Cloud Computing and Modeling Dynamic Competition in the U.S. Airline Industry

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Motivation.

- **Industry competition as a dynamic game**

\[ V_f(s_t, a_{ft}) = \mathbb{E}[\pi_f(s_t, a_{ft}) + \beta V_f(s_{t+1})|s_t, a_{ft}] \]

- **Two airlines: American and Delta**

- \( a_{ft} \)=number of flights, DFW to ATL (AA)

- \( a_{-ft} \)=number of flights, DFW to ATL (DL)

- \( s_t \)=(total flights (AA+DL), jet fuel)
Motivation.

\[ V_f(s_t, a_{ft}) = \mathbb{E} \left[ \pi_f(s_t, a_{ft}) + \beta V_f(s_{t+1}) | s_t, a_{ft} \right] \]

- Complexity increases with state variables

Jet fuel_{t+1} = $2.00/gal.
Jet fuel_{t} = $1.39/gal.
Jet fuel_{t+1} = $1.20/gal.

- Cardinality: \(|s_t| = 5000 \times 100 = 500,000\)
Interest

- Handbook of Industrial Organization, Chapter 29 (Berry and Reiss)
  “Dynamic, strategic models often raise difficult econometric and computational issues. Thus, while these models are more theoretically appealing, they are not easily applied to commonly available data. To date, there have been relatively few attempts at estimating such models.”

- Stylized models, state variables chosen by assumption

- More complicated in network industries (airlines, big-box retailers, cable companies)
Two Things I Learned at UW

- Cloud Computing and Parallelization
  - eScience Institute and AWS (Bill Howe, Andrew Whitaker, Lori Clithero)
  - Fall 2014 Incubator
- Machine Learning
  - Pat Bajari (Amazon and UW)
  - Greg Duncan (Amazon and UW)
  - UW Machine Learning curriculum

→ Machine Learning feature selection reduces dimensionality
→ Conditional expectations can be computed in parallel
Airline Projects and Data

- Two projects
  - Predatory Incentives (with Ying Jiang)
  - Capacity Collusion

- Ticket and Segment Data (U.S. Department of Transportation)
  - Origin and Destination Survey (DB1B)
  - T100 Segment Passengers

- Scheduled Flights Data (OAG)
Predatory Incentives

- Low cost carrier (LCC) expansion after mergers
- Example: Northwest Airlines at Minneapolis-St. Paul (MSP)
- Timeline
  - 1980s to 2008 - no Southwest, 5% LCC share (MSP)
  - 2008q2 – Delta and Northwest announce merger
  - 2008q4 – Southwest announces first nonstop flights (MSP)
  - 2008q4 to 2014q4 – huge increase in LCC share (MSP)
- Predation: flight capacity reallocation (network)
Value of Predation (Mean), Millions of $

- Merger Change: 27.56
- Northwest Unmerged: 16.56
- Northwest/Delta Merged: 44.12
- Southwest: -0.58, -0.45

□ Southwest Never Entered □ Southwest Entered After 2008q1
Capacity Collusion

- 5 major mergers since 2005
  - Leaves: American, Delta, United, Southwest
  - Restriction of number of flights (capacity)

- U.S. Department of Justice – capacity collusion investigation (2015)
Capacity Collusion

- Strategies might support “apparent” collusion
- Cross market initiatives
  - 2009 US Airways, price decrease in Detroit to Philadelphia (Delta hub)
  - Delta, price decrease Washington Reagan to Boston (US Airways hub)
  - US Airways relented
- Explicitly network-wide
Future Directions

■ Additional projects
  – Rich macroeconomic models of firm financing

■ Empirical results
  – Capacity collusion results
  – Predatory incentives results for other mergers

■ Theoretical results
Thank you and Questions