whole network), and entry/exit.

Methodology

Main alternative:

- Completely specify dynamic oligopoly model (entry, exit, investment, etc)
- Estimate all parameters of this model imposing eq conditions
- Compute MPE under alt. policy regimes

May be useful, but difficult/impossible

Methodology

Proposed method: Using data on past outcomes,

1. Estimate the "reduced form" choice distributions,

$$Pr(a_i|\mathbf{s}_t)$$

2. Estimate state transition function,

$$P(\mathbf{s}_{t+1}|\mathbf{a}_t, \mathbf{s}_t)$$

- Not necessarily the same as estimating strategy functions
- Underlying model could be very complex and have multidimensional unobserved shocks

Methodology

The main assumption:

Assumption 1 The same Markov perfect equilibrium profile, σ, is played for all t, whether or not the merger of interest takes place.

Need to hold policy environment fixed:

- If merger approval/nonapproval signals a change in anti-trust policy, then MPE strategies could change
- Any other contemporaneous policy changes will also be problematic

Recall: Industry structure is endogenous, and equilibrium strategy profile is defined for any number of firms

Methodology

As long as this assumption holds:

- the first stage estimates completely determine the future distribution of states and actions:

$$P((\mathbf{a}_{t+1}, \mathbf{s}_{t+1}), ..., (\mathbf{a}_{t+r}, \mathbf{s}_{t+r})|\mathbf{a}_t, \mathbf{s}_t), \text{ for all } r$$

  whether or not merger occurs.
- Merger is simply a change in the starting state, $\mathbf{s}_t$
- Use estimates of choice distributions and transition probabilities to simulate future distribution of states and actions above

Note: Turns computational problem into a data problem. Require enough past data to fully identify choice distributions in all circumstances of interest.

Estimation

Estimation For the airline model, the choice distributions are:

$$Pr(n_i^{t+1}|N_t, Z_t) \qquad \text{for all } i$$

- Complex high dimensional object, many Y's, X's
- Handle this using "big data" techniques, LASSO, ANN
- Instead of putting (N_t, Z_t) in explicitly, make informed choices of variables ("features") to include
- Estimation based on a Probit model
- Also experiment with correlation in Probit errors

Data

Main data source: T100S “segment” data

- All nonstop flights by quarter, airline, plane type, includes seats and enplaned passengers.
- Period: 2003-2008
- Top 75 airports by enplaned passengers
- Aggregated to CSA level: Top 60 CSA’s
- Smallest CSA’s: Anchorage, Albany, Norfolk, Boise
- 1770 segments and markets
- 10 major airlines, plus 2 groups of small carriers
- Entry/exit definitions
- Regional carriers
- Supplement with T100M, DB1B
- American Travel Survey (1995), Census

Table : Examples of “features”

Regressor	Avg	SD	Min	25%	50%	75%	Max
Pop1*Pop2 (*1e-12)	8.46	17.6	0.030	1.49	3.40	8.30	350
Pop1*Pop2 (*1e-12) * 2002 Dens=0	0.82	3.24	0	0	0	0.341	82.0
Log 2002 Passenger Density	7.62	5.60	0	0	10.7	12.6	16.0
Percent Tourist	0.37	0.35	0	0	0.33	0.67	1
Num Big 3 Comps.	2.06	0.92	0	1	2	3	3
Num Other Major Comps.	1.70	1.04	0	1	2	2	5
Southwest Competitor	0.48	0.50	0	0	0	1	1
Num Oth. Low Cost Comps.	0.422	0.58	0	0	0	1	2
Num Oth. Comps.	0.3	0.46	0	0	0	1	1
Number Nonstop Comps	0.78	0.99	0	0	0	1	6
Number One-Stop Comps	3.52	1.97	0	2	4	5	9
Number CS Agreements	0.051	0.23	0	0	0	0	3
Competitor Hub on Route	0.68	0.467	0	0	1	1	1
HHI Among Others (Market)	4869	4445	0	0	5085	9993	10000
HHI Among Others Large (City)	3377	1762	49	2018	3030	4200	8933
HHI Among Others Small (City)	1695	889	6	1200	1561	2023	7861
Own Share Large (City)	0.15	0.17	0	0.0367	0.089	0.19	0.94
Own Share Small (City)	0.05	0.06	0	0.0001	0.027	0.06	0.83
Present in Segment	0.09	0.29	0	0	0	0	1
Present in Market (not Segment)	0.41	0.49	0	0	0	1	1
Present at One Airport (not Both)	0.23	0.42	0	0	0	0	1
Present at Both Airports (not Market)	0.27	0.44	0	0	0	1	1
One Hub	0.135	0.34	0	0	0	0	1
Both Hubs	0.004	0.07	0	0	0	0	1
Number of Hubs	0.15	0.37	0	0	0	0	2
Hub Conv (NS dist/OS dist)	0.76	0.28	0.01	0.57	0.89	0.99	1
Dist Nearest Hub Small	440	489	0	119	286	553	4679
Dist Nearest Hub Large	1180	932	0	495	857	1797	4756
Log Pass. Dens. New Markets	2.63	4.46	0	0	0	5.2	15.8
# Nonstops Small (City)	2.28	3.10	0	0	2	3	53
# Nonstops Large (City)	8.38	11.8	0	2	4	8	56

Estimation

- Most important variables:
  1. Route presence
  2. Competition
  3. Own Share Lg & # Nonstops Lg
- Endogeneity has big impact on comp vars
- Next: fit is outstanding, not much variation left to explain

Merger Simulations

Simulating the U.S. airline route network:

1. Start at state $\mathbf{s}_0$ (different for each scenario)
2. Take draws on entry/exit for every segment conditional on X's
3. Update dynamic X's for every market
4. Move to next period and repeat steps 2-3

Merger Simulations

- Simulate industry under four scenarios:
  1. No merger
  2. Delta-Northwest
  3. United-USAir
  4. United-Continental
- (All scenarios assume US Air-America West merger.)
- Difference in scenarios is starting value of state variables

Results

Merger Simulations

Aggregate U.S. market findings:

- Merged carrier expands more than no-merger case
  - Cost efficiency or demand?
- Aggregate response by other carriers is small:
  - SW & AL crowded out by DL-NW
  - AL & JB more entry under UA-US
  - SW & DL crowded out by UA-CO

Merger Simulations

Aggregate U.S. market findings (cont):

- Base case has market less concentrated in 10 yrs
- DL-NW:
  - Initially: 3 extra monopoly markets but in 10 years: 1
  - Many more duopoly and triopoly markets
- UA-US:
  - Initially: 3 extra monopoly markets but in 10 years: 0
  - More duopoly and triopoly markets
- UA-CO:
  - One less monopoly market initially and long run
  - More duopoly and triopoly markets

Merger Simulations

Worst case cities:

- In many cases entry response to merger is small (DL-NW, UA-CO)
- Sometimes there is an entry response (UA-US)

Merger Simulations

Worst case routes, DL-NW:

- 11 routes flown by both carriers
- Of these, 6 are 2→1
  - None of these have new entry in 10 yrs.
- 2 are 4→3, 2 are 5→4, 1 is 6→5
  - All of these routes have new entry within 10 yrs
- <u>Reason:</u> realistic set of potential entrants
- Five routes (SLC→IND,MEM→RSW,MEM→SLC, MKE→SLC, CVG→HNL) have large increases in prob of gaining nonstop service

Merger Simulations

Worst case routes, UA-US:

- 38 routes flown by both carriers
- Of these, 5 are 2$\rightarrow$1
  - All except one (PHL$\rightarrow$DEN) have significant chance ($>$0.5) of offsetting entry
- Rest: often offsetting entry
- No routes gain service

Merger Simulations

Worst case routes, UA-CO:

- 16 routes flown by both carriers
- 1 is 2→1 (CLE→DEN) and it shows no offsetting entry
- 4 are 3→2 and half of these show significant chance of offsetting entry
- Rest: often offsetting entry, but not always
- No routes gain service

Conclusions

- Simple, data driven, approach
- Big data techniques
- Consistent with rich underlying model, without need to estimate structural parameters of such a model

Main Drawbacks:

- Requires assumption about stability of policy regime and general environment
- Relatively high data requirement
- Difficult to handle serially correlated unobservables

Conclusions

- Empirical findings:
  - Dynamic analysis leads to different conclusions than static analysis
  - All three mergers look better in 10 years than static analysis
  - UA-US (blocked) looks much better after 10 years, perhaps best of three
- Value of new service?
- To do list: AA-US, retrospective analysis