# O&D Control:
# What Have We Learned?

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# O-D Control: What Have We Learned?

**Summary of results from over a decade of research**

- ✈ Supported by PODS Consortium simulations at MIT
- ✈ Theoretical models and practical constraints on O-D control

**O-D control can increase network revenues, but impact depends on many factors**

- ✈ Optimization, forecasting and effective control mechanism
- ✈ Your airline's network and RM capabilities of competitors
- ✈ Operational realities such as airline alliances, low-fare competitors, and distribution system constraints

# What is Origin-Destination Control?

**The capability to respond to different O-D requests with different seat availability on a given itinerary**

- ✈ Based on network revenue value of each request
- ✈ Irrespective of yield or fare restrictions

**Can be implemented in a variety of ways**

- ✈ EMSR heuristic bid price (HBP)
- ✈ Displacement adjusted virtual nesting (DAVN)
- ✈ Network probabilistic bid price control (PROBP)

**Control by <u>network revenue value</u> is key concept**

# RM System Alternatives

| RM System | Data and Forecasts | Optimization Model | Control Mechanism |
|---|---|---|---|
| FCYM Base | Leg/class | Leg EMSR | Leg/class Limits |
| Heuristic Bid Price | Leg/bucket | Leg EMSR | Bid Price for Connex only |
| Disp. Adjust. Virt. Nesting | ODIF | Network LP + Leg EMSR | Leg/bucket Limits |
| Prob. Netwk. Bid Price | ODIF | Prob. Netwk. Convergence | O-D Bid Prices |

# PODS RM Research at MIT

**Passenger Origin Destination Simulator simulates impacts of RM in competitive airline networks**

- ✈ Airlines must forecast demand and optimize RM controls
- ✈ Assumes passengers choose among fare types and airlines, based on schedules, prices and seat availability

**Recognized as "state of the art" in RM simulation**

- ✈ Realistic environment for testing RM methodologies, impacts on traffic and revenues in competitive markets
- ✈ Research funded by consortium of seven large airlines
- ✈ Findings used to help guide RM system development

# Network Revenue Gains of O-D Control

**Airlines are moving toward O-D control after having mastered basic leg/class RM fundamentals**

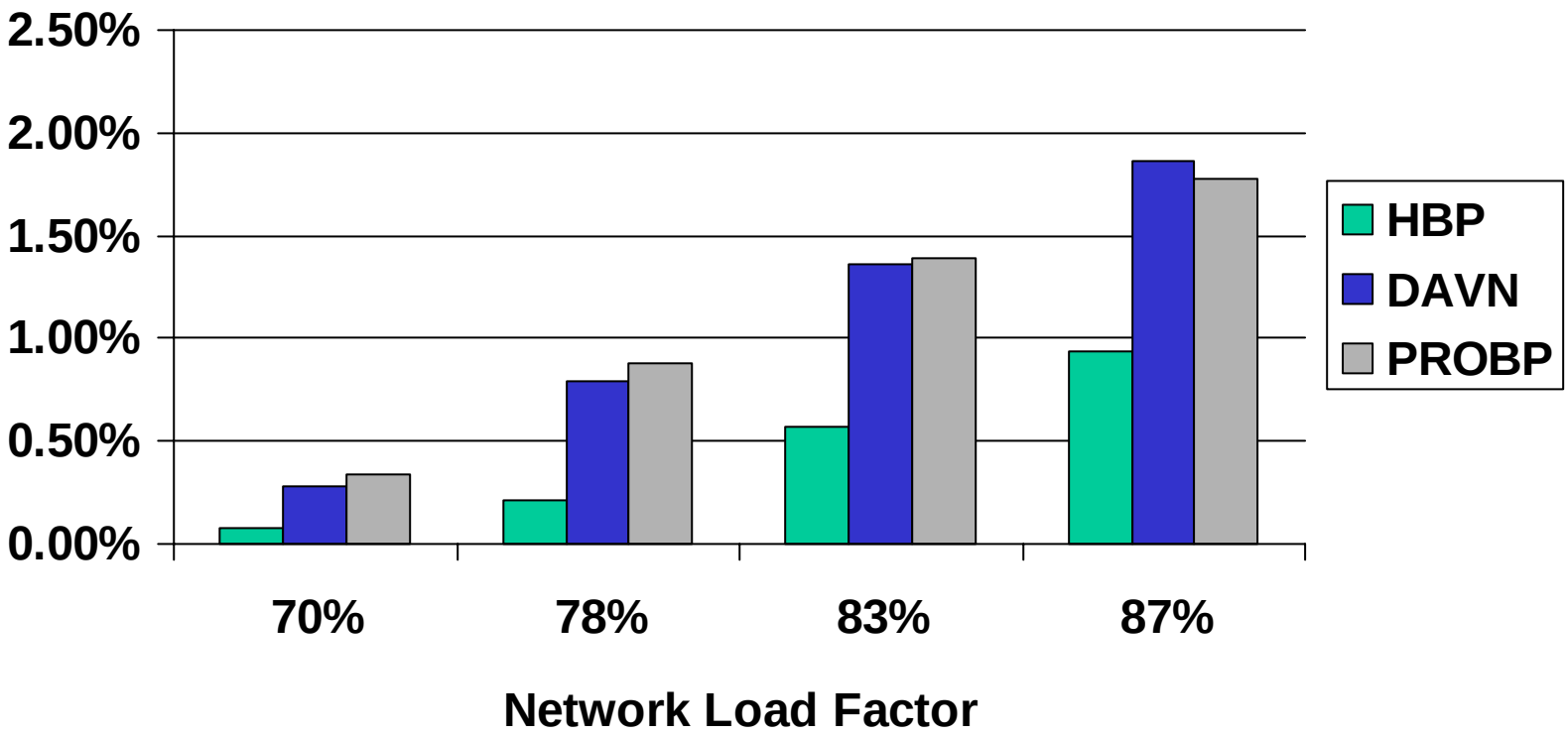
- ✈ Effective leg-based fare class control and overbooking alone can increase total system revenues by 4 to 6%

**Effective O-D control can further increase total network revenues by 1 to 2%**

- ✈ Range of incremental revenue gains simulated in PODS
- ✈ Depends on network structure and connecting flows
- ✈ O-D control gains increase with average load factor
- ✈ But implementation is more difficult than leg-based RM

# O-D Revenue Gain Comparison

## Airline A, O-D Control vs. Leg/Class RM



# Value Bucket vs. Bid Price Control

**Network Bid Price Control:**

- ✈ Simpler implementation of control mechanism
- ✈ Performance depends on frequent re-optimization

**Value buckets ("virtual nesting")**

- ✈ Substantially more complicated (and costly) changes to inventory required
- ✈ Requires off-line re-mapping of ODFs to buckets

**Most PODS (and other) simulations show little significant difference in network revenue gains**

# Network Optimization Methods

**Several network optimization methods to consider:**

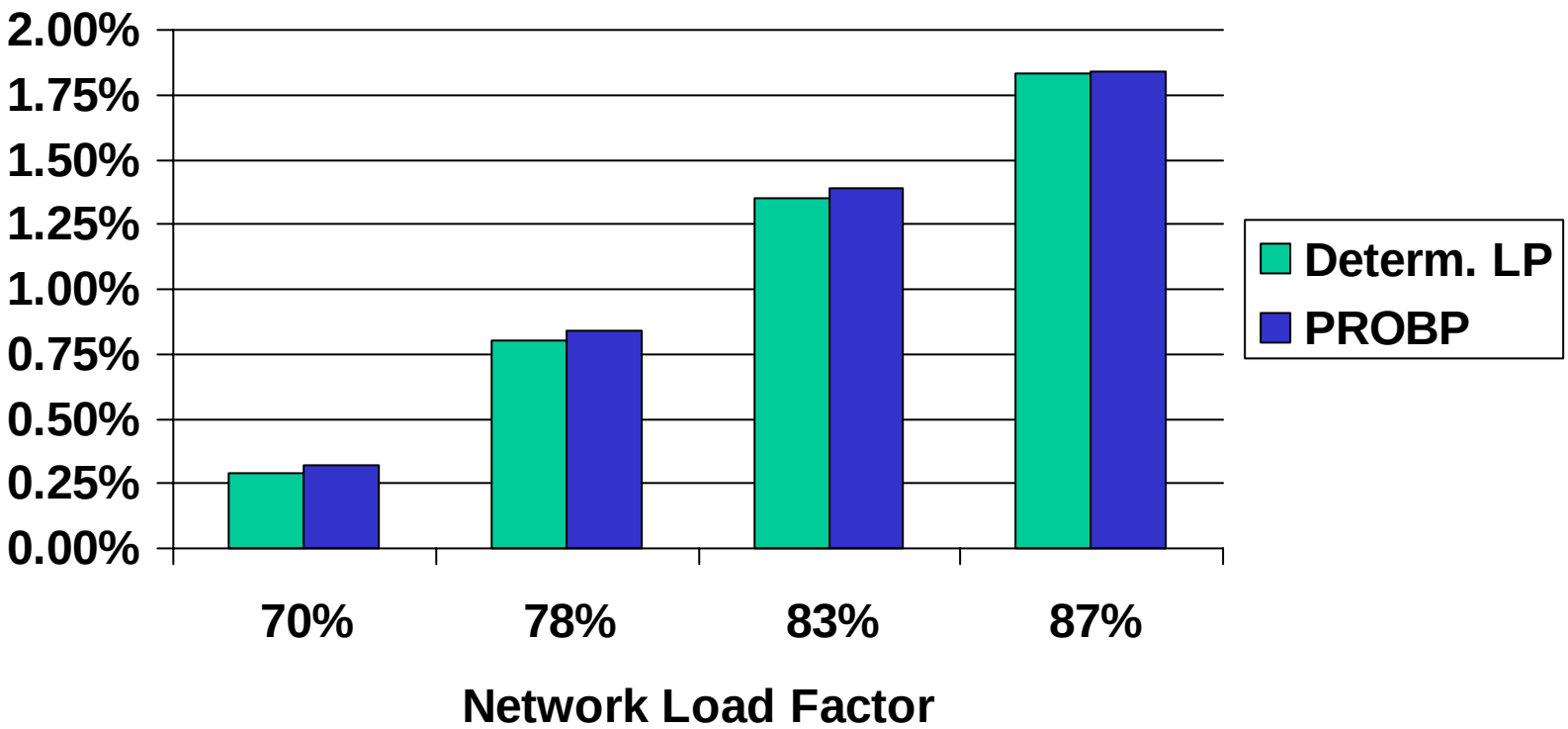
- ✈ Deterministic Linear Programming (LP)
- ✈ Dynamic Programming (DP)
- ✈ Nested Probabilistic Network Convergence (MIT)

**How important is optimization method?**

- ✈ DAVN uses deterministic LP network optimization, while PROBP uses a probabilistic network model
- ✈ How do these methods compare under the DAVN and Bid Price control schemes?

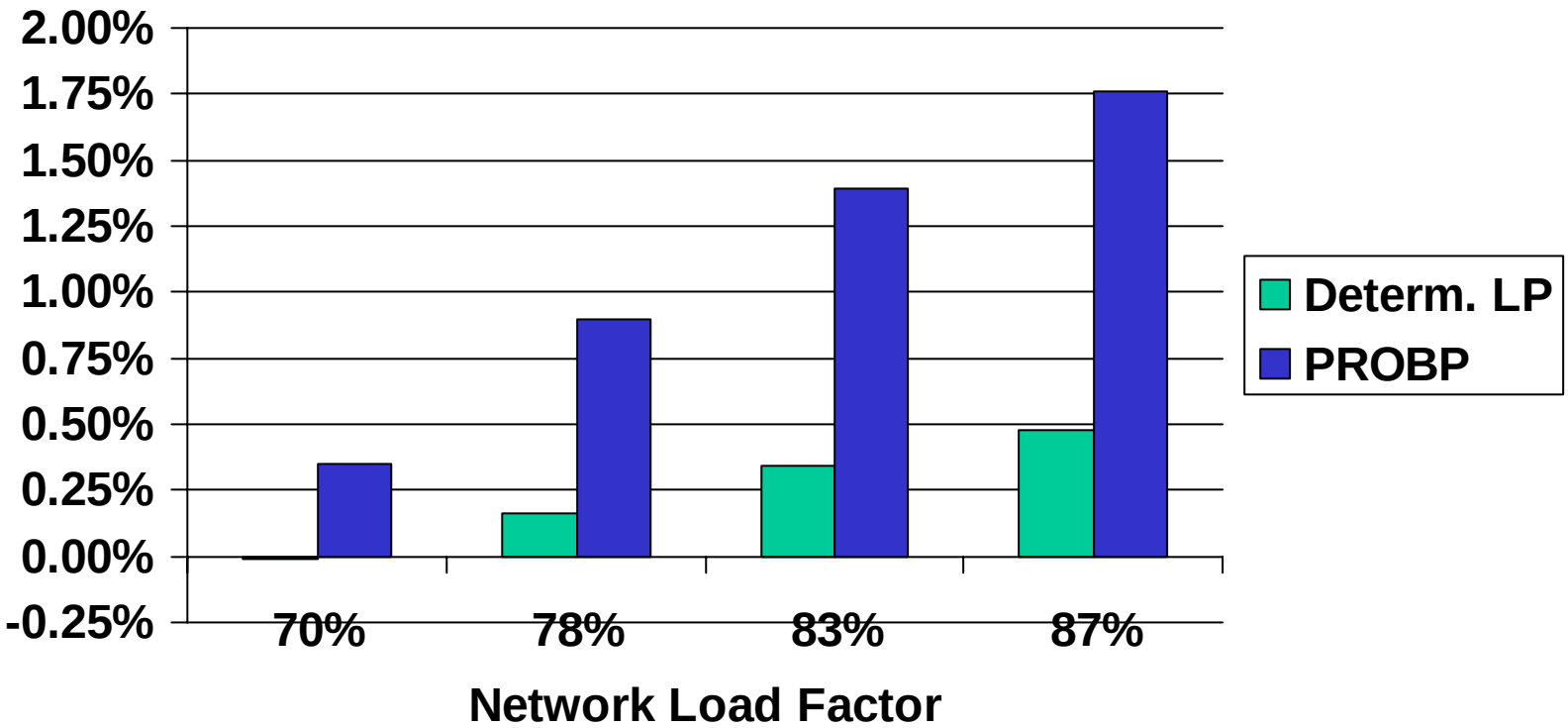
# DAVN Revenue Gains

## Deterministic LP vs. PROBP Displacement Costs



# Network Bid Price Control

## Deterministic LP vs. PROBP Bid Prices



# Sensitivity to Optimization Methods

**Shift from deterministic LP to probabilistic displacement costs in DAVN has little impact:**

- ✈ Probabilistic estimates better by 0.05% or less
- ✈ DAVN control structure is quite robust to choice of network optimization method

**On the other hand, pure Bid Price control is quite sensitive to choice of network optimizer:**

- ✈ Deterministic LP bid prices substantially more volatile, and have a direct impact on accept/reject decisions

# Impacts of Forecasting Models

**Baseline PODS results assume relatively simple ODF forecasting and detruncation methods:**

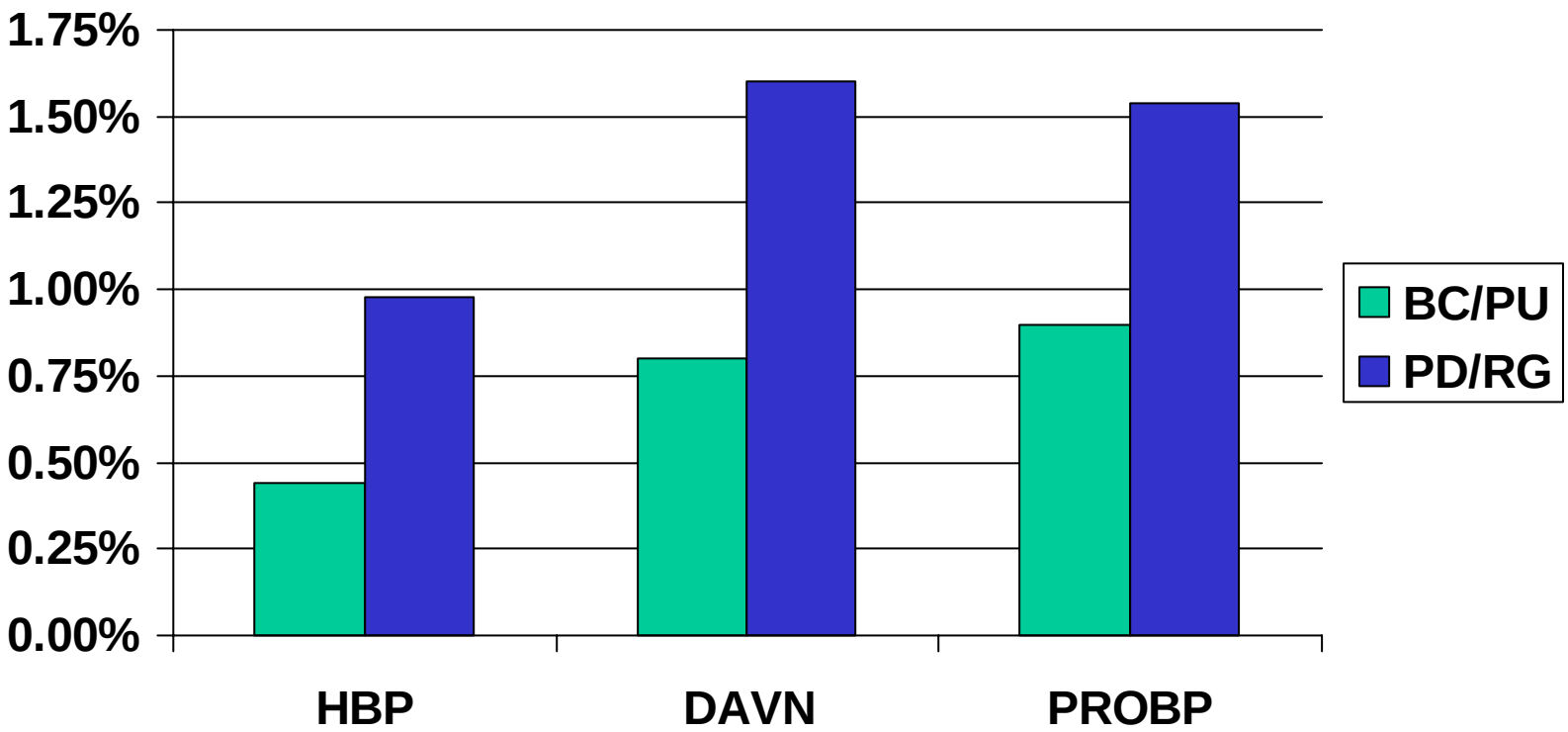
- ✈ "Booking curve" detruncation of closed flights
- ✈ "Pick-up" forecasts of bookings still to come

**PODS simulations have shown large impacts of forecasting and detruncation models:**

- ✈ "Projection" detruncation based on iterative algorithm (Hopperstad)
- ✈ Regression forecasting of bookings to come based on bookings on hand

# Impacts of Forecasting/Detruncation

## vs. FCYM with Same Forecaster, ALF=78%



# Sensitivity to Forecasting Models

**O-D methods benefit from more "advanced" detruncation and forecasting models**

- ✈ Revenue gains almost double vs. FCYM base case
- ✈ Forecasting model can have as great an impact as choice of optimization model

**Possible explanations for improved gains**

- ✈ ODF Forecasts are not more "accurate"-- inability to accurately measure actual demand
- ✈ Overall forecasts are now larger due to more aggressive detruncation, leading to more seat protection for higher revenue passengers

# Competitive Impacts of O-D Methods

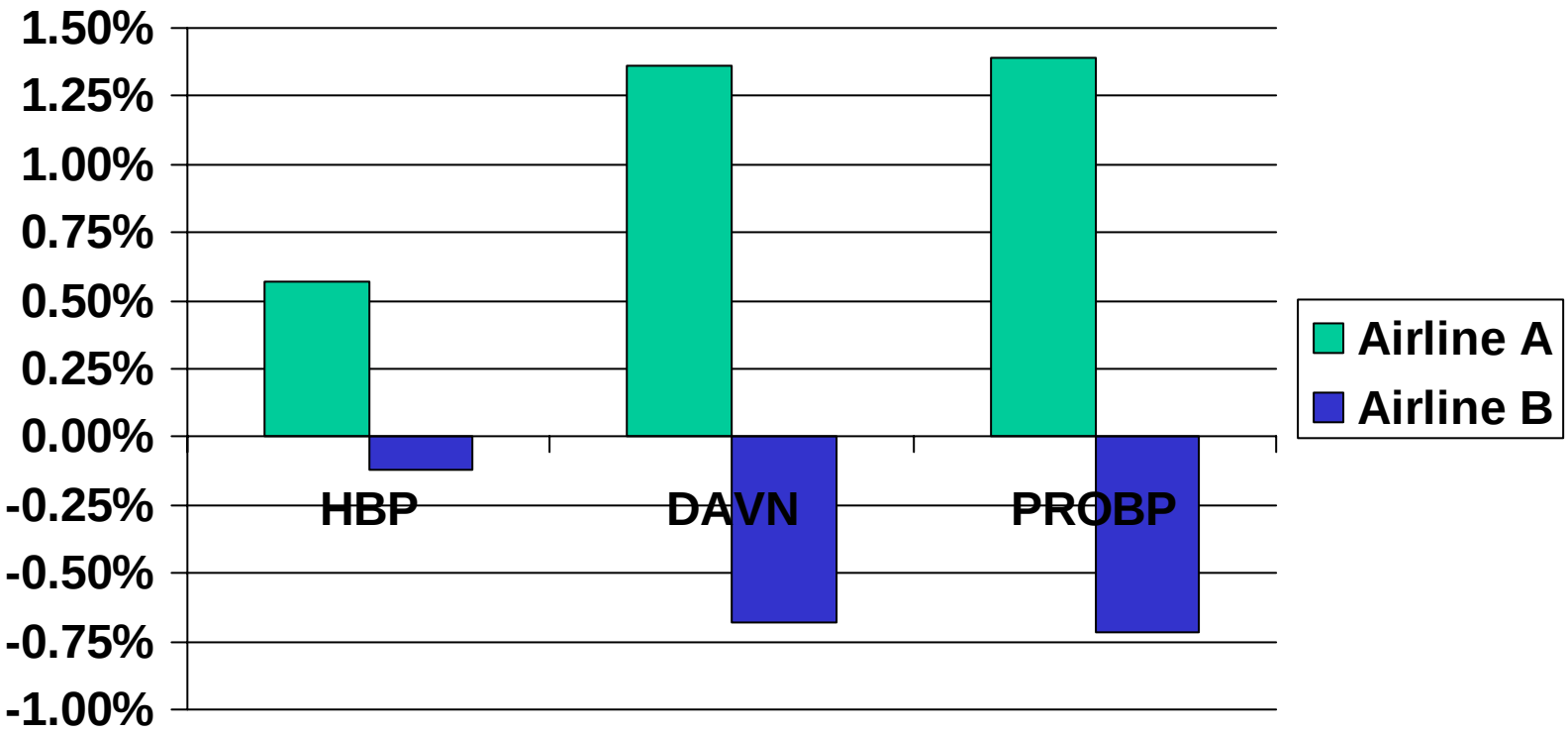
**Implementation of O-D control can have negative revenue impacts on competitor:**

- ✈ Continued use of basic FCYM by Airline B against O-D methods used by Airline A results in revenue losses for B
- ✈ Not strictly a zero-sum game, as revenue gains of Airline A exceed revenue losses of Airline B
- ✈ Other PODS simulation results show both airlines can benefit from using more sophisticated O-D control

**Failure to implement network RM (O-D control) can actually lead to revenue losses against competitor!**

# Competitive Impacts of O-D Control

## Network ALF=83%, Airline B with Basic YM



# Response to Low-Fare Competition

**Under basic leg/fare class RM, no control over value of different passengers booking in each class**

- ✈ With low-fare competitor, matching fares requires assignment to specific fare class
- ✈ Fare class shared by all O-D itineraries using same flight leg and supply of seats

**With O-D control, bookings are limited by network revenue value, not fare type or restrictions**

- ✈ Low matching fares will still be available on empty flights
- ✈ But will not displace higher revenue network passengers

# Matching Low-Fare Pricing Structures

**Low-fare airlines offer "simplified" fare structures**

- ✈ Elimination or reduction of advance purchase requirements
- ✈ Removal of "Saturday night minimum stay" restrictions

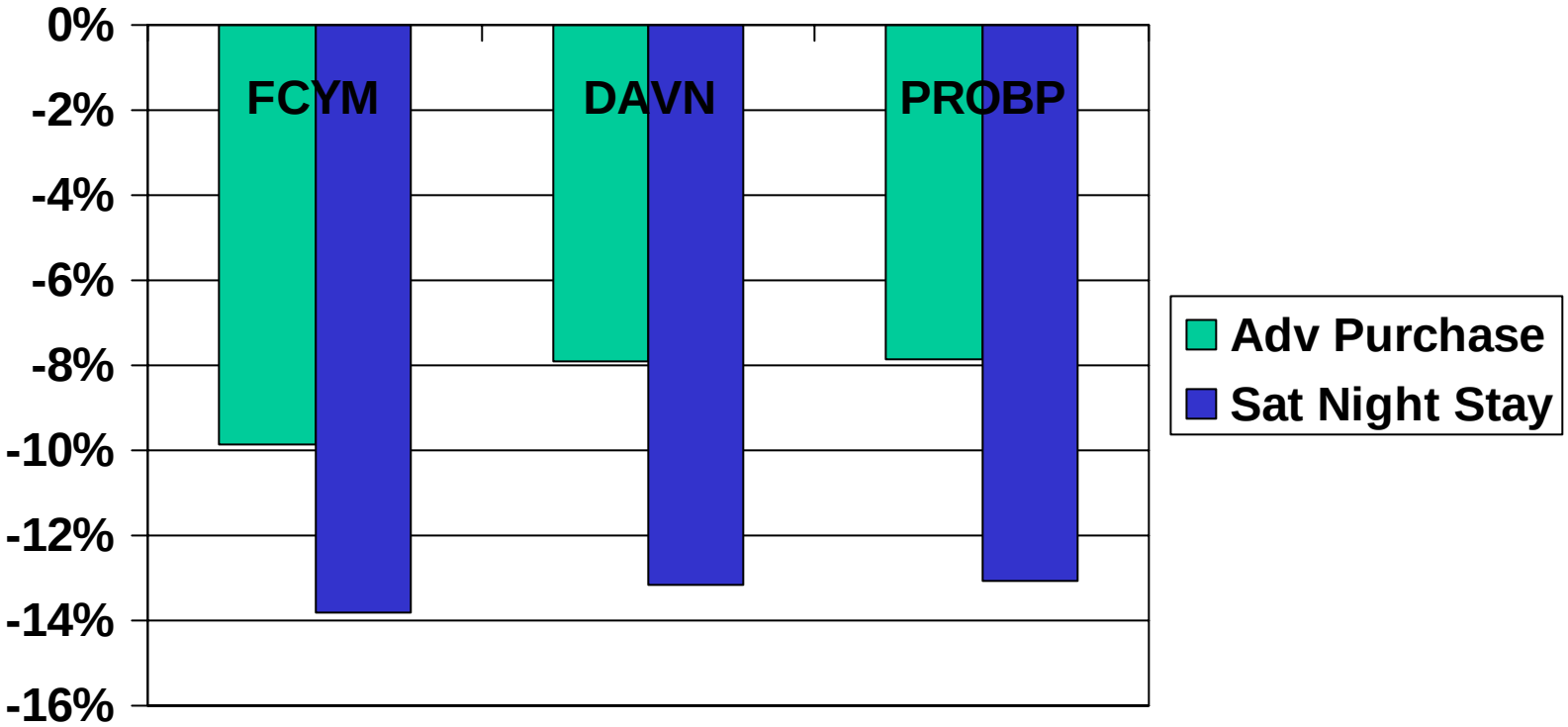
**Matching will <u>reduce</u> revenue for traditional airlines**

- ✈ By as much as 8-9% with removal of advance purchase
- ✈ By 13% or more with no Sat. night stay requirements

**Revenue loss is mitigated by O&D control methods**

- ✈ Compared to less sophisticated FCYM practices
- ✈ But, no evidence that O&D control will eliminate revenue loss – fare restrictions are critical to revenue performance

# Revenue Losses – Removal of Restrictions on Lower Fares



# Alliance Network O-D Control

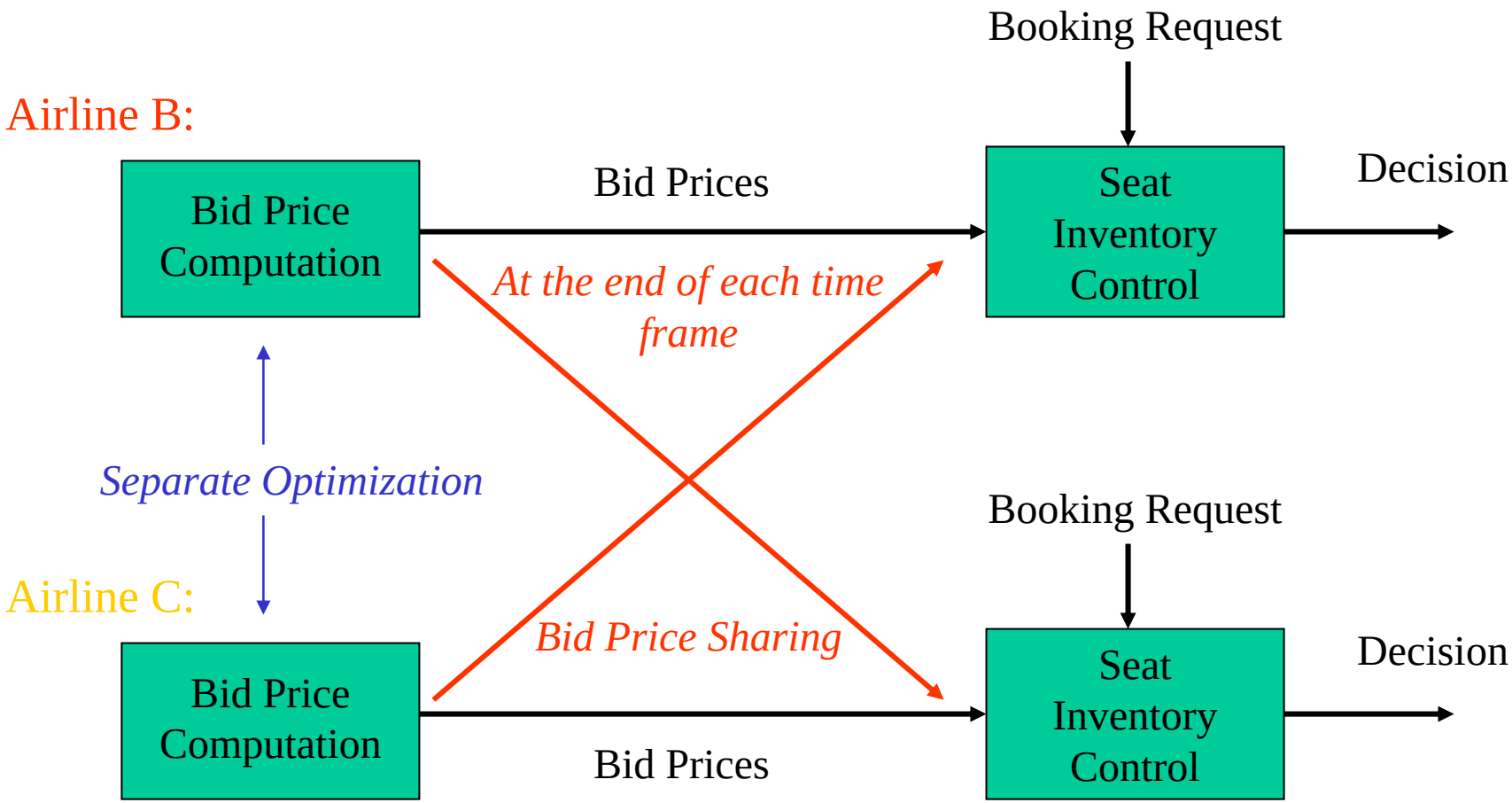
## Alliance code-sharing affect revenue gains of O-D control

- Ability to distinguish between ODIF requests with different network revenue values can give O-D control airline a revenue advantage
- With separate and uncoordinated RM, one partner can benefit more than the other, even causing other partner's revenues to decrease

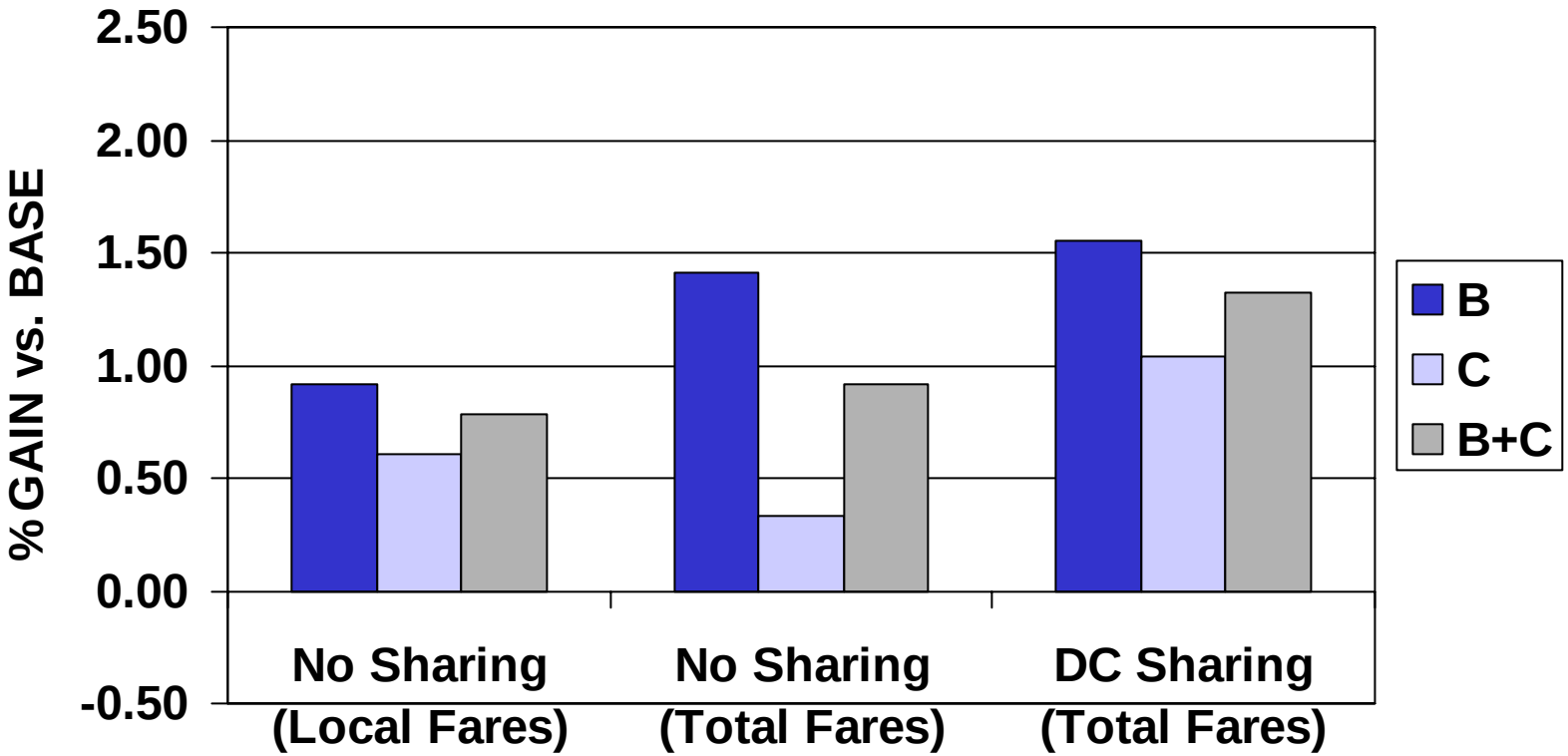
## Information sharing improves network revenue gains, even if partners use different O-D methods:

- Exchanges of network displacement costs or bid prices
- Currently limited by technical and possibly legal constraints.

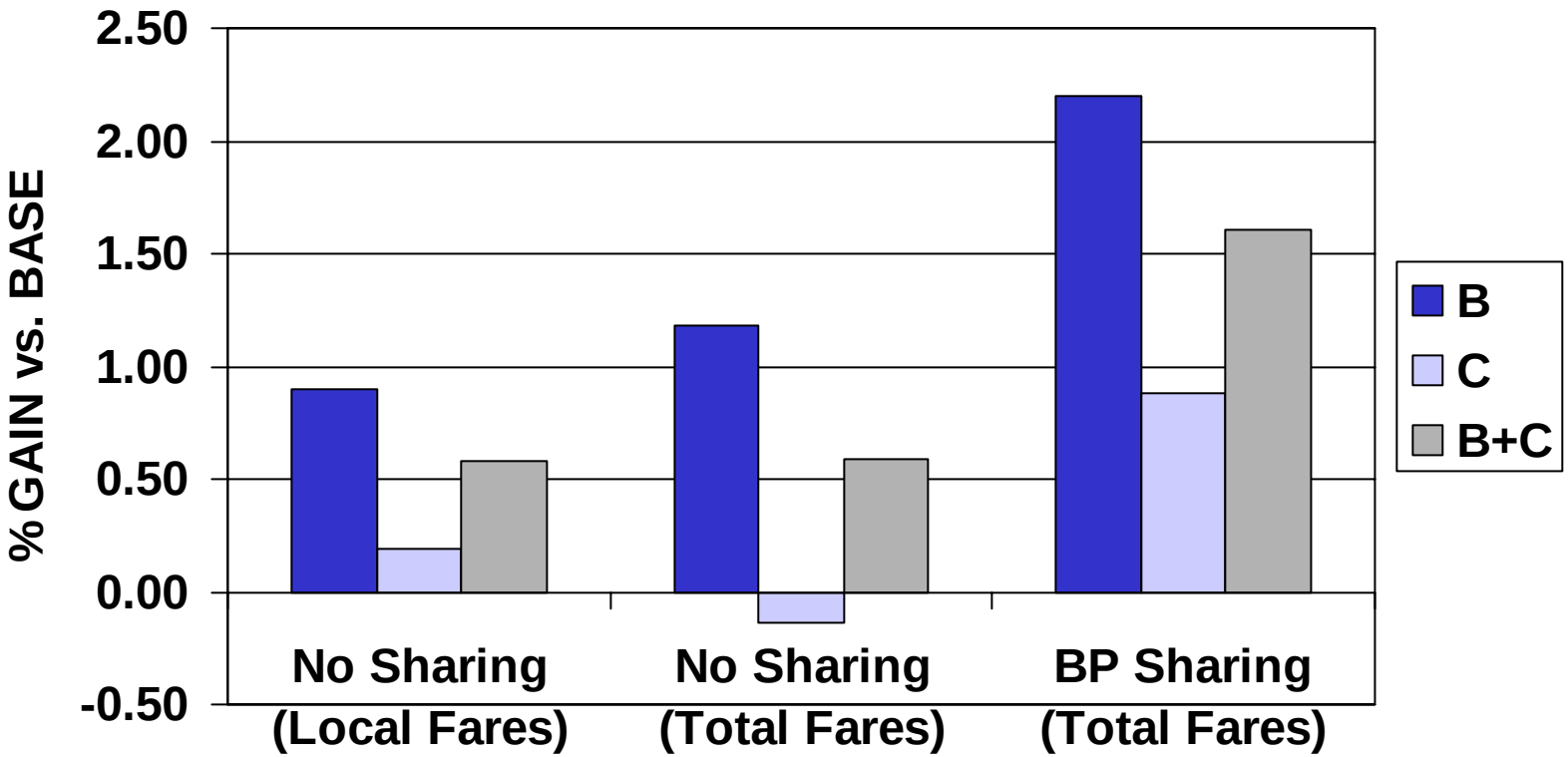
# Alliance Information Sharing



# Displacement Cost Sharing: DAVN/DAVN



# Bid Price Sharing: ProBP/ProBP



# “Abuse” of O-D Controls

**GDS and website technology has evolved to provide “improved” fare searches:**

- Objective is to consistently deliver lowest possible fare to passengers and/or travel agents in a complicated and competitive pricing environment

***Example:*** **Booking two local legs when connecting itinerary not available, then pricing at the through O-D fare in the same booking class.**

- Appears to be occurring more frequently, as web site and GDS pricing search engines look for lowest fare itineraries

# Revenue Impacts of O-D Abuse

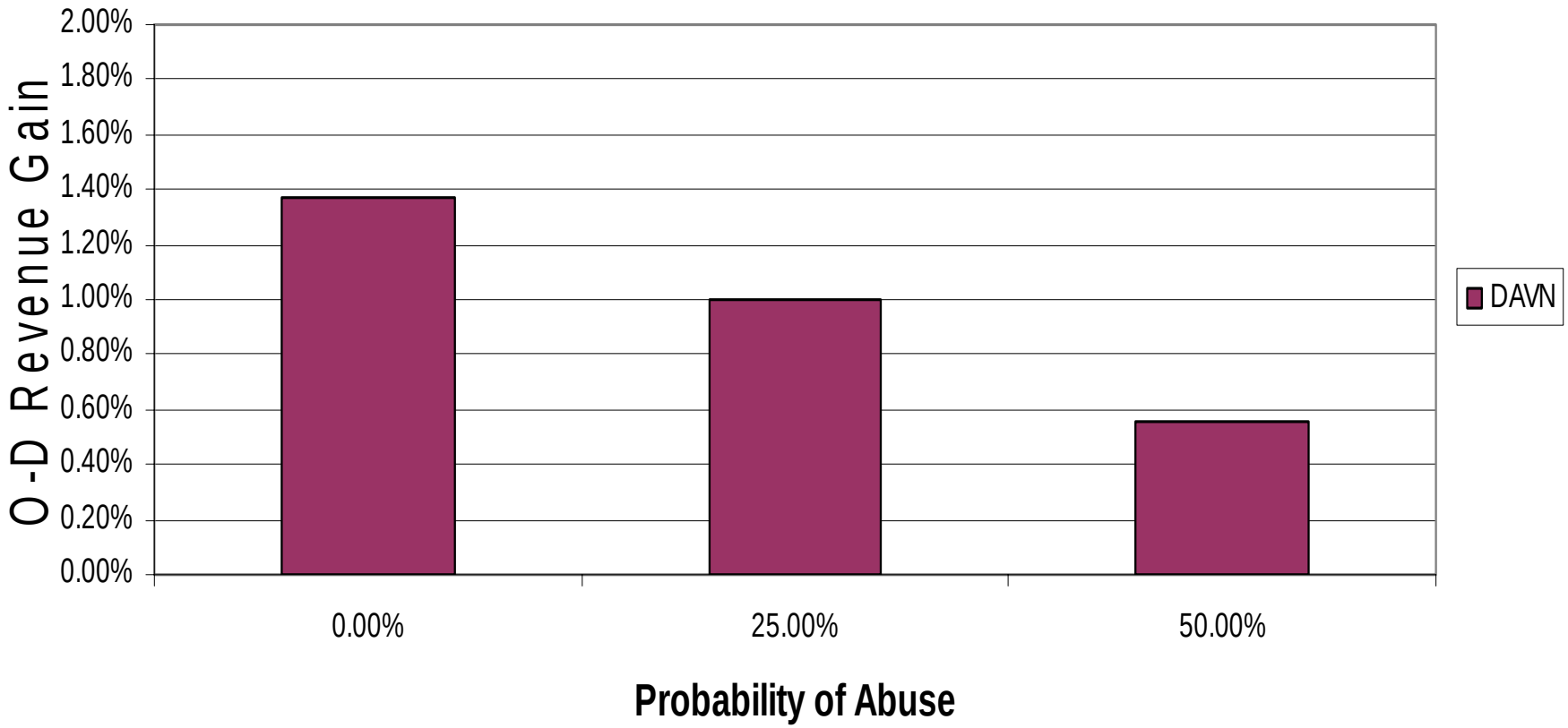
## How big is the revenue impact on O-D methods?

- No revenue impact on FCYM control, since no distinction between local and connecting requests

## Impact depends proportion of eligible booking requests that actually commit abuse

- Even at 25% probability of abuse, revenue gains of DAVN are reduced by up to 1/3
- Means actual revenue gain of DAVN is closer to 1.0% than estimates of 1.4% under perfect O-D control conditions

# O-D Revenue Gains with Varying Probability of Abuse (Base Case: Eb vs. Eb, DF=1.0, LF=83%)



# O-D Control: What Have We Learned?

**Revenue gains of O-D control affected by:**

- ✈ Network characteristics, demand levels and variability
- ✈ Combined implementation of optimization, forecasting and control mechanisms
- ✈ Airline alliances, fare structures and distribution constraints

**A strategic and competitive necessity for airlines:**

- ✈ Typical network revenue gains of 1-2% over basic FCYM
- ✈ Protect against revenue loss to competitors with O-D control
- ✈ Improved control of valuable inventory in the face of pricing pressures, distribution channels, and strategic alliances