



MIT International Center for Air Transportation

Analysis of Profit Cycles In the Airline Industry

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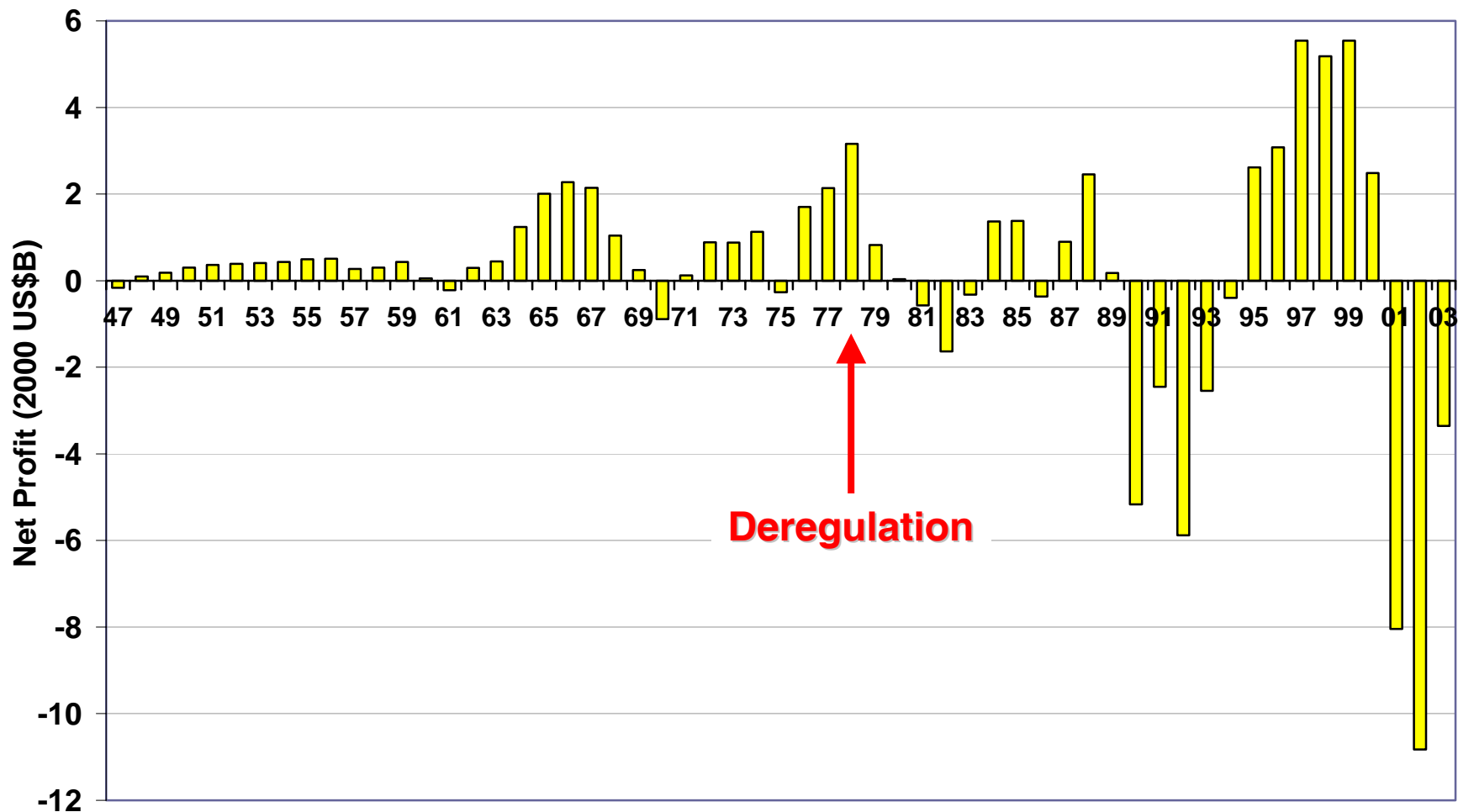
MIT Global Airline Industry Program

Industry Advisory Board Meeting

November 4th, 2004, MIT

US Airline Net Profit (1947-2002)

Cyclic Industry Undamped 2nd Order System Since Deregulation





Motivation

- **Understand the financial dynamics of airline industry**
 - Identify fundamental cycles of US/world airline industry profits
 - Identify driving factors of the system's financial behavior

- **Investigate policies and strategies to mitigate profit oscillations**
 - Evaluate tradeoffs of policies and strategies

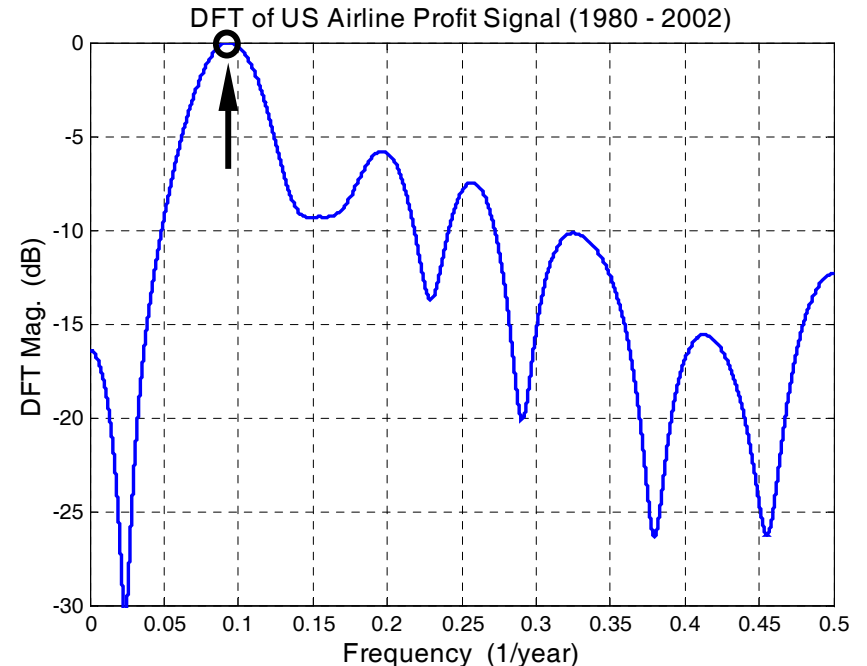
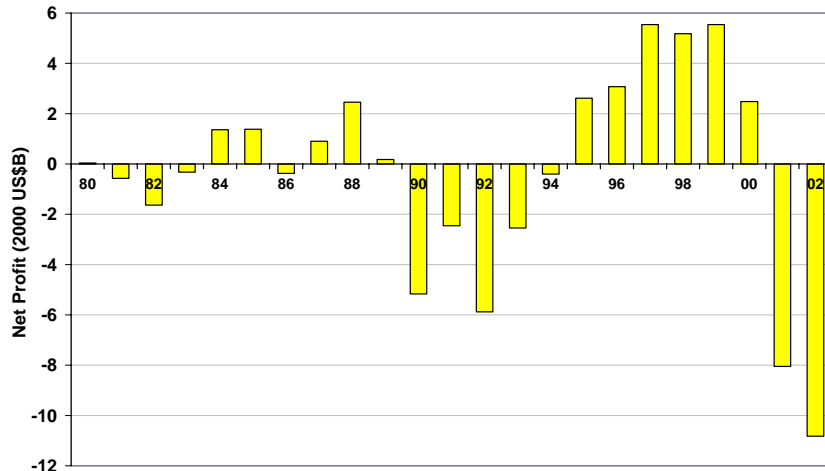
Identify Fundamental Cycle US Airline Industry

■ Approach

- ❑ Assume the industry as an undamped 2nd order system
- ❑ Discrete Fourier Transform (DFT) in frequency domain
- ❑ Analyze before and after deregulation for cycle period and profit growth

■ Results

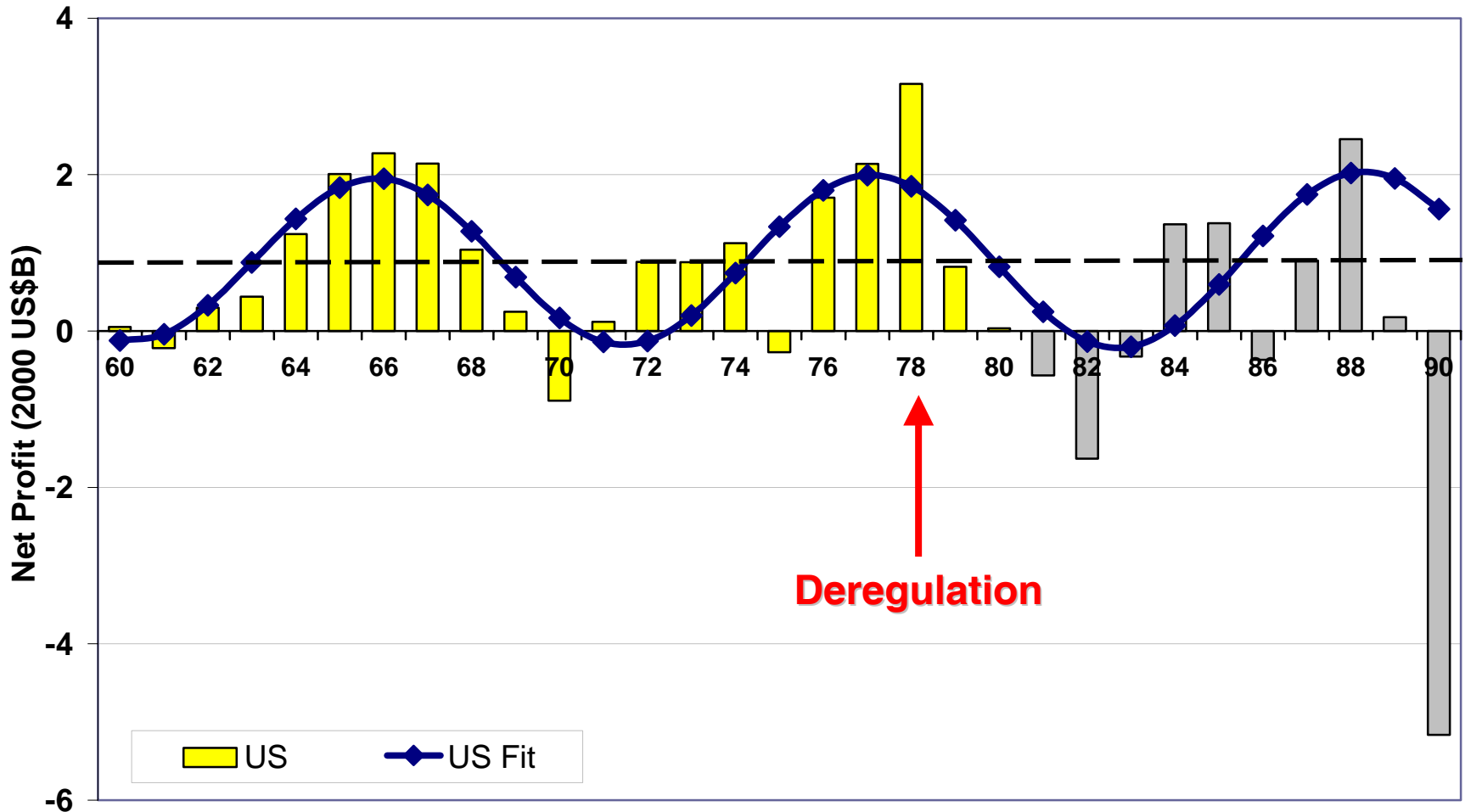
- ❑ Fundamental frequency $\cong 0.09/\text{yr}$
- ❑ Cycle period $\cong 11 \text{ yr}$



Data source: ATA, US airlines, all services

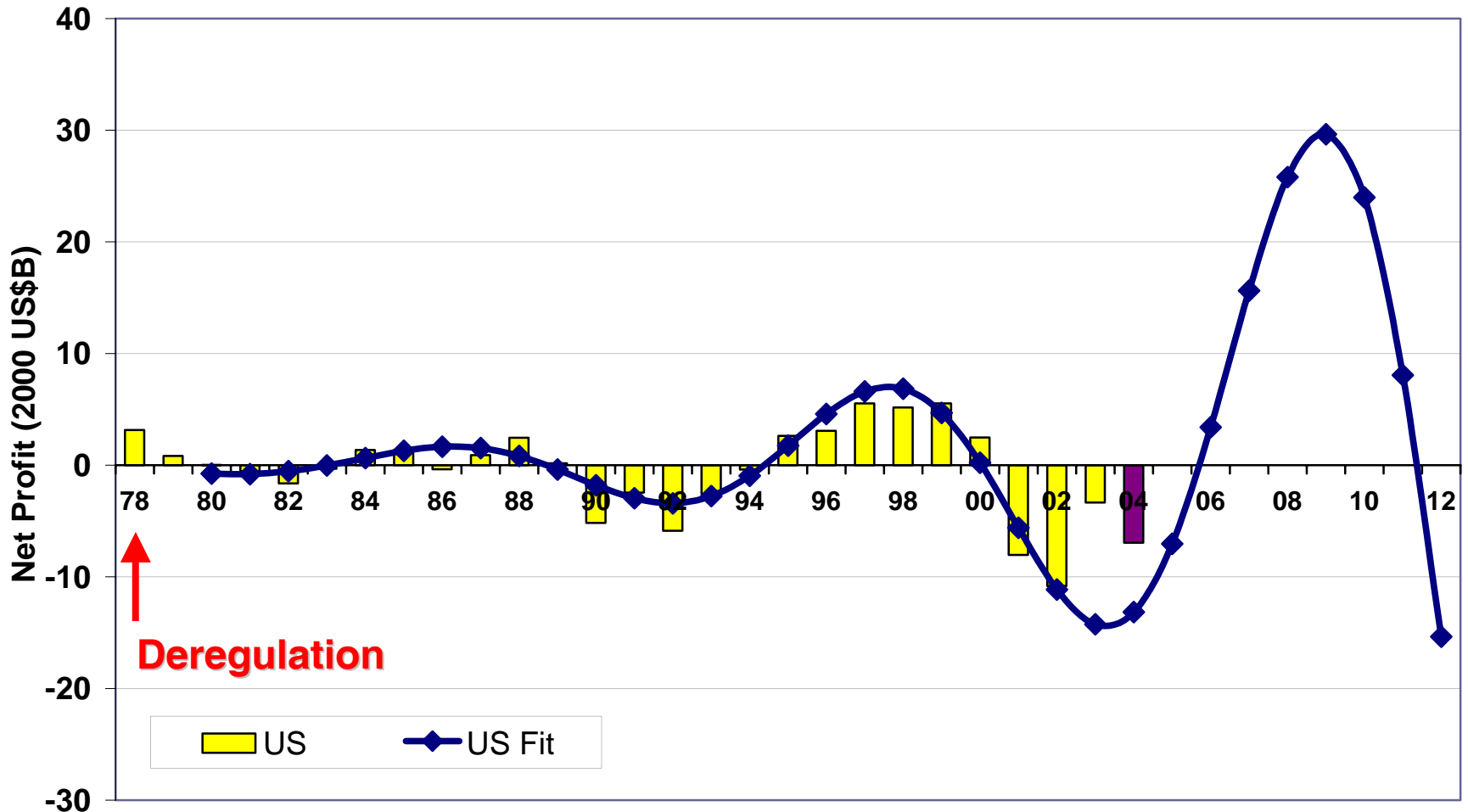
US Airline Net Profit Analysis Before Deregulation

Cycle Period = 11.2 yr Mean = 0.90 \$B



US Airline Net Profit Analysis After Deregulation

Cycle Period = 11.3 yr eFolding Time = 7.9 yr



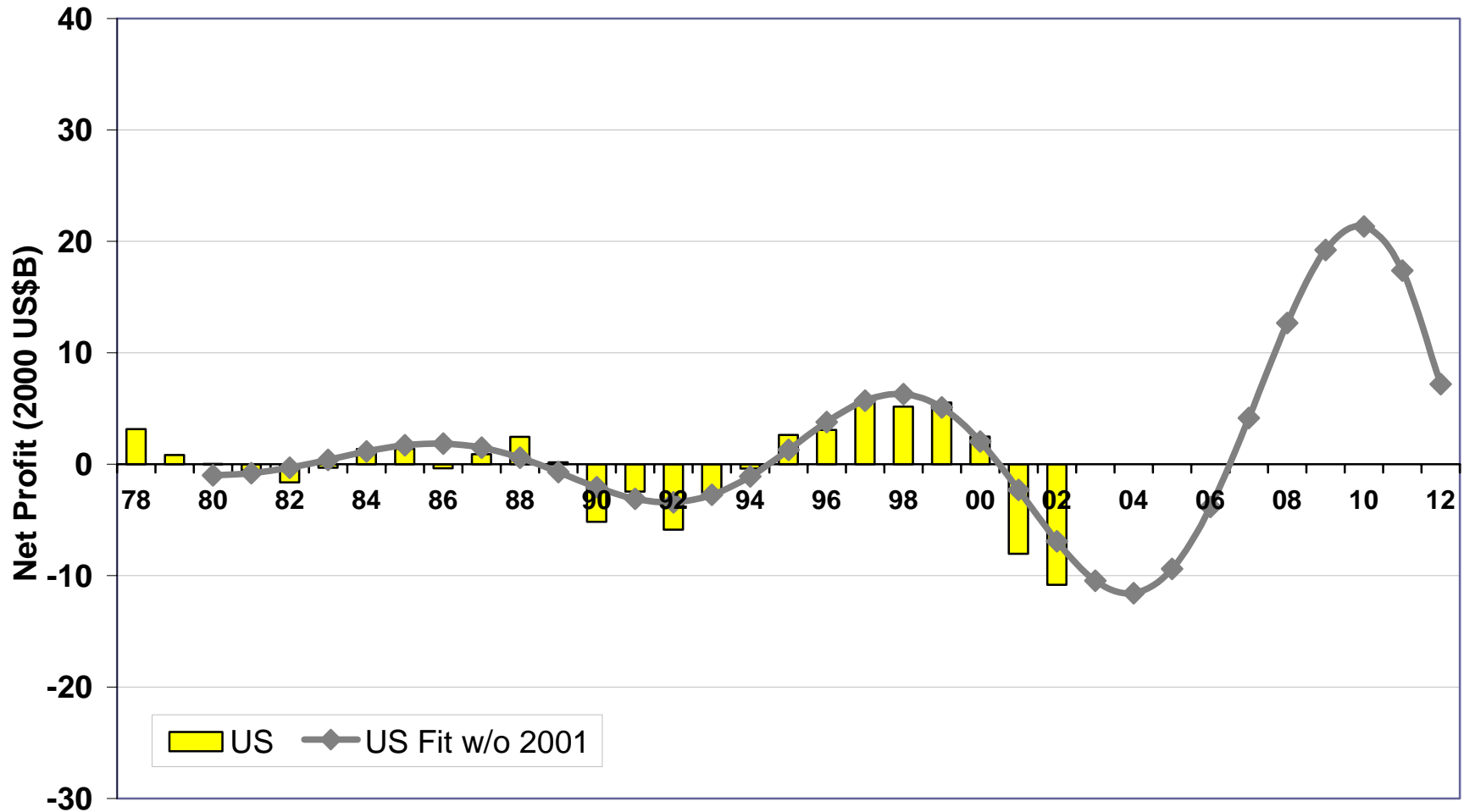
NB: 2004 profit estimated by prorating US major's performance in the 1st half.



September 11 Does not Significantly Change Trend

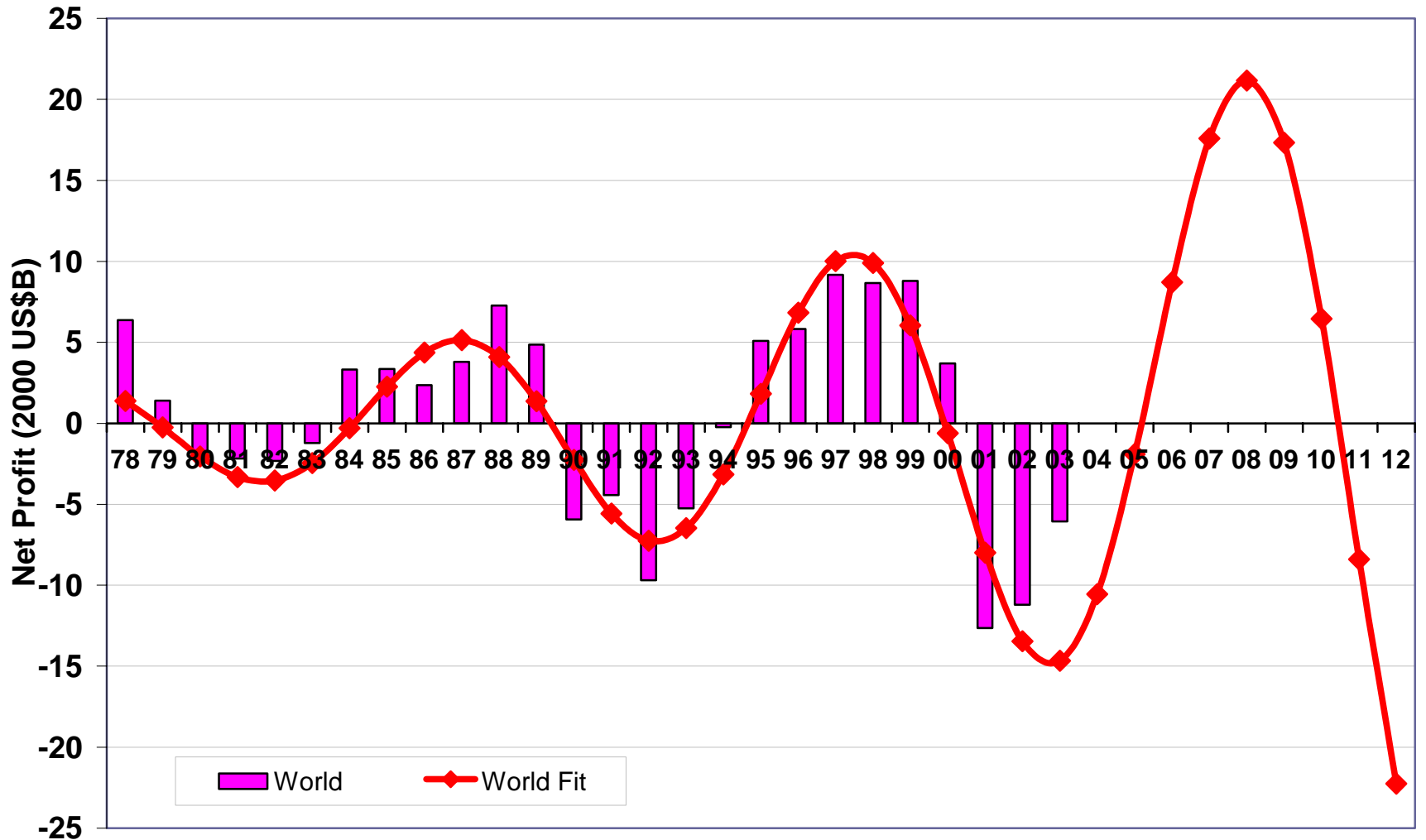
(Analysis using only data before 2001)

Cycle Period = 12 yr eFolding Time = 9.8 yr



World Airline Net Profit Analysis

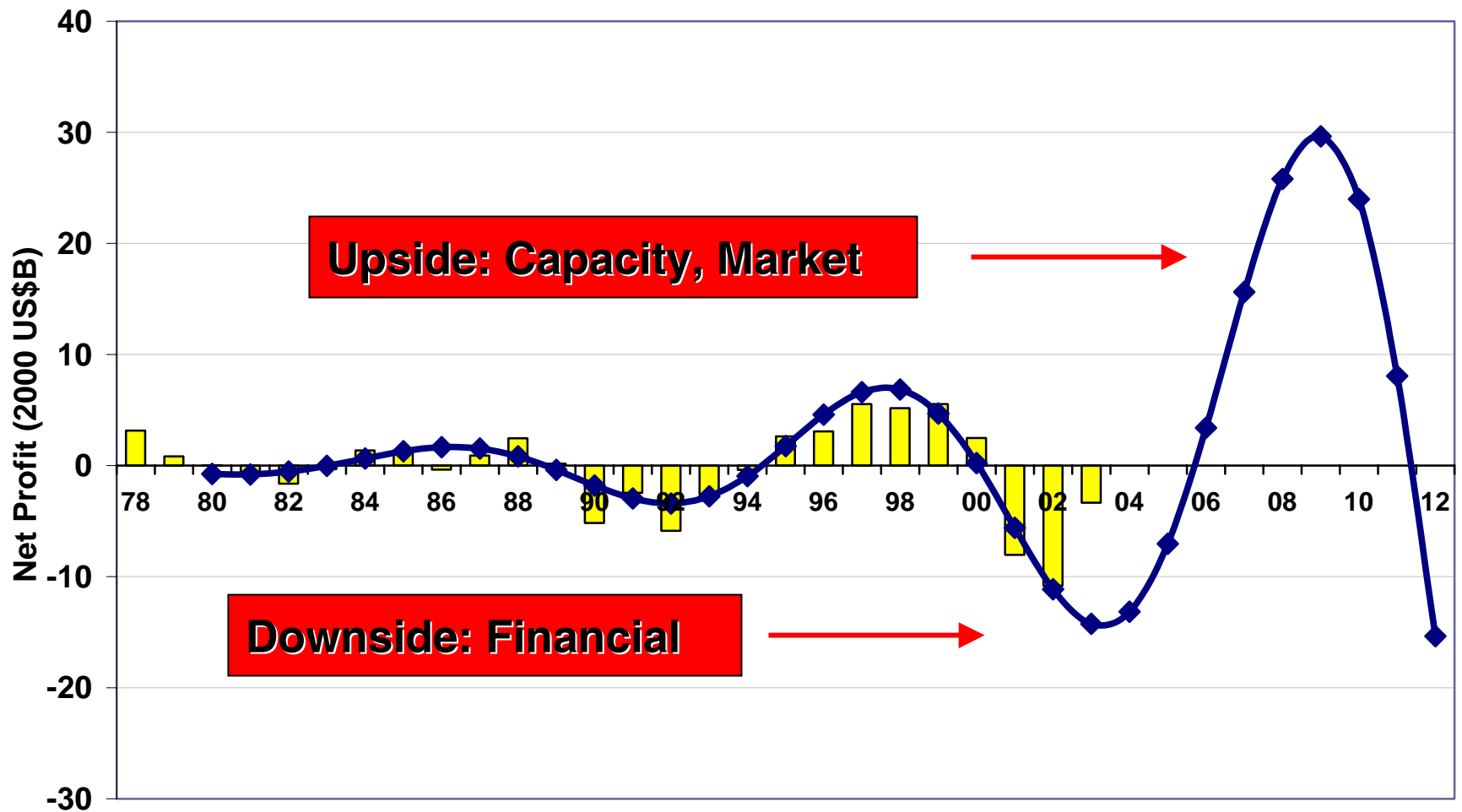
Cycle Period = 10.5 yr eFolding Time = 14.9 yr



Source: ICAO data

Growth Limits

Constraints vs Damping





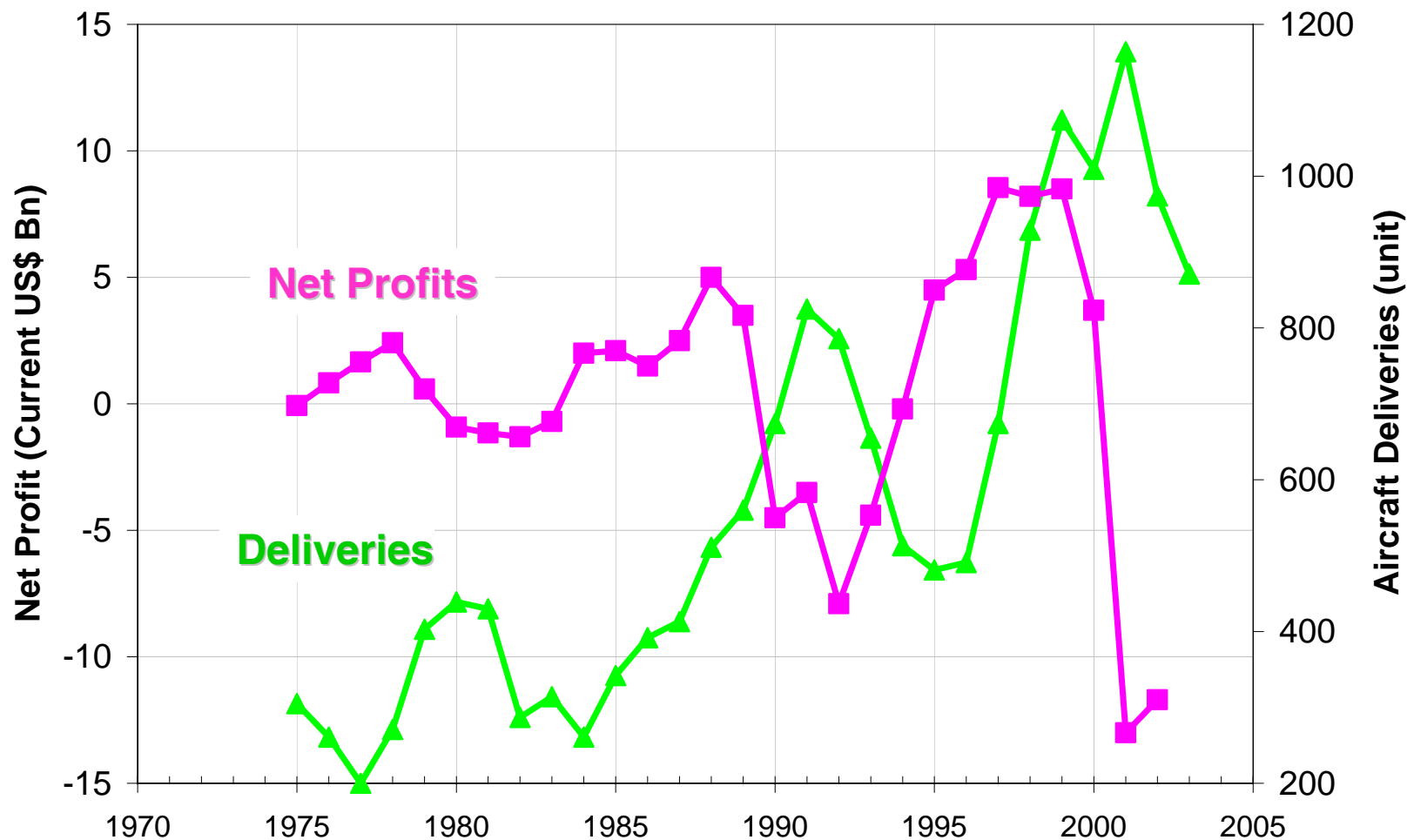
Hypotheses

Potential Sources of Phase Lag

- **The undamped behavior is due to the phase lag in the system**
- **Two potential sources of phase lag**
 - Lag in capacity response
 - Lag in cost adjustment

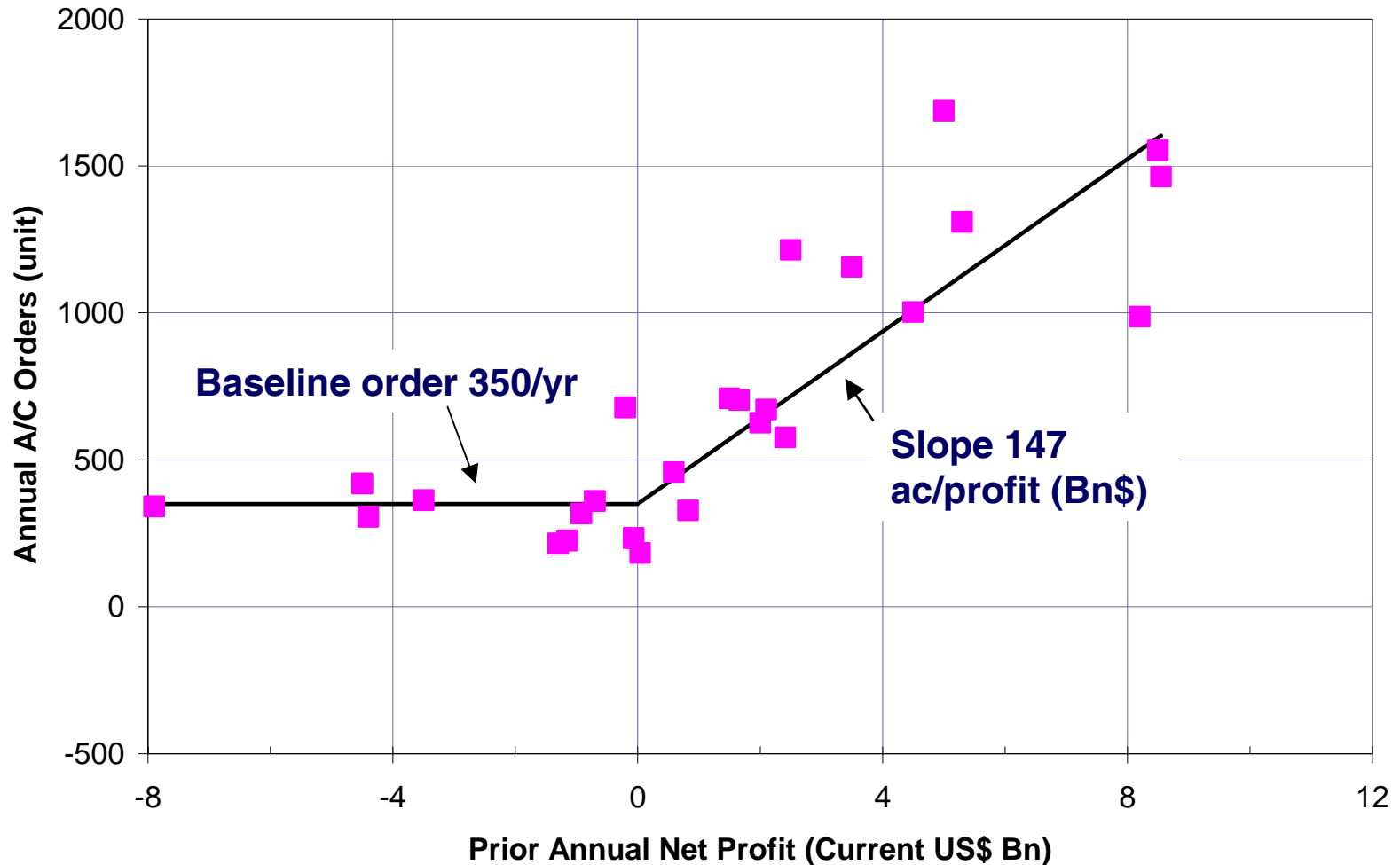
Capacity Hypothesis

World Airline Net Profits vs. Aircraft Deliveries



Estimation - World A/C Orders and Annual Net Profit with 1Yr Delay

$A/C\ Order = 350 + 147 \times Profit(Bn\$)$ when profitable



Source: based on ICAO data

Annual A/C order is plotted with respect to last year's annual net profit

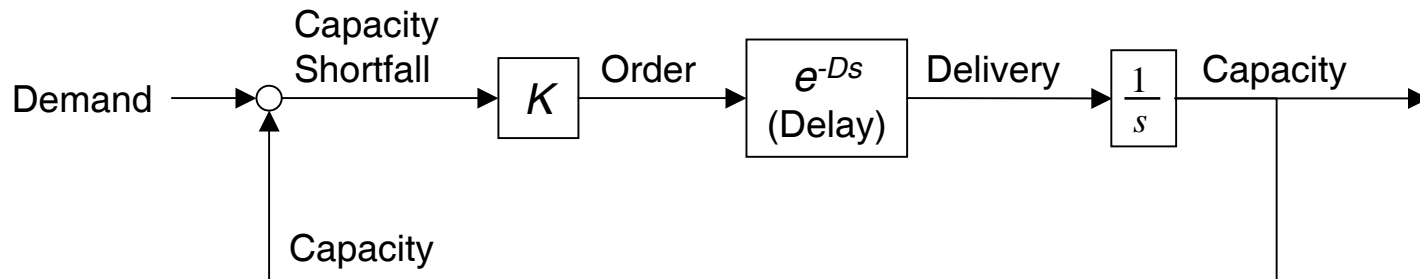
$R^2 = 0.637$

Parametric Model for Capacity

■ Hypothesis

- Phase lag in **capacity** response causes system oscillate

■ Simple Parametric Model



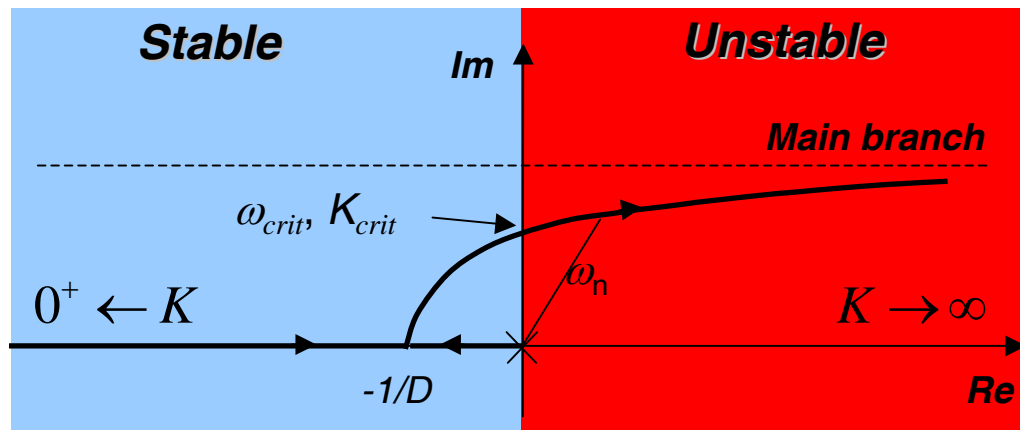
- Closed loop transfer function

$$H(s) = \frac{\frac{Ke^{-Ds}}{s}}{1 + \frac{Ke^{-Ds}}{s}}$$

Root Locus Analysis of System Stability

- System becomes unstable when

$$\omega > \omega_{crit} \quad \text{and/or} \quad K > K_{crit}$$

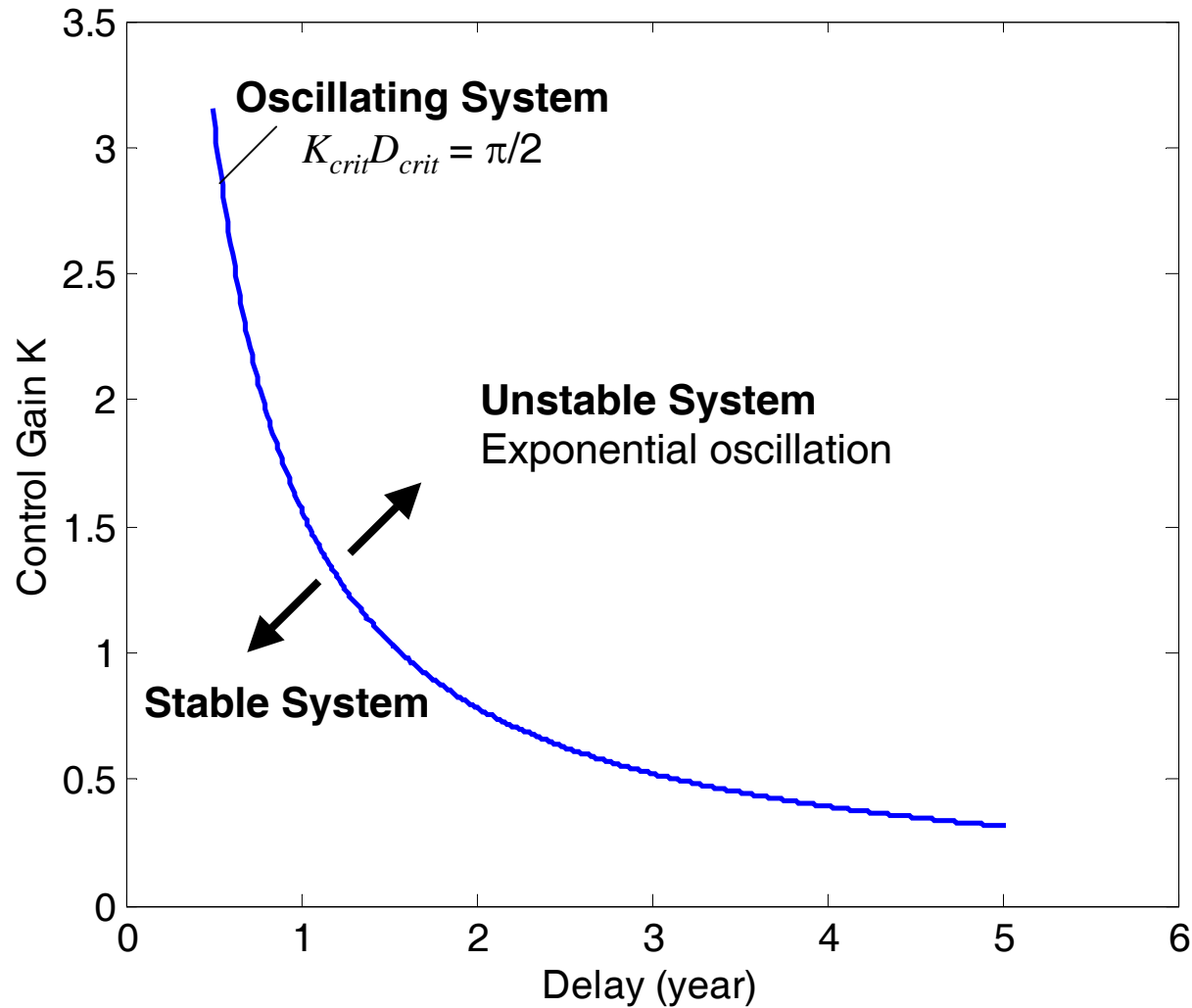


- Critical frequency and gain

$$\omega_{crit} = \frac{\pi}{2D} \quad \text{or} \quad T_{crit} = \frac{2\pi}{\omega_{crit}} = 4D$$

$$K_{crit} = \frac{\omega_{crit}}{\sin(\omega_{crit}D)} = \omega_{crit} = \frac{\pi}{2D}$$

Relationship between System Stability and Delay/Gain Values





Delay/Gain Values for Airline Industry

■ Assumption

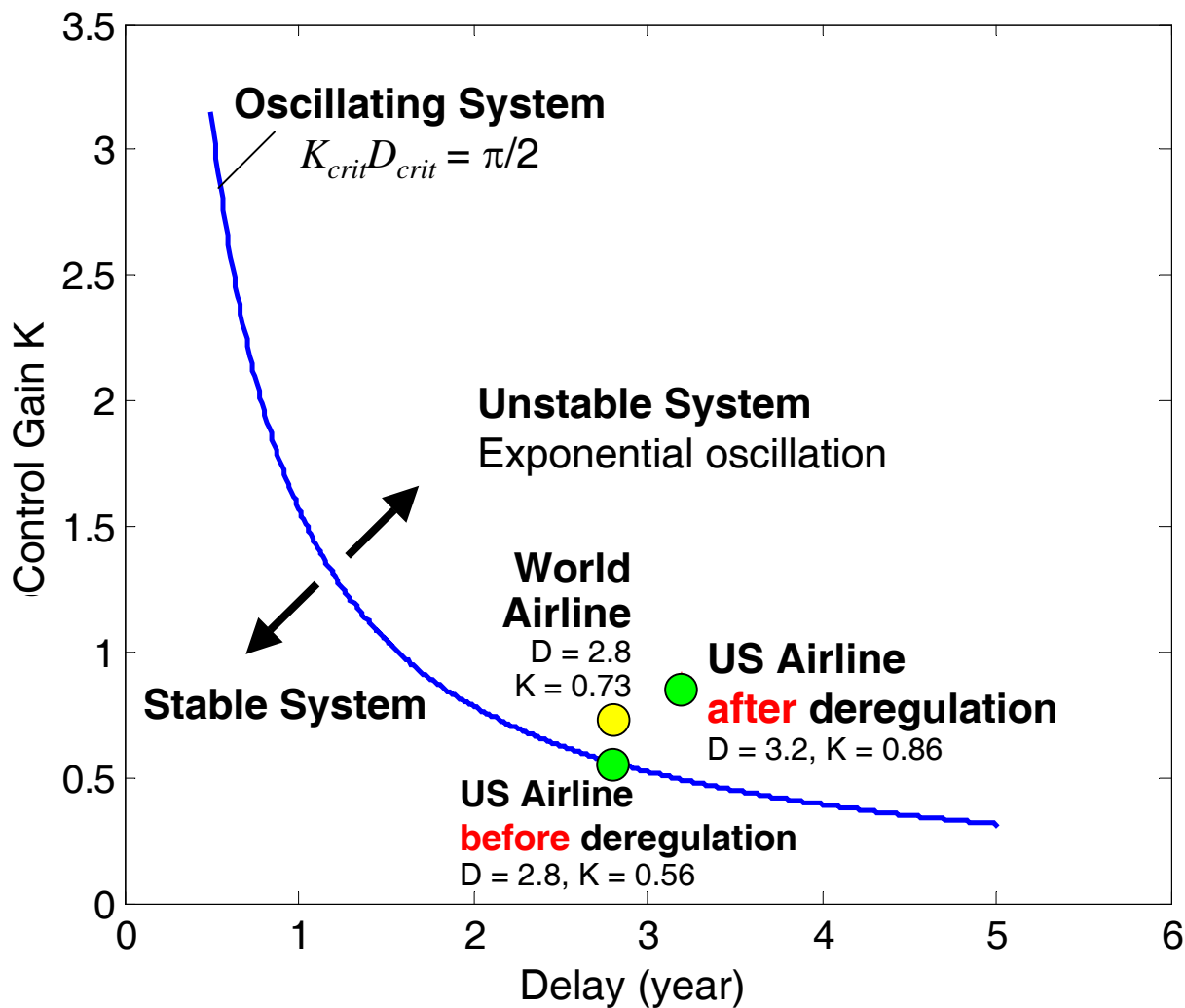
- Industry profit proportional to capacity shortfall

$$Profit = C (Demand - Capacity)$$

■ Convert profit data into delay and gain

- Gain K is the orders based on capacity shortfall, units in [%]
- Delay D has the units in [year]

Relationship between System Stability and Delay/Gain Values





Factors Contributing to Delay and Gain

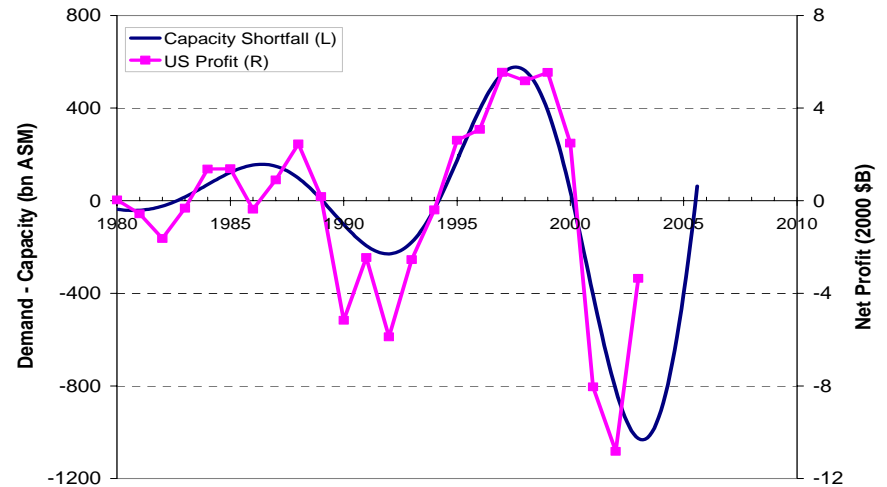
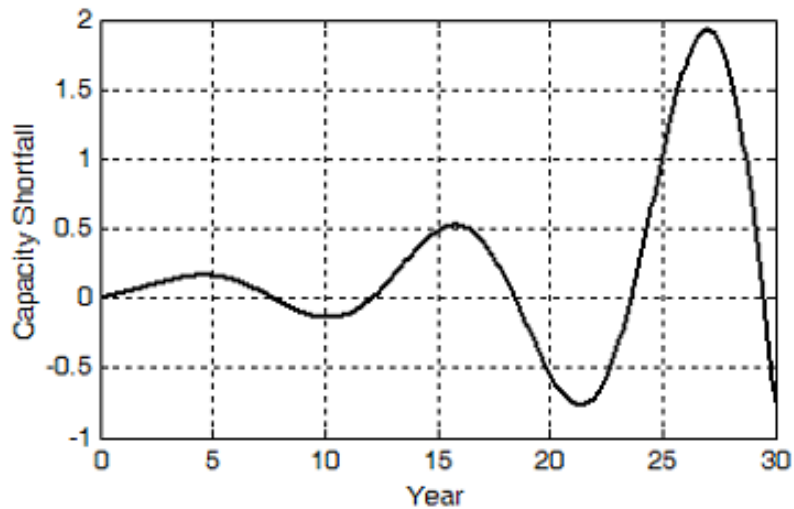
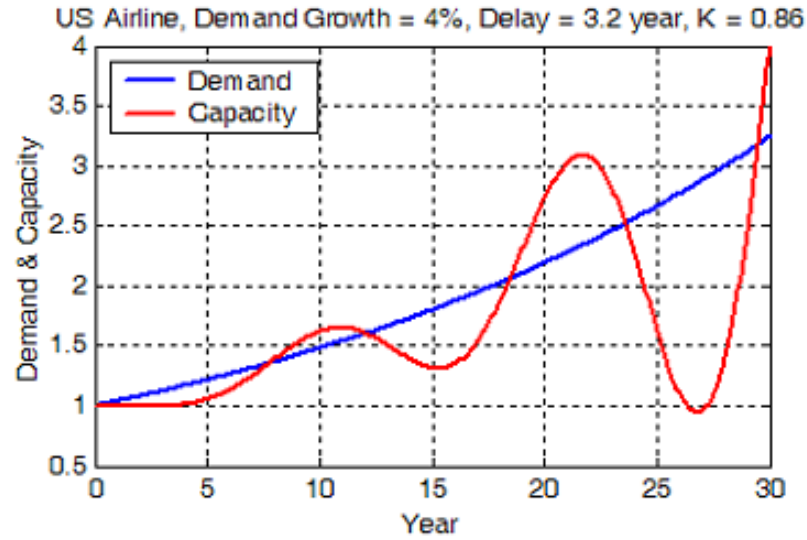
■ Delay

- Order decision time and processing time
- Manufacturing lead time

■ Gain

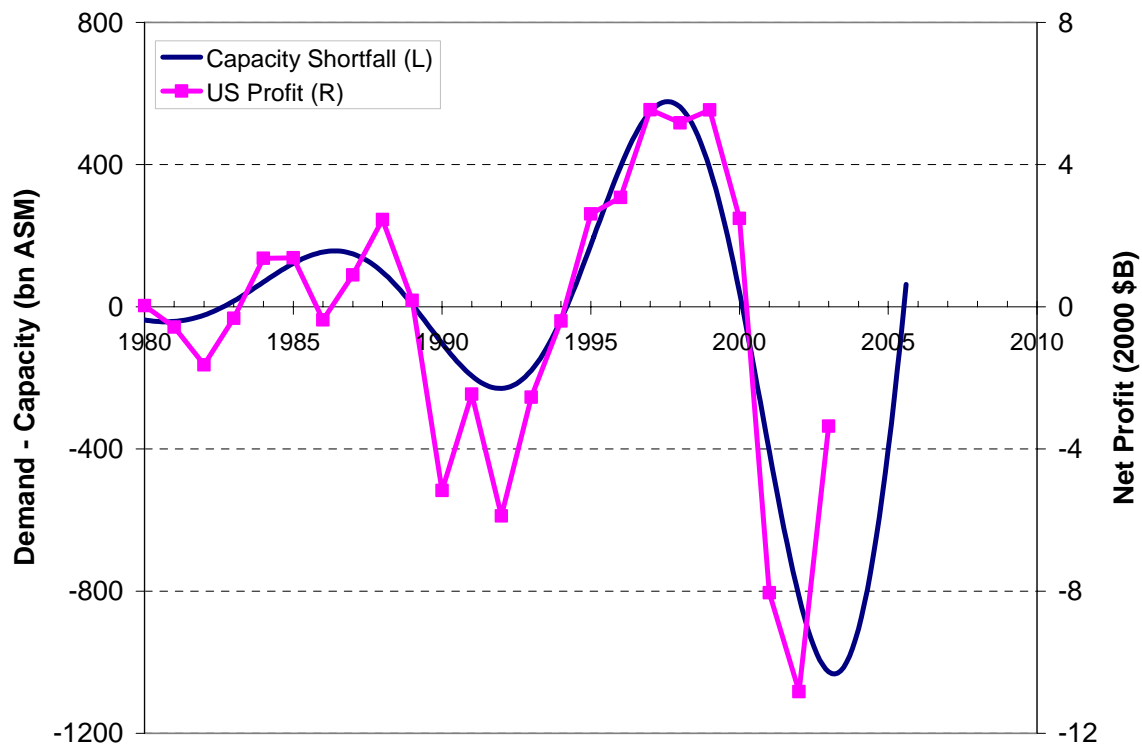
- Optimistic in total capacity projection
- Collective market share perspective $\geq 100\%$
 - Aggregate effect of individual airlines' projection in market share
- Aggressiveness in ordering airplanes

Capacity Simulation US Airline



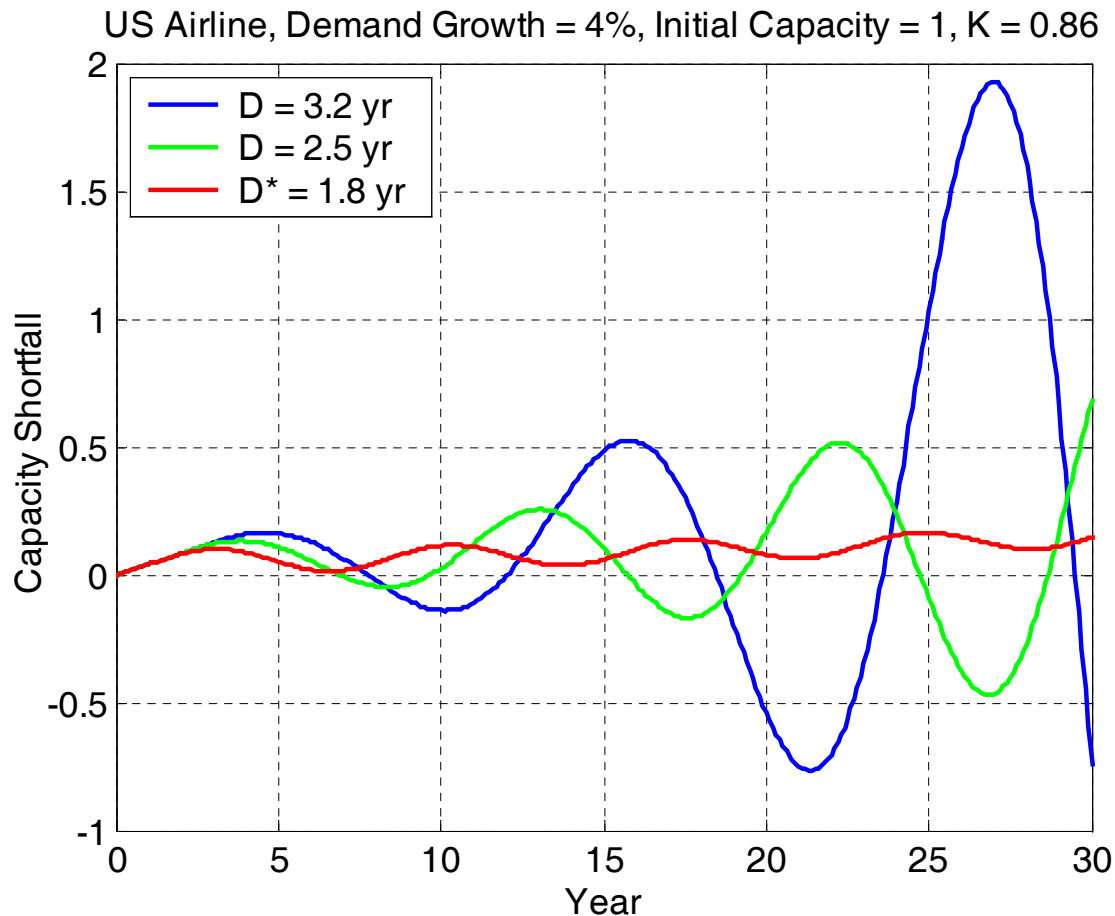
Cost of Adding Capacity US Airline

- Oscillation behavior in capacity shortfall is consistent with industry profit
- Under the simple assumption of $Profit = C (Demand - Capacity)$
 - Given demand grow at 4%, initial demand = 416 billion ASM (ASM in 1979)
 - $C \cong 0.01$ \$ profit (2000 \$) per SM in capacity shortfall (preliminary results)



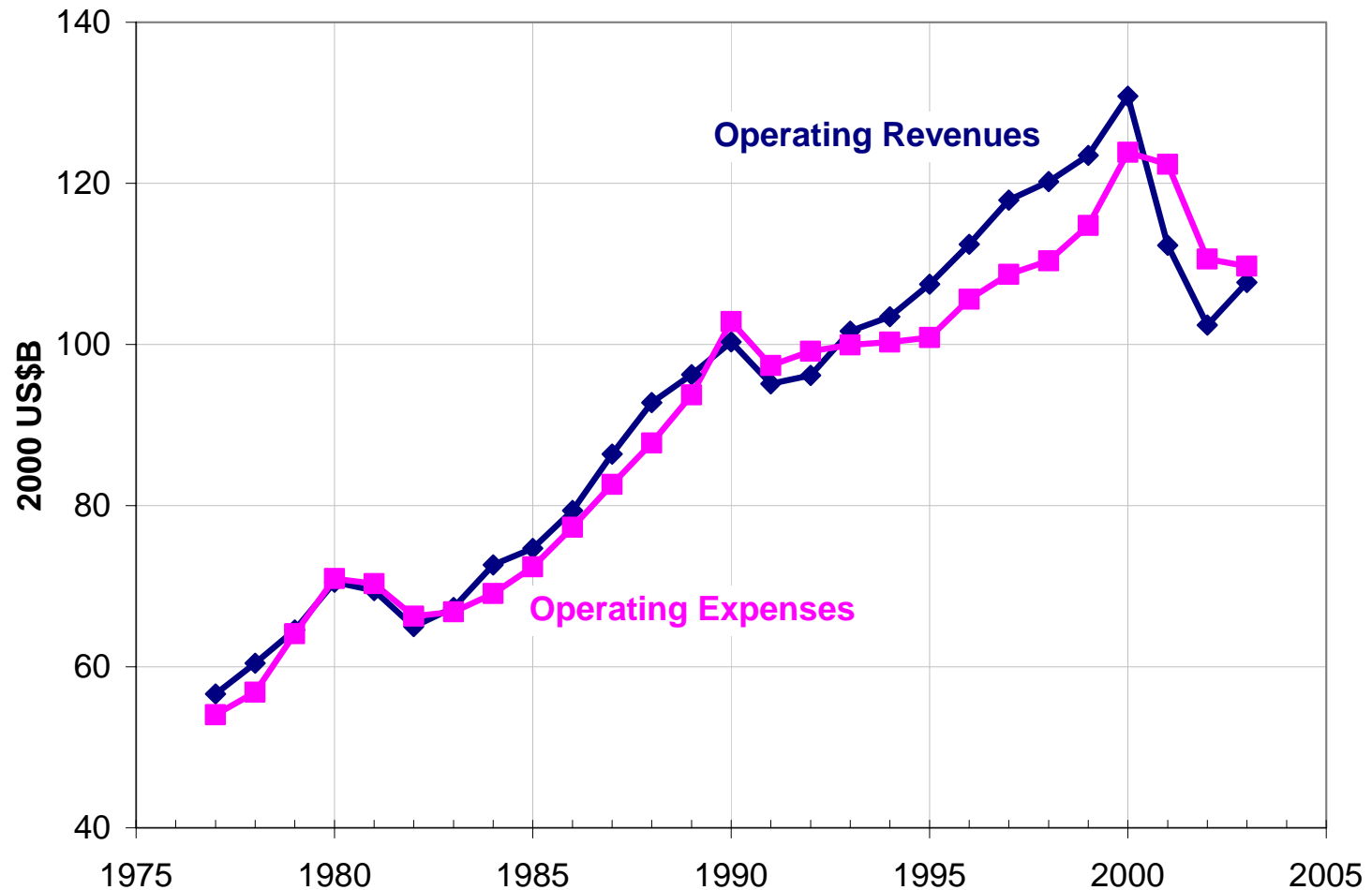
Mitigate System Oscillations US Airline

- System stabilized when delay is reduced to critical value 1.8 years if gain K holds unchanged
 - Assume airplane ordering behavior unchanged



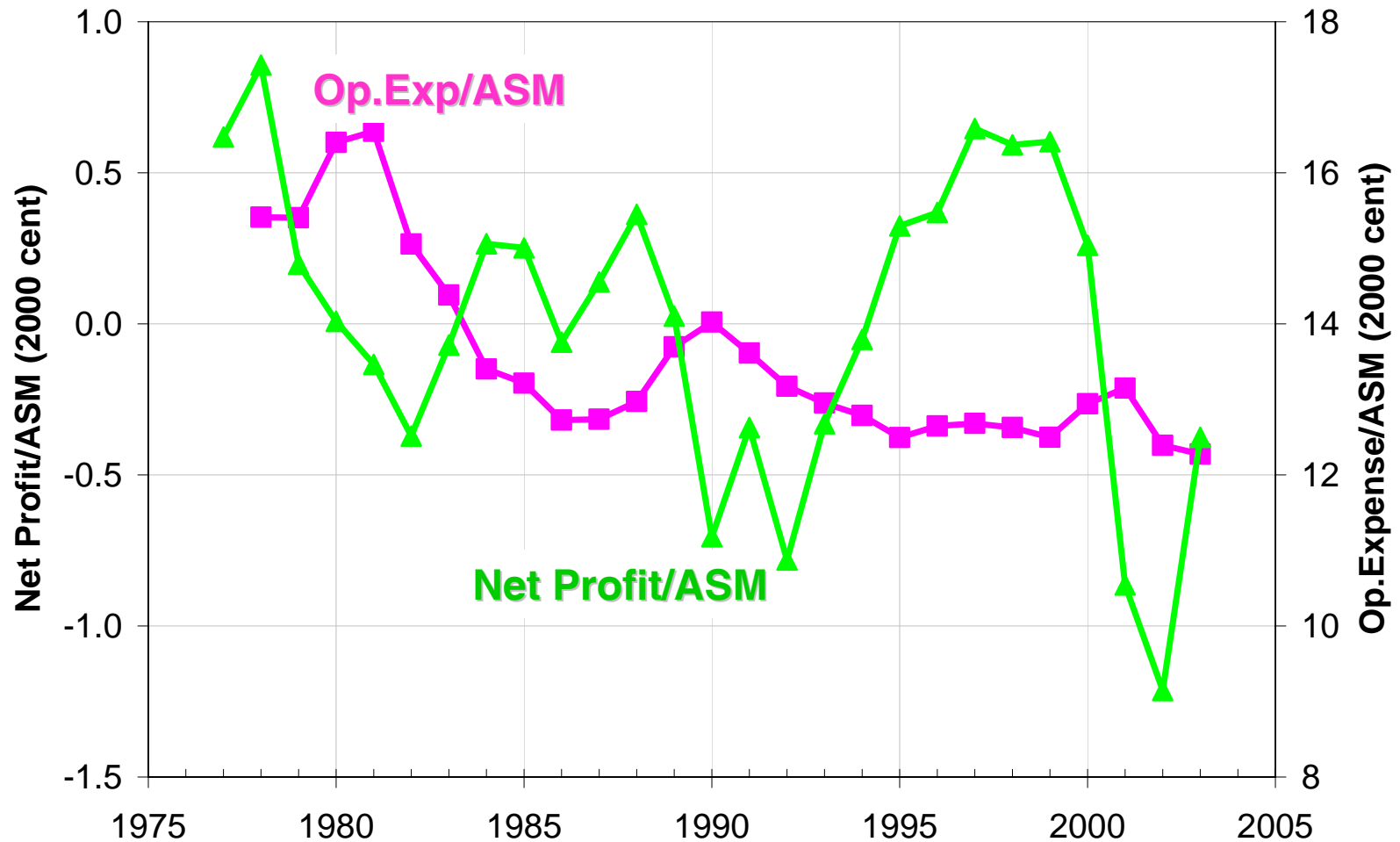
Operating Performance of US Airline

US Airline Operating Revenues and Expenses



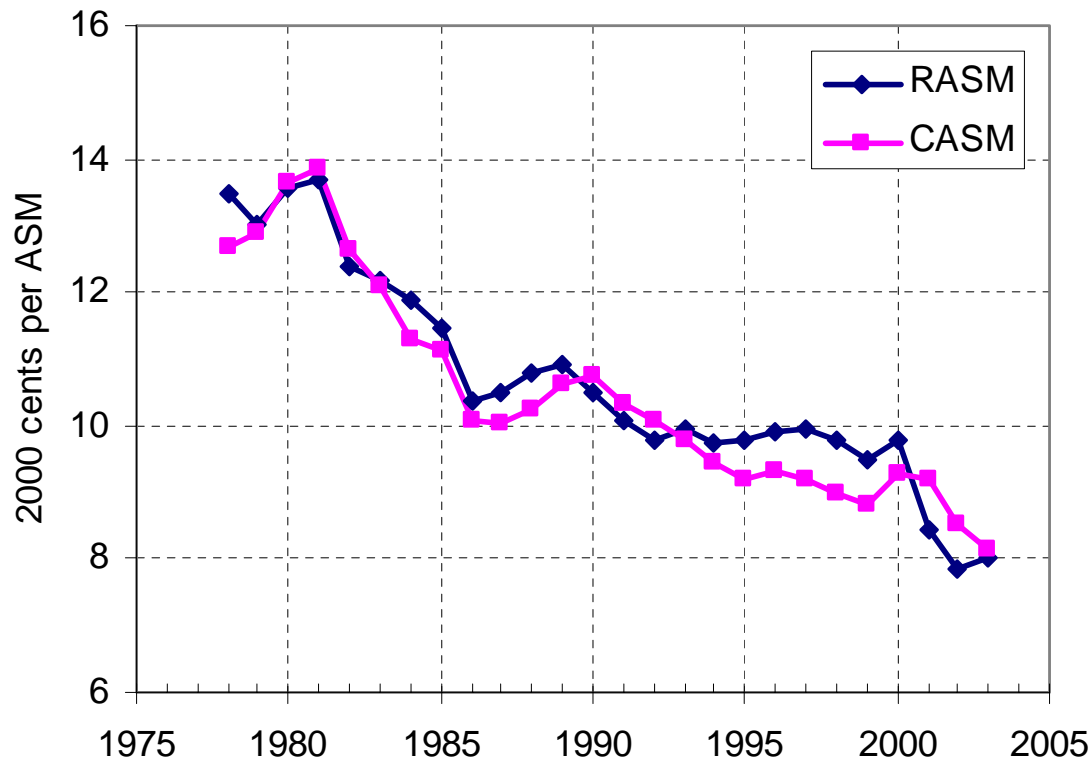
Cost Hypothesis

US Airline Net Profit/ASM vs. Operating Expense/ASM



RASM and CASM US Airline

- RASM – Pax revenue per ASM decreases 1.6% annually on average in 1980-2000
- CASM – Cost per ASM with respect to pax services

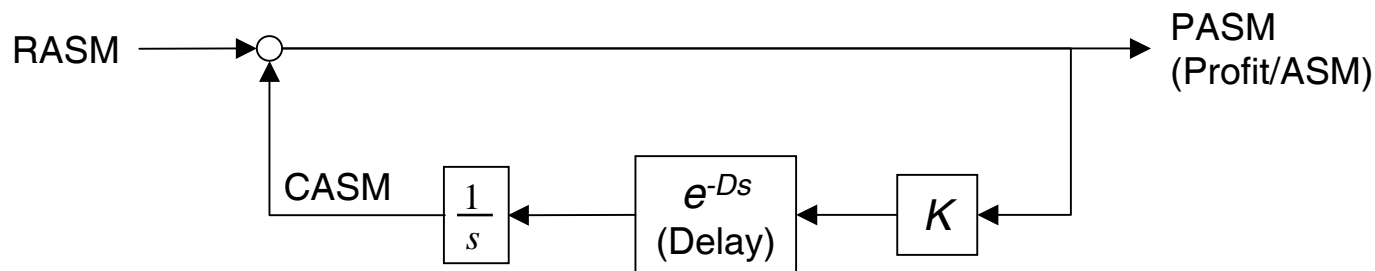


Note: CASM computed assuming expense distribution proportional to the revenue distribution
 Source: ATA data, US major, national and regional passenger airlines, scheduled services

■ Hypothesis

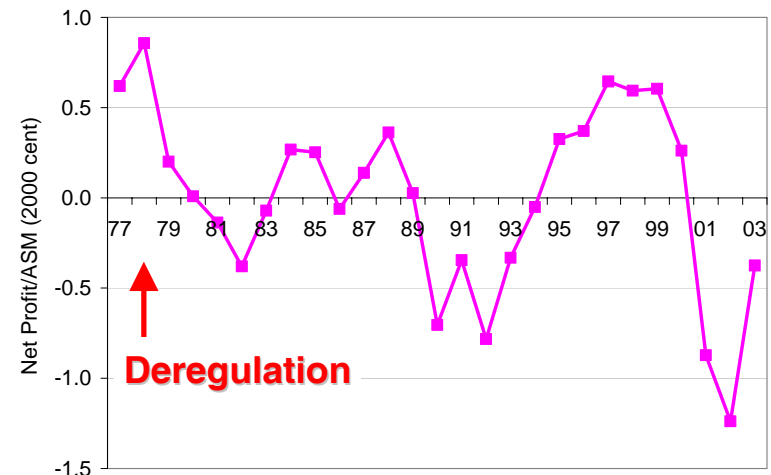
- Phase lag in **cost** adjustment causes system oscillate

■ Parametric Model for Cost Analysis

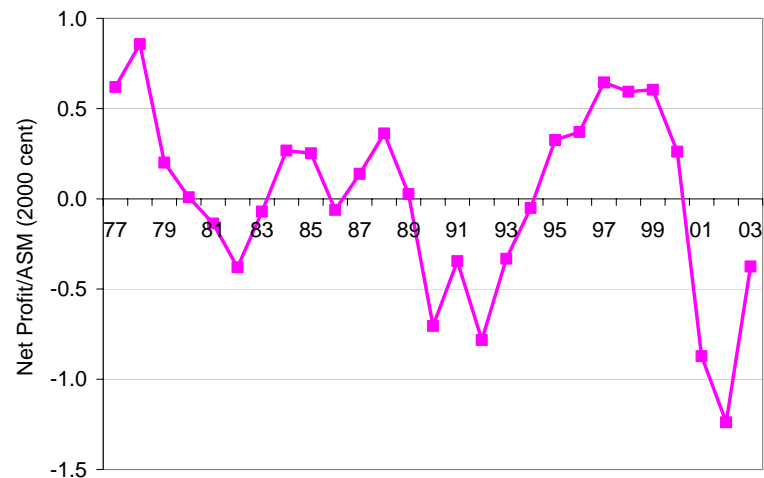
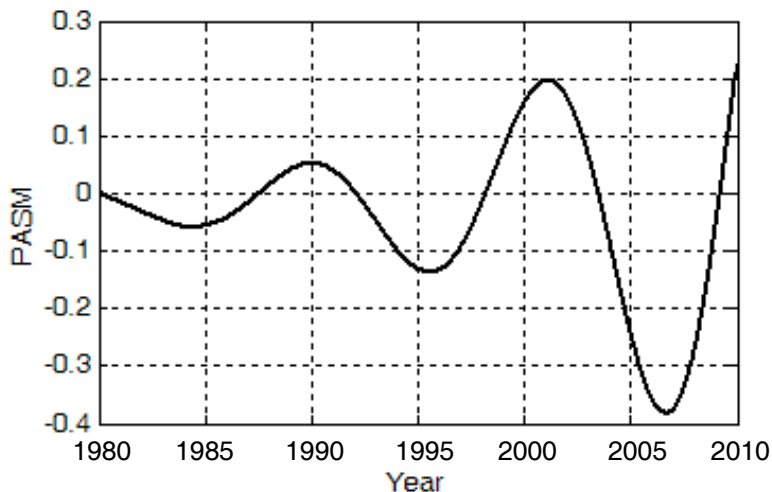
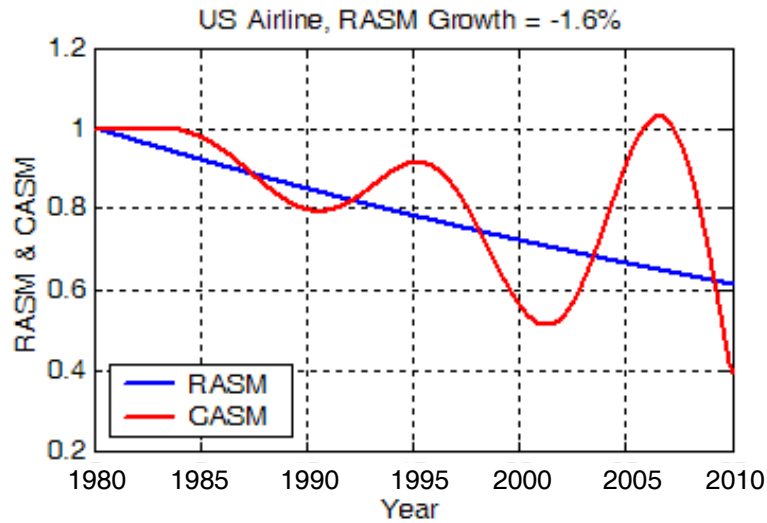


US Airline after Deregulation

- $D \cong 3.1$ year
- $K \cong 0.78 > K_{crit} = 0.50$

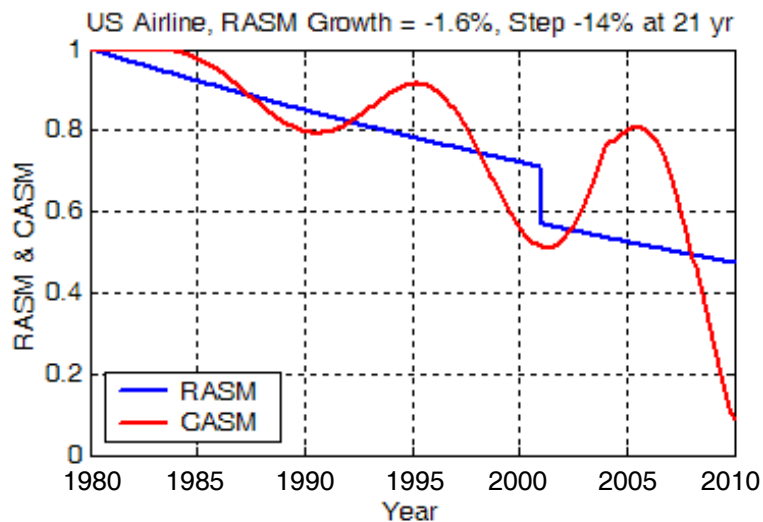


Preliminary Cost Simulation US Airline

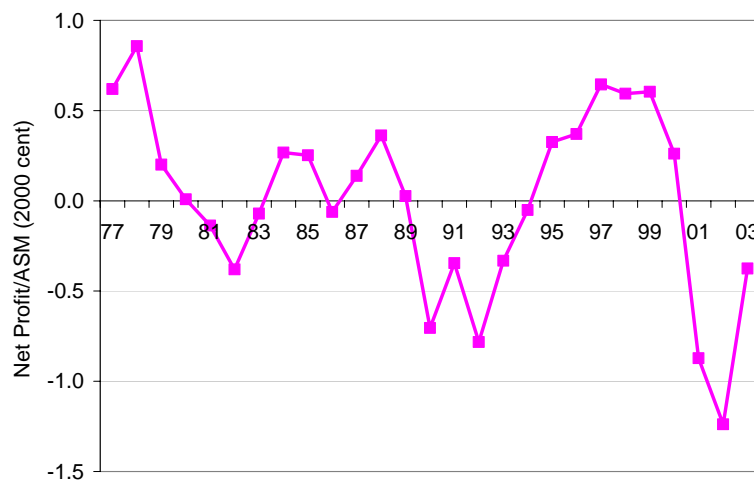
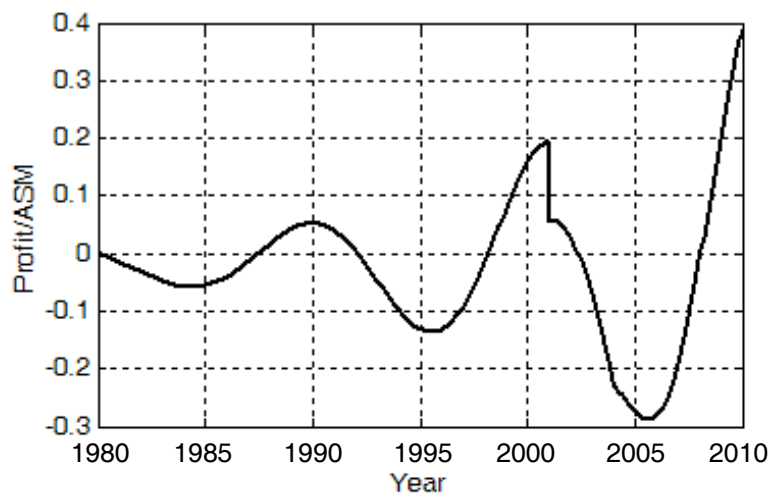


Note: preliminary results, not calibrated

Preliminary Cost Simulation US Airline



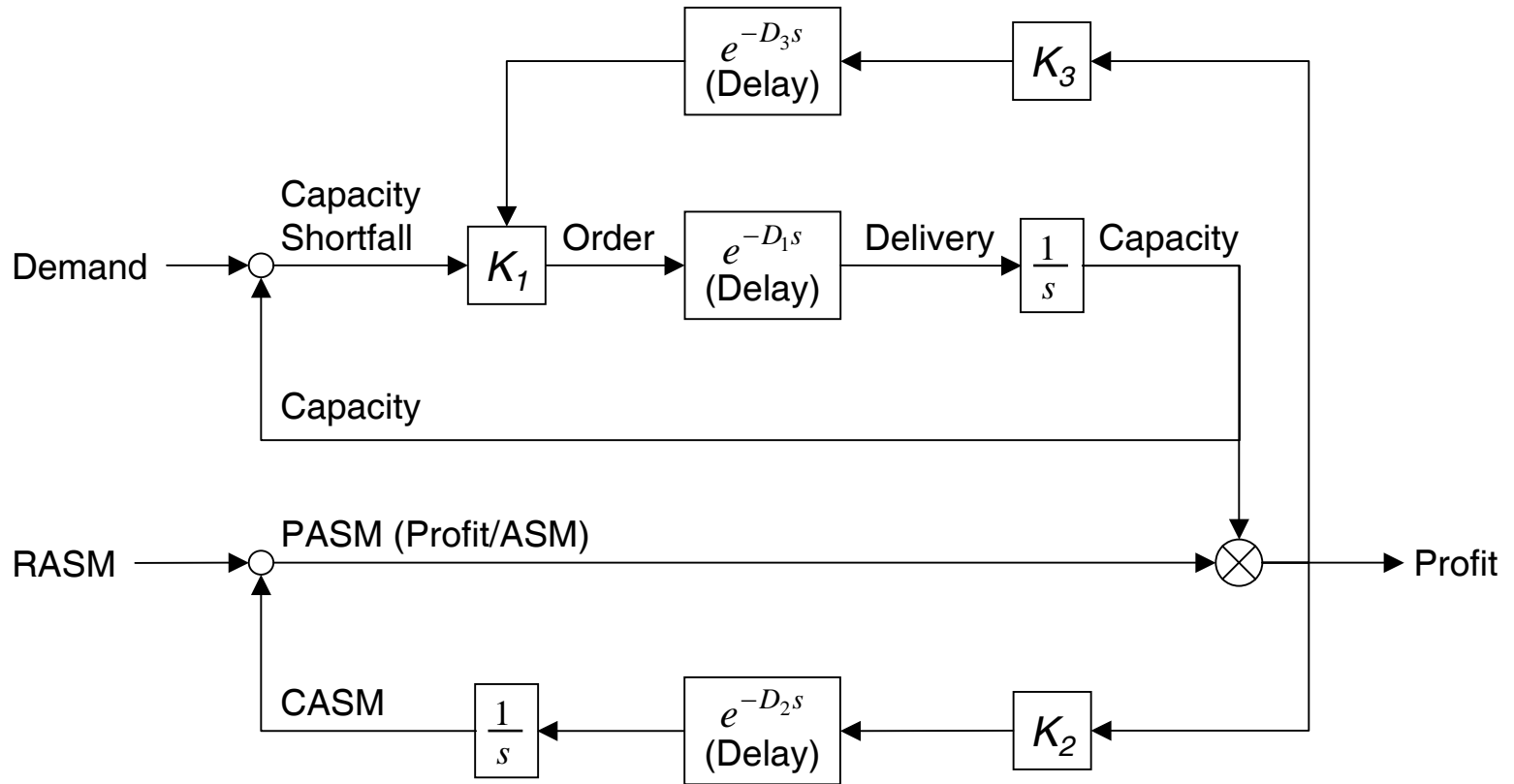
14% Step reduction of RASM
in 21st year (2001)



Note: preliminary results, not calibrated

Coupling Capacity and Cost Effects

- Couple cost latency with capacity delay. The coupling effects deliver oscillating profits.



Summary

- Identified fundamental cycle periods of airline industry profits
- In the simple parametric models, capacity and cost appear to be driving factors of system behavior and their responses are highly coupled.
- A model that couples capacity and cost effects would be more appropriate for the system
- Behavior of parametric model is consistent with 11-year-cycle profit data analysis



**Questions
&
Comments**

Thanks!