A Comparison of Static and Dynamic Schemes for Airline Alliance Revenue Management

Robert Shumsky
Tuck School of Business at Dartmouth
Chris Wright and Harry Groenevelt
Simon School, University of Rochester

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Agenda

- Alliance RM overview
- Static and dynamic schemes
- A model to evaluate the schemes
- Numerical comparisons
- Further work

International Alliances

American, British Airways, Cathay Pacific…

Air France/KLM, Delta, Northwest…

United, Lufthansa, Singapore…

International code-share flights (# daily departures)

2003	2005	2007
17,000	33,000	39,000

Source: International Air Transport Association

U.S. domestic airline alliances in 2005

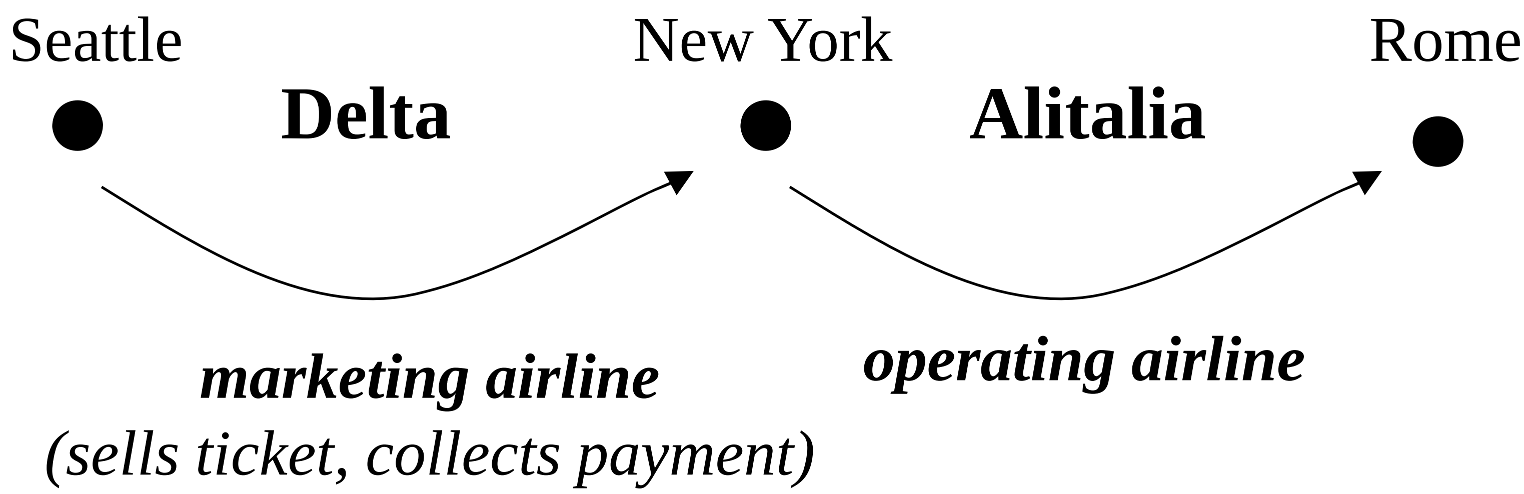
- For 20% of domestic passenger coupons, the operating airline was different from the ticketing (*marketing*) airline.

- A majority of these were flights by national-regional partners (e.g., American-American Eagle, Delta-Chautauqua).

- 2% of coupons were sold via **code-sharing** agreements among national network airlines (e.g., Northwest-Continental)

Source: U.S. DOT Ticket Sample/Database 1B

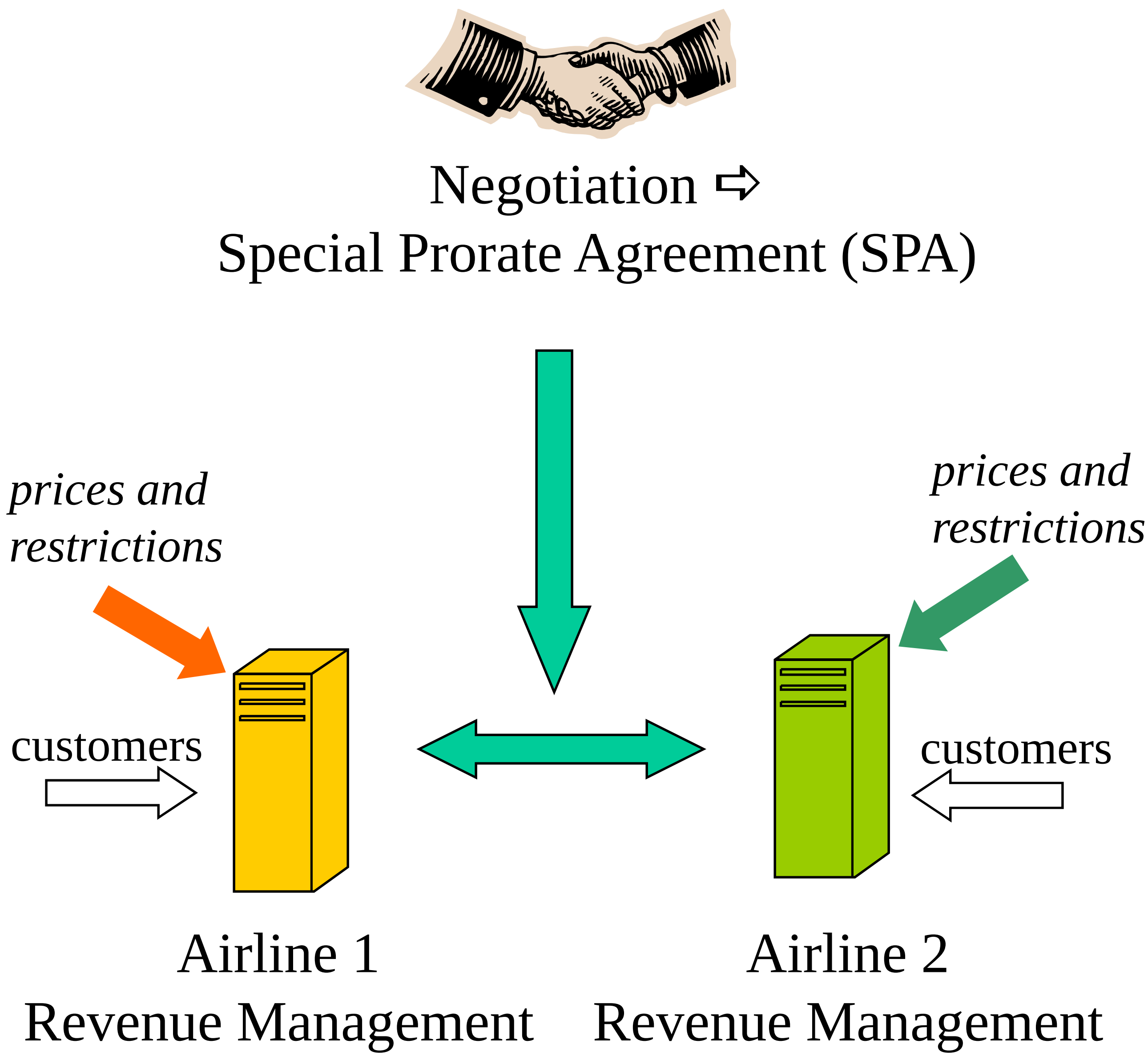
Marketing vs. operating: Definitions and Questions



Delta (the marketing airline) has a $1600 fare class for the Seattle-New York-Rome itinerary.

- Should Delta open that fare class?
  - How much money does Alitalia receive?
  - Will Alitalia make its inventory available to Delta?

Overall alliance coordination problem



Designing the SPA is a cooperative game.

Given SPA, Alliance RM is a competitive game

In practice, SPA's have two functions

1. Ensure an ‘equitable’ split of revenues
   - Cover costs of the operating airline
   - Reward partners with more negotiating power

2. Coordinate revenue management decisions
   - Share marginal cost information
   - Share revenue information

These functions can conflict.

Typical (Static) Agreements under ‘Free Sale’

- Airlines sell seats in real time;
  availability communicated via reservations systems.
- Revenue to operating airline based on
  – static fraction of revenue allocated to each airline
  – mileage proration
  – other static prices, negotiated in advance.
- Agreements seem designed for Function 1 (cost-sharing/equity).
- These static agreements can fail miserably at Function 2 (RM coordination) – see Boyd, 1998.

Dynamic revenue-sharing

Schemes based on bid-prices have been considered by at least one major international alliance.

Barriers to implementation:

- Incompatible revenue management and accounting systems.
- A lack of trust.
  Would alliance members inflate bid-price values?

Would ‘cheating’ really hurt?

Is it worth the effort to implement dynamic schemes?

A stylized model to assess the performance of dynamic and static schemes

- Each airline uses network bid-price controls (Talluri and van Ryzin, 1998)

- Each operating airline can accept or reject the marketing airline’s offer to buy seats for an itinerary

- Both airlines have perfect information about the other airline's inventory and demand forecasts (!)

Notation

for events in time period k,

$$q_k^{cj} = \text{probability of a customer arrival to airline } c \text{ to purchase itinerary } j$$

$$q_k^{0} = \text{probability of no arrival}$$

$$R_k^{cj} = \text{revenue from a customer to airline } c \text{ for itinerary } j \text{ (if } c \text{ is the marketing airline); A random variable.}$$

$$p_k^{cj}\left(\vec{x}\right) = \text{transfer price paid to airline } c \text{ for itinerary } j\text{, given inventory vector } \vec{x} \text{ (if } c \text{ is the operating airline).}$$

Airline *c*'s value function

Arrival of a local (code-share) (non-code-share) customer to *c*

$$
J_k^c\left(\vec{x}\,\middle|\,u_k^{-c},\overline{p}_k^{-c}(\vec{x})\right)=\left(\begin{array}{l}
\sum_{j\in N_c} q_k^{cj}\,\mathrm{E}\left[R_k^{cj}u_k^{cj}\left(R_k^{cj},\vec{x}\right)+J_{k-1}^{c}\left(\vec{x}-A^j u_k^{cj}\left(R_k^{cj},\vec{x}\right)\right)\right]+\\
\sum_{j\in N_S} q_k^{cj}\,\mathrm{E}\left[\widetilde{R}_k^{cj}(\vec{x})u_k^{cj}\left(\widetilde{R}_k^{cj}(\vec{x}),\vec{x}\right)+J_{k-1}^{c}\left(\vec{x}-A^j u_k^{cj}\left(\widetilde{R}_k^{cj}(\vec{x}),\vec{x}\right)\right)\right]+\\
\sum_{j\in N_S} q_k^{-cj}\,\mathrm{E}\left[p_k^{cj}(\vec{x})u_k^{-cj}\left(\widetilde{R}_k^{-cj}(\vec{x}),\vec{x}\right)+J_{k-1}^{c}\left(\vec{x}-A^j u_k^{-cj}\left(\widetilde{R}_k^{-cj}(\vec{x}),\vec{x}\right)\right)\right]+\\
\sum_{j\in N_{-c}} q_k^{-cj}\,\mathrm{E}\left[J_{k-1}^{c}\left(\vec{x}-A^j u_k^{-cj}\left(R_k^{-cj},\vec{x}\right)\right)\right]+q_k^0 J_{k-1}^1(\vec{x})
\end{array}\right),
$$

Arrival of a local customer to -*c*

Arrival of a code-share customer to -*c*

$$
J_0^c(\vec{x})=0 \quad \forall \vec{x}\geq\vec{0},
$$

where $u_k^{cj}(r,\vec{x})=\arg\max_{u\in\{0,1\}}\left\{ru+J_{k-1}\left(\vec{x}-A^j u\right)\right\}$ and $\widetilde{R}_k^{cj}(\vec{x})=R_k^{cj}-p_k^{-cj}(\vec{x})$.

We examine three dynamic transfer prices

bid price: marketing airline pays the marginal value (bid price) of the operating airline's seats to the operating airline (Boyd, 1998);

bid-price proration: revenue is split proportionally, based on the bid prices:

$$p_k^{1j}(\vec{x}) = \left[\frac{\Delta J_{k-1}^1\left(\vec{x}, A^j\right)}{\Delta J_{k-1}^1\left(\vec{x}, A^j\right) + \Delta J_{k-1}^2\left(\vec{x}, A^j\right)} \right] r$$

partner price: the price for a seat is set dynamically by the *operating airline* to maximize its own revenue, i.e., cheating on the ***bid price*** scheme.

Technical results

For the partners' accept/reject decisions, there is a unique, pure-strategy markov-perfect equilibrium:

Each airline rejects an offer if its net revenue is less than the total cost (own bid price plus any transfer price) of the itinerary.

Technical results, Partner Price

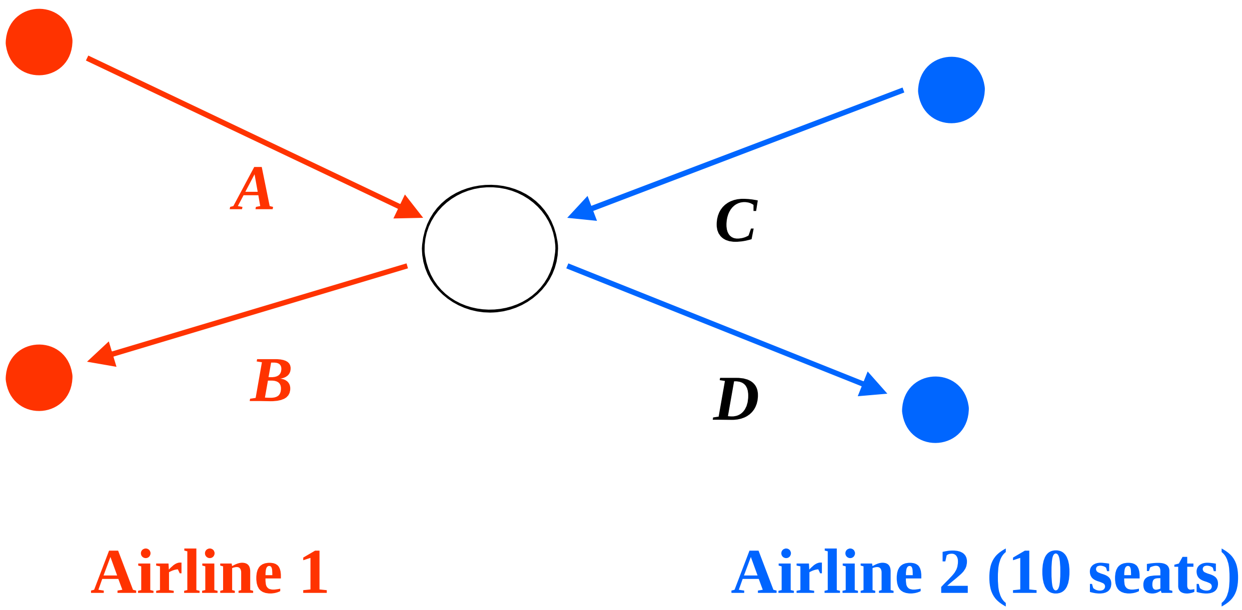
Let $f_k^{2j}(r)$ and $F_k^{2j}(r)$ be the pdf and cdf for airline 2's distribution of revenue for itinerary j in period k.

For the partner price scheme, if $F_k^{2j}(r)$ has Increasing Generalized Failure Rate (IGFR) then there is a unique equilibrium price.

The price charged by airline 1 for itinerary j is defined by:

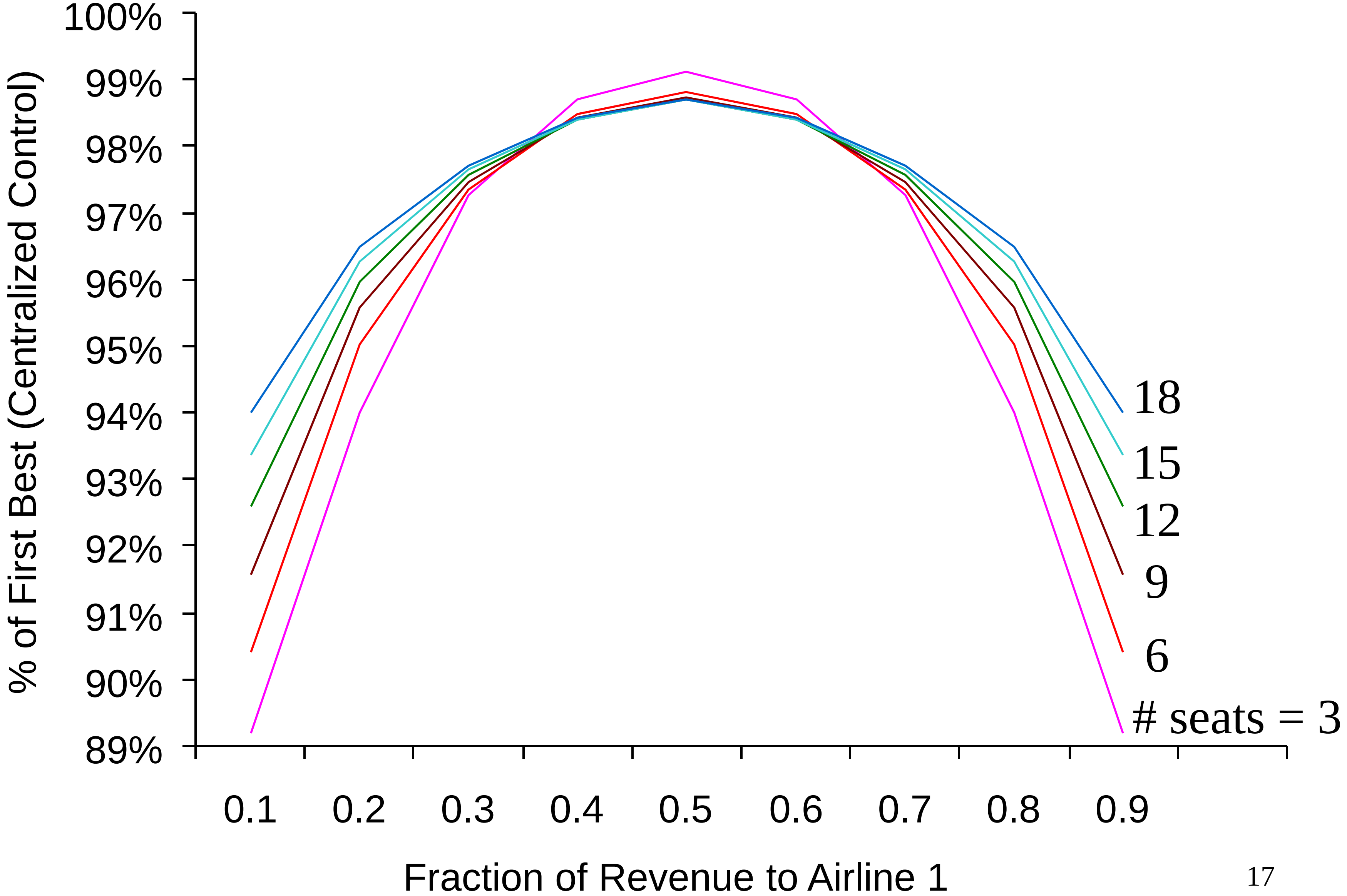
$$\underbrace{p_k^{1j}(\vec{x})}_{\text{price}} = \underbrace{\Delta J_{k-1}^{1}(\vec{x}, A^j)}_{\text{1's marginal value}} + \underbrace{\frac{F_k^{2j}\left(\Delta J_{k-1}^{2}(\vec{x}, A^j) + p_k^{1j}(\vec{x})\right)}{f_k^{2j}\left(\Delta J_{k-1}^{2}(\vec{x}, A^j) + p_k^{1j}(\vec{x})\right)}}_{\text{1's price premium balances direct revenue \& losses due to 2's response}}$$

Numerical Comparison 1: Equal Partners

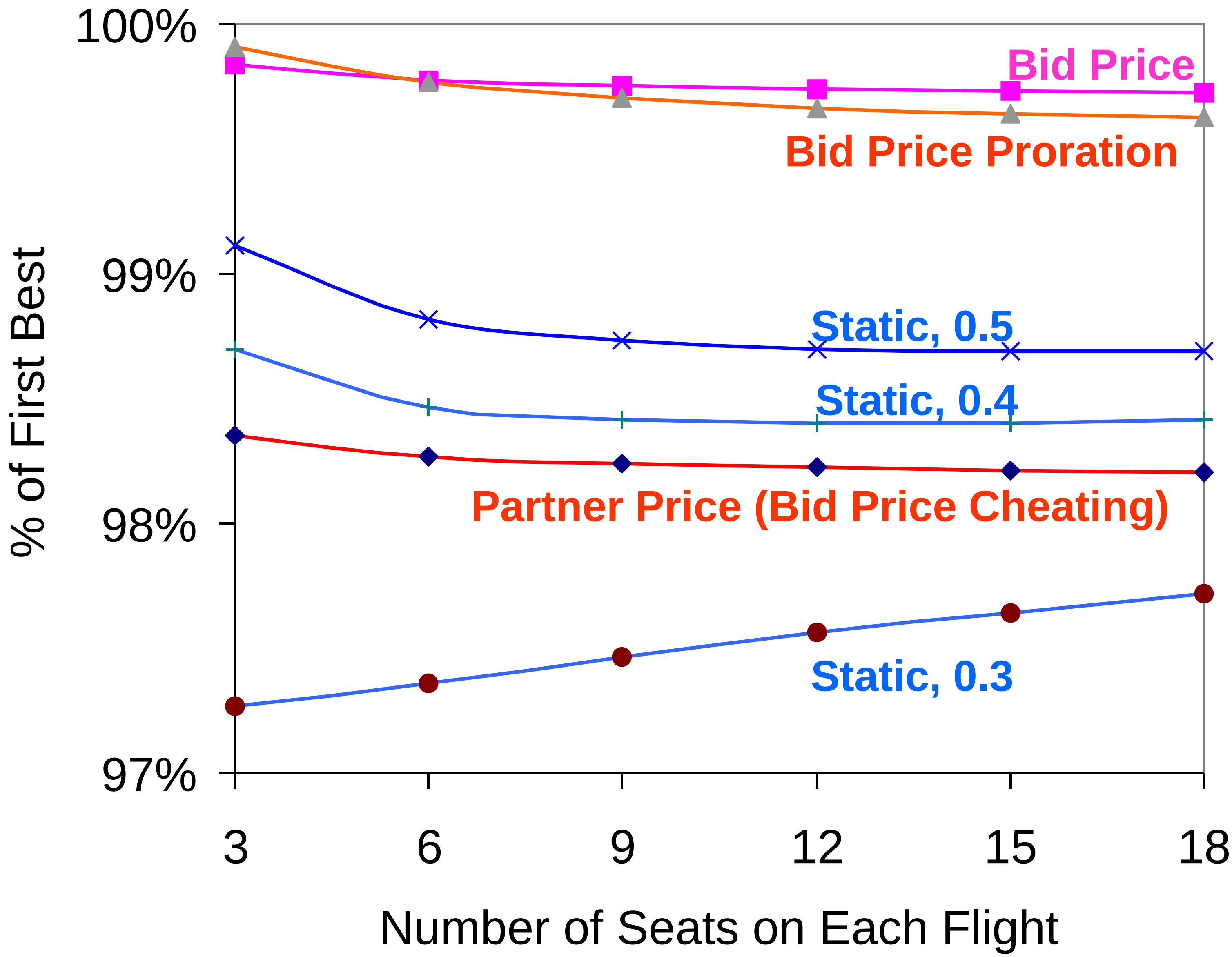


- Possible itineraries: A, B, C, D, AB, CD, AD, CB
- Airlines have equal average demand and revenue distributions; both see 50% of code share requests.
- Number of seats available on each flight = 3, 6, 9, …, 18, with demand scaled appropriately.

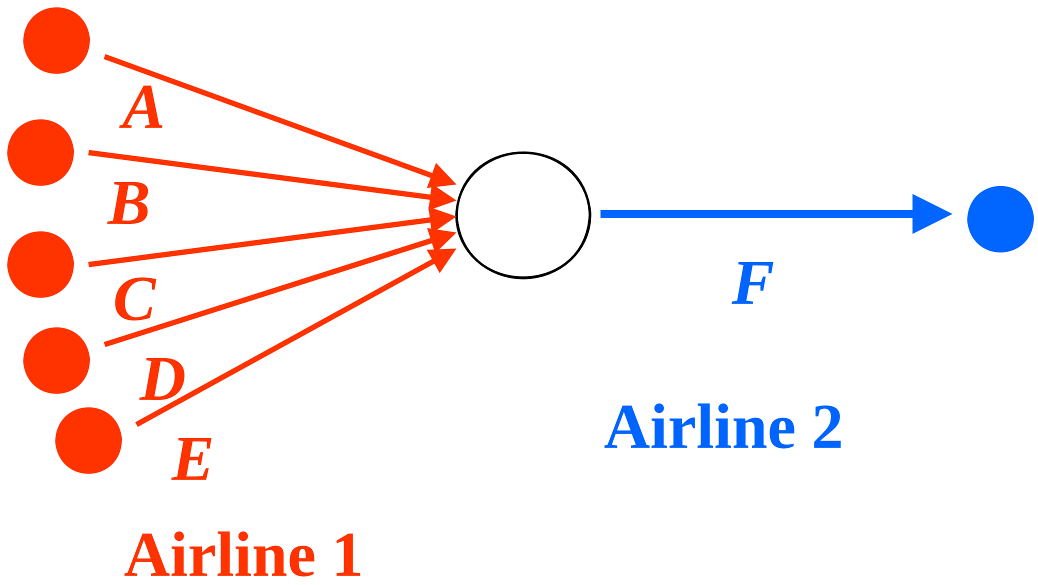
Performance of Static Split in Revenues



Performance of Static vs. Dynamic Schemes



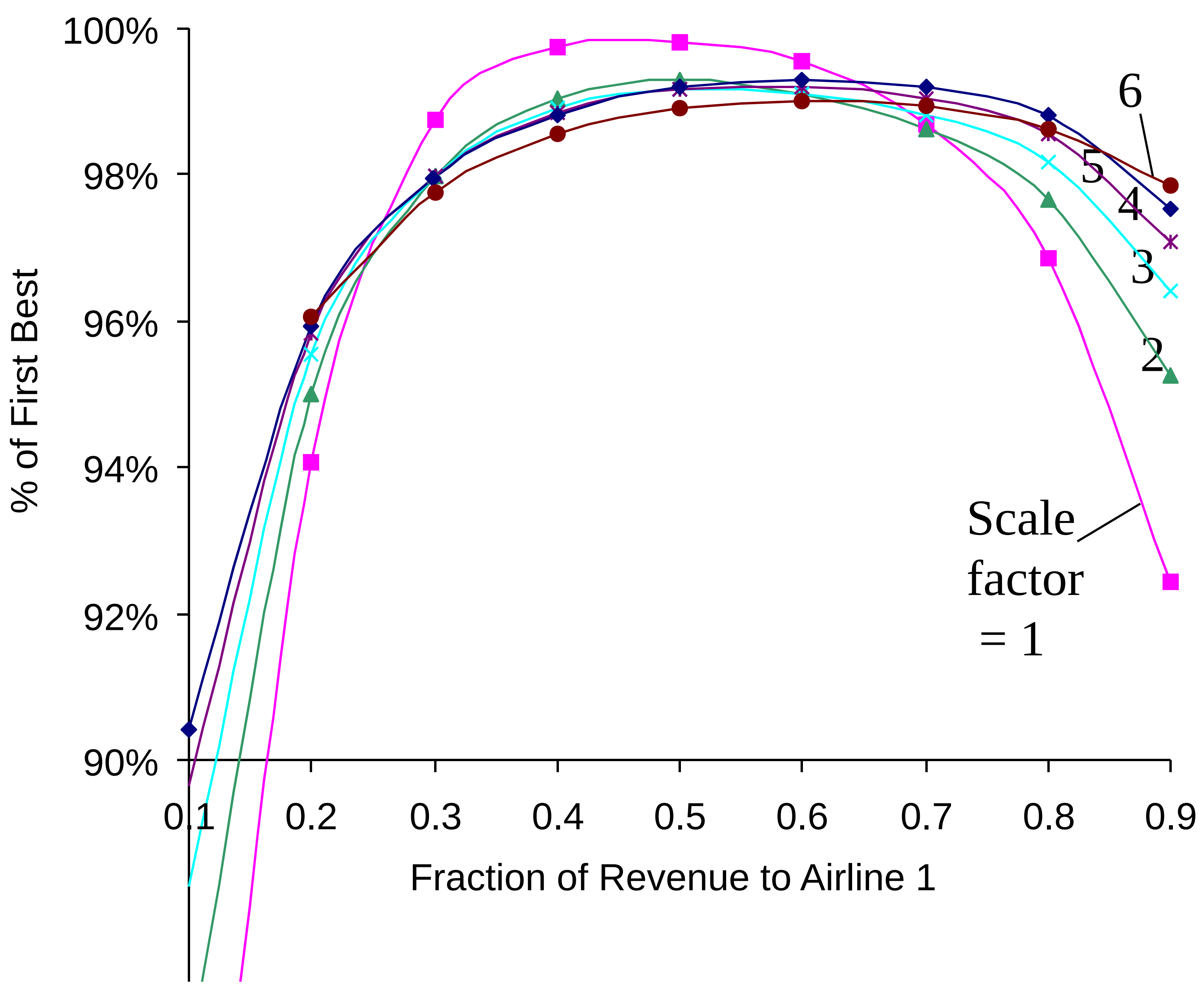
Numerical Comparison 2: International Feeder



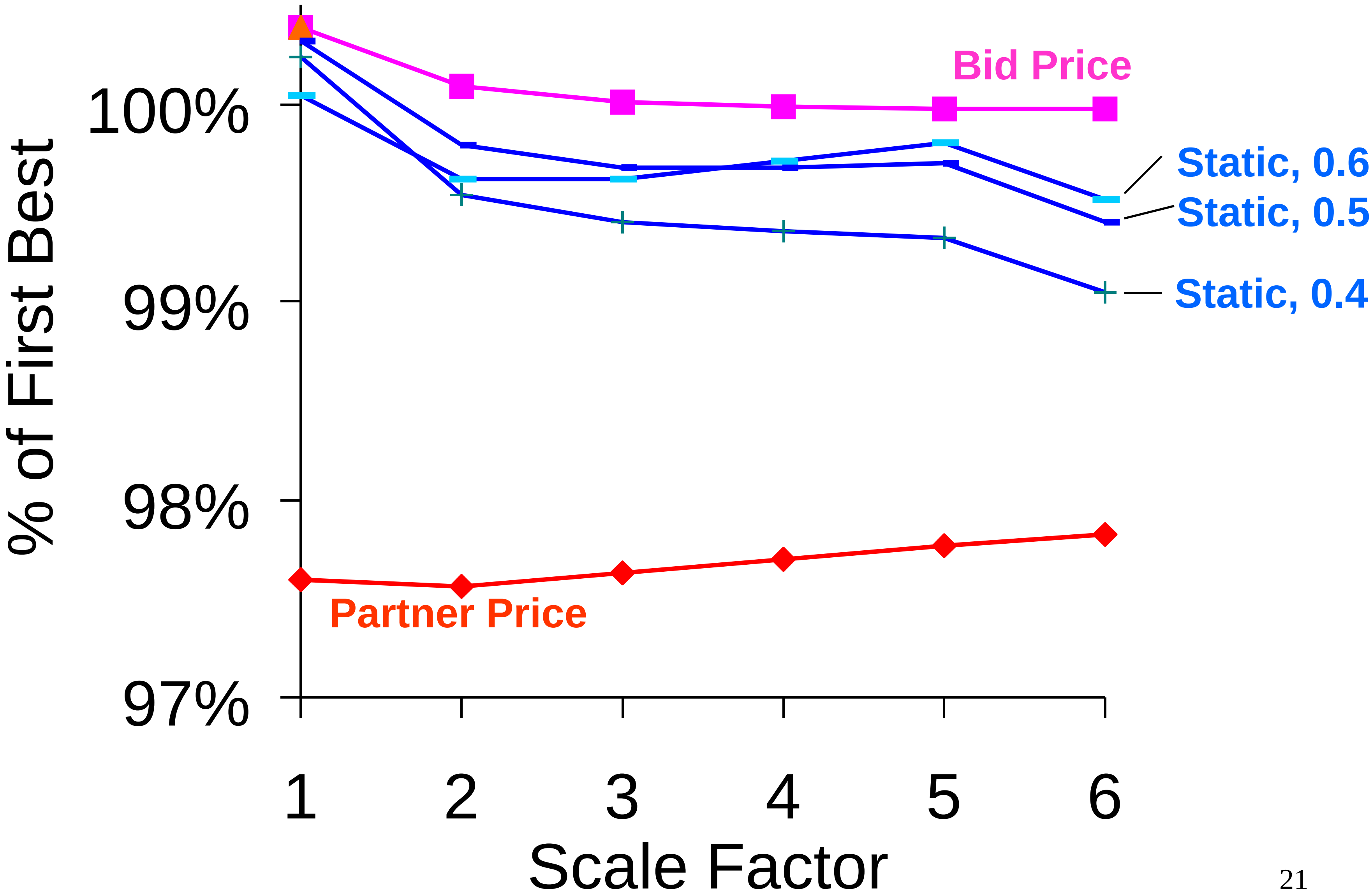
- Possible itineraries: A, AF, B, BF, etc.
- Each airline receives half of all code-share requests.
- Number of seats available on first (second) leg:

  = 1 (3), 2 (6), … 6 (18)

Performance of Static Split in Revenues



Performance of Static vs. Dynamic Schemes



Implications

- Static scheme are more robust in larger systems
- *Optimal* static scheme performs well
  - we have not yet identified a scenario that ‘breaks’ the best static scheme
  - non-optimal static schemes may be very bad
- If partners ‘cheat’, static schemes may significantly outperform dynamic schemes

Implications, Continued

- Bid price proration *sometimes* is superior to the bid price scheme, but has implementation issues.

$$p_k^{1j}(\vec{x}) = \left[\frac{\Delta J_{k-1}^{1}\left(\vec{x}, A^j\right)}{\Delta J_{k-1}^{1}\left(\vec{x}, A^j\right) + \Delta J_{k-1}^{2}\left(\vec{x}, A^j\right)} \right] r$$

denominator sometimes 0 or even < 0

- A more stable (?) alternative:

$$p_k^{1j}(\vec{x}) = \Delta J_{k-1}^{1}\left(\vec{x}, A^j\right) + \alpha\left[r - \Delta J_{k-1}^{1}\left(\vec{x}, A^j\right) - \Delta J_{k-1}^{2}\left(\vec{x}, A^j\right)\right]$$

Further Work

- Relax the full information assumption:
  In each period, each airline assumes,

  partner's future bid prices = current bid prices.

  – Is there an equilibrium?
  – Does performance suffer significantly?
  – Can *current* bid prices be monitored? (using business intelligence data companies, e.g., QL2)

- Numerical methods to evaluate larger networks (necessary to make significant modifications to standard approximations).

References

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