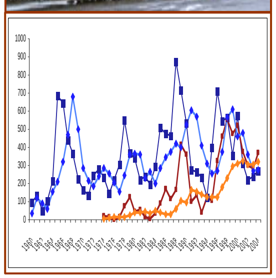

Symbiotic Strategies in Enterprise Ecology: Modeling Commercial Aviation as an Enterprise of Enterprises

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Agenda

Overview, Motivation, and Methodology

Research Questions

Modeling Commercial Aviation as an Enterprise of Enterprise

Results and Conclusions

Contributions

Future Work

Motivation

- Cyclicality exists in Commercial Aviation
- Cyclicality has repercussions across the *enterprise ecosystem*
- Lack of centralized control makes *coordinated* action to moderate cyclicality difficult
- *Symbiotic strategies* that can moderate cyclicality in a way beneficial to multiple stakeholders are not readily identifiable

Overview & Methodology

Understanding key aspects of:

- Commercial Aviation
- Business cycles in economics and supply chains
- Enterprise modeling

Representing Commercial Aviation as *Enterprise of Enterprises* (CA EoE) to identify leverage points, strategic alternatives and interests

Modeling of the CA EoE using System Dynamics

Testing strategic alternatives for effectiveness and implementability

Key Finding

- If Boeing follows the Airbus aircraft delivery model then
  - BOTH the manufacturers (Boeing: +87%, Airbus: +55% total op. profit)
  - AND the airline industry as a whole (Airline NPV: +20%)

  will enjoy increased profitability
  - WHILE passenger surplus will not be affected substantially (total passenger welfare may actually increase)

  (Until 2025, one scenario, assuming no new entrants in the large commercial aircraft (>100 seats) category)

- More combinations of strategic alternatives (policies) improve on this performance!

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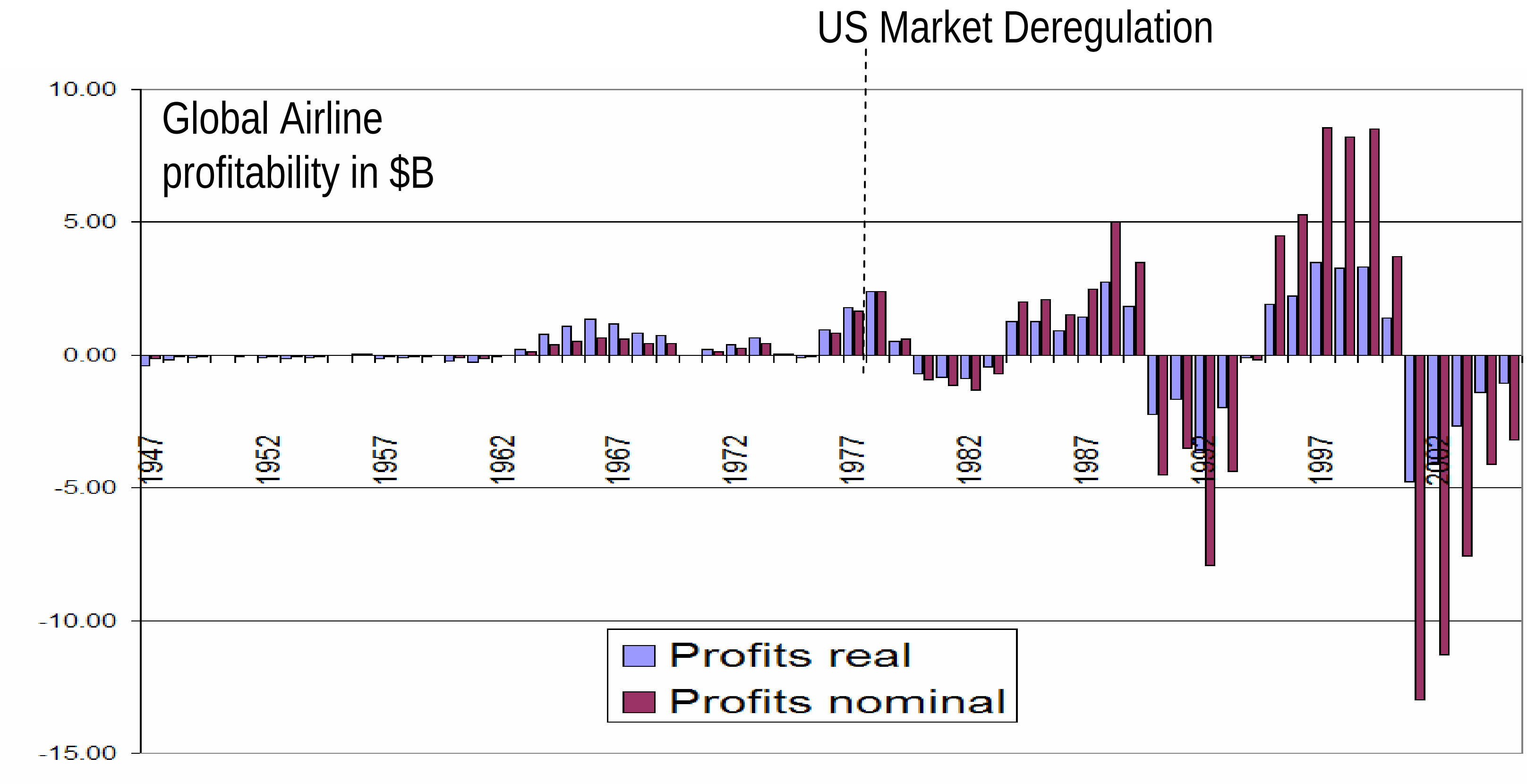
Research Questions

- **How is cyclicality manifested in commercial aviation? What are the impacts from cyclicality in commercial aviation?**
- **What are the salient causal mechanisms that induce the cyclical behavior in commercial aviation?**
- **What are implementable strategic alternatives for dampening that cyclicality and what are their benefits?**

How is cyclicality manifested in commercial aviation? (I)

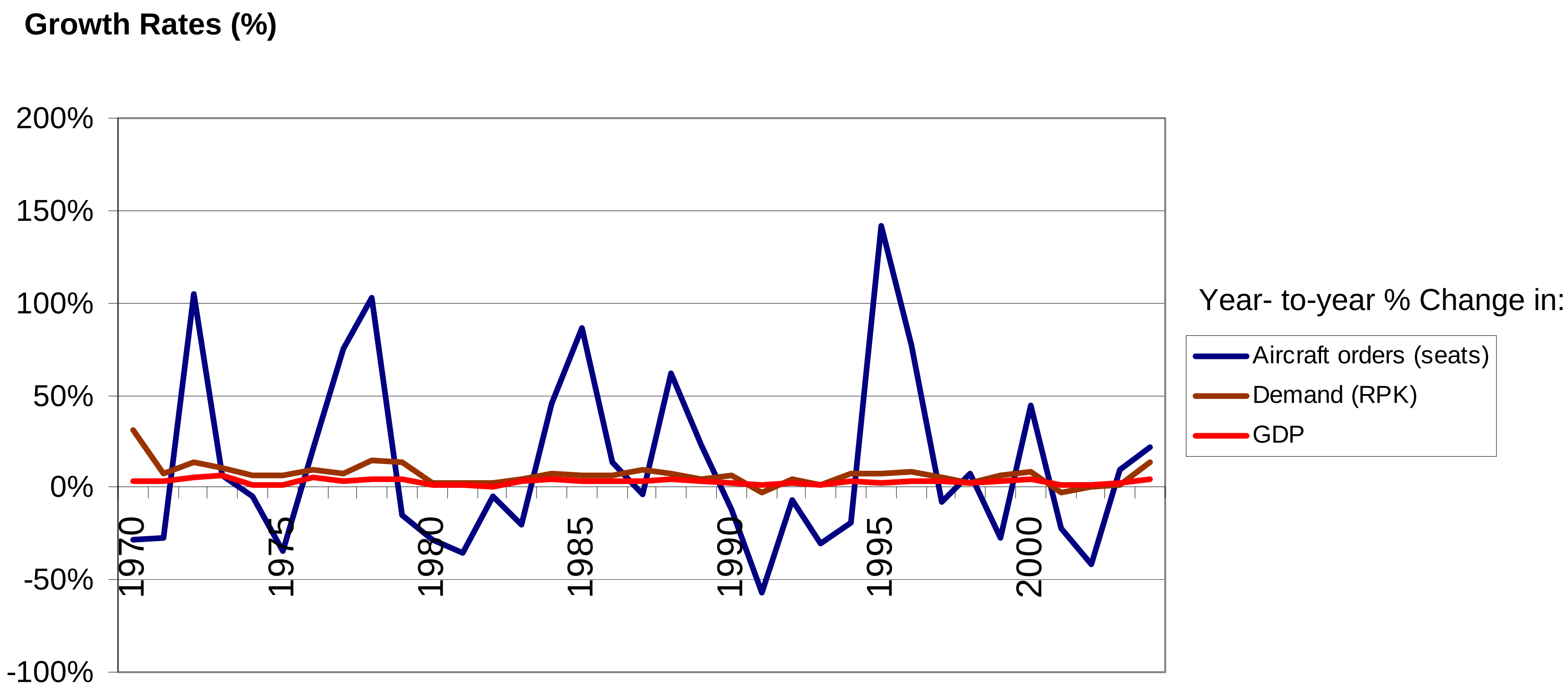


→ **Cyclical profitability for airlines**

→ **Increasing amplitude post-deregulation**

Global Data – Data Sources: ATA (2006)

How is cyclicality manifested in commercial aviation? (II)

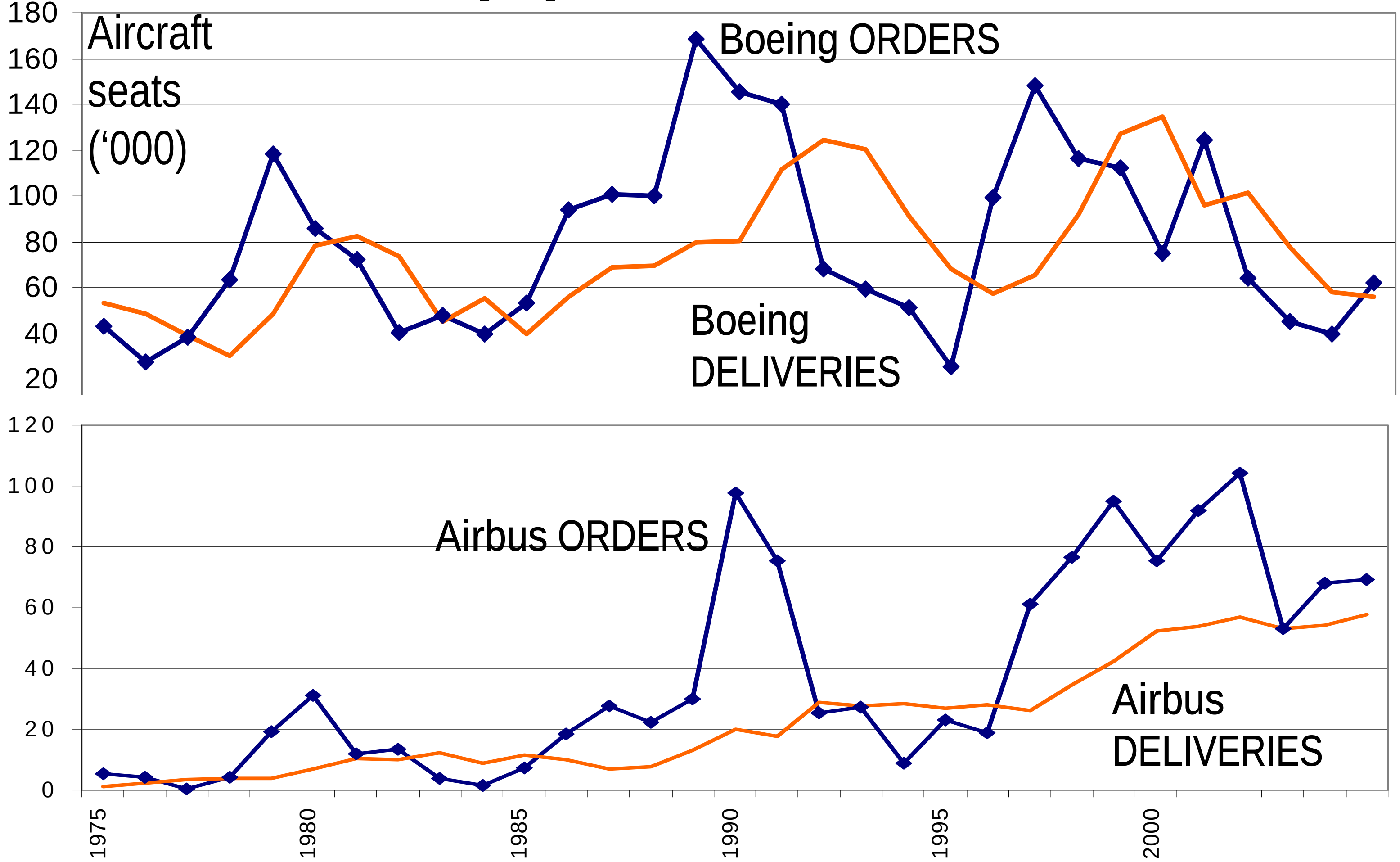


→ **Correlation between GDP growth and travel demand**

→ **Bullwhip effect in aircraft orders**

Global Data – Data Sources: ATA (2006), Boeing and Airbus Databases

How is cyclicality manifested in commercial aviation? (III)



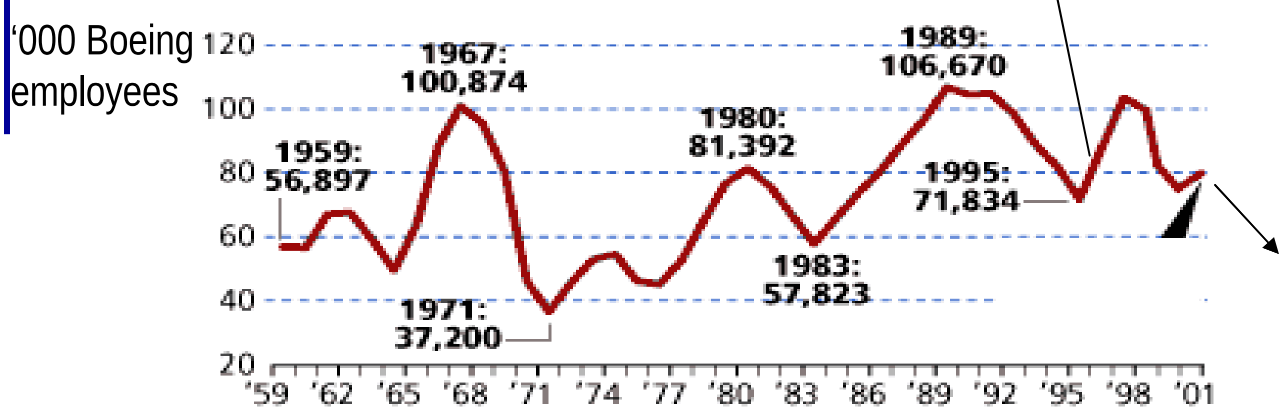
→ **Different Aircraft Production Strategies: Boeing and Airbus**

Global Data – Data Sources: Boeing and Airbus Databases

What are the impacts from cyclicality in commercial aviation?

- **Low industry-wide return on invested capital**
- **Periodic overcapacity and constrained capacity of aircraft:**
  - **Hire fire cycles. Airport and ATC planning. Inconsistent LOS and fares.**
- **Periodic overcapacity and constrained capacity of manufacturing resources:**
  - **Hire/fire cycles. Production efficiency deterioration. Labor/mgt relations.**

$2.6B write-off and 8% overnight stock value loss (Boeing) (Newhouse 2006)



$3.7B requested assistance

Source: Pope and Nyhan 2002

What are the salient causal mechanisms that induce the cyclical behavior? From business cycle literature

- **Triggers:**
  - ***Macroeconomic cycle*** ✓
  - ***Input variability*** ✓
- **Psychological Factors**
  - ***Bounded Rationality*** (Metzler 1941, Abramovitz 1950, Lucas 1975) ✓
  - ***Supply chain discounting*** (Sterman 1989, Croson et al 2004, 2006) ✓
  - ***Investment exuberance, risk tolerance and strategic optimism*** **(Pigou 1929, Krainer 2003)** ✓
- **Industry Structure**
  - ***Imperfect financing and capital market volatility*** (Carpenter et al. 1994, Bernanke and Getler 1989) ✓
  - **Inventory investment accelerator** (Clark 1917, Kitchin 1923, Lucas 1975, Anderson and Fine 2000) ✓
  - ***Investment irreversibility and intertemporal substitution*** (Timbergen 1931, Einarsen 1938) ✓
  - ***Underutilized capacity and labor 'hoarding'*** **(Petersen and Strongin 1996)** ✓
  - ***Technological change*** (Schumpeter 1911,1939) ✓
  - ***Low barriers to entry, high barriers to exit,* commoditization** **(Weil 1996)** ✓
- **Supply chains** **(Simchi-Levi et al. 2003, Lee et al. 1997, Forrester 1961, Towill 1996)**
  - **Order batching** ✓
  - **Inventories.** ✗
  - **Long lead times.** ✓
  - **Order gaming due to constrained supply** ✓
  - **Price fluctuations (promotions, bulk discounts)** ✓
  - **Strong seasonality or network effects** ✓

✓: applicable to commercial aviation

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Modeling an Enterprise of Enterprises (EoE)

1. Define EoE Study Objectives:

2. Qualitatively Represent the EoE:
Identify:
• Primary constituent enterprises,
• Interests and objectives of constituents (value functions),
• Interfaces between constituents

3.1. Define the Plausible Futures

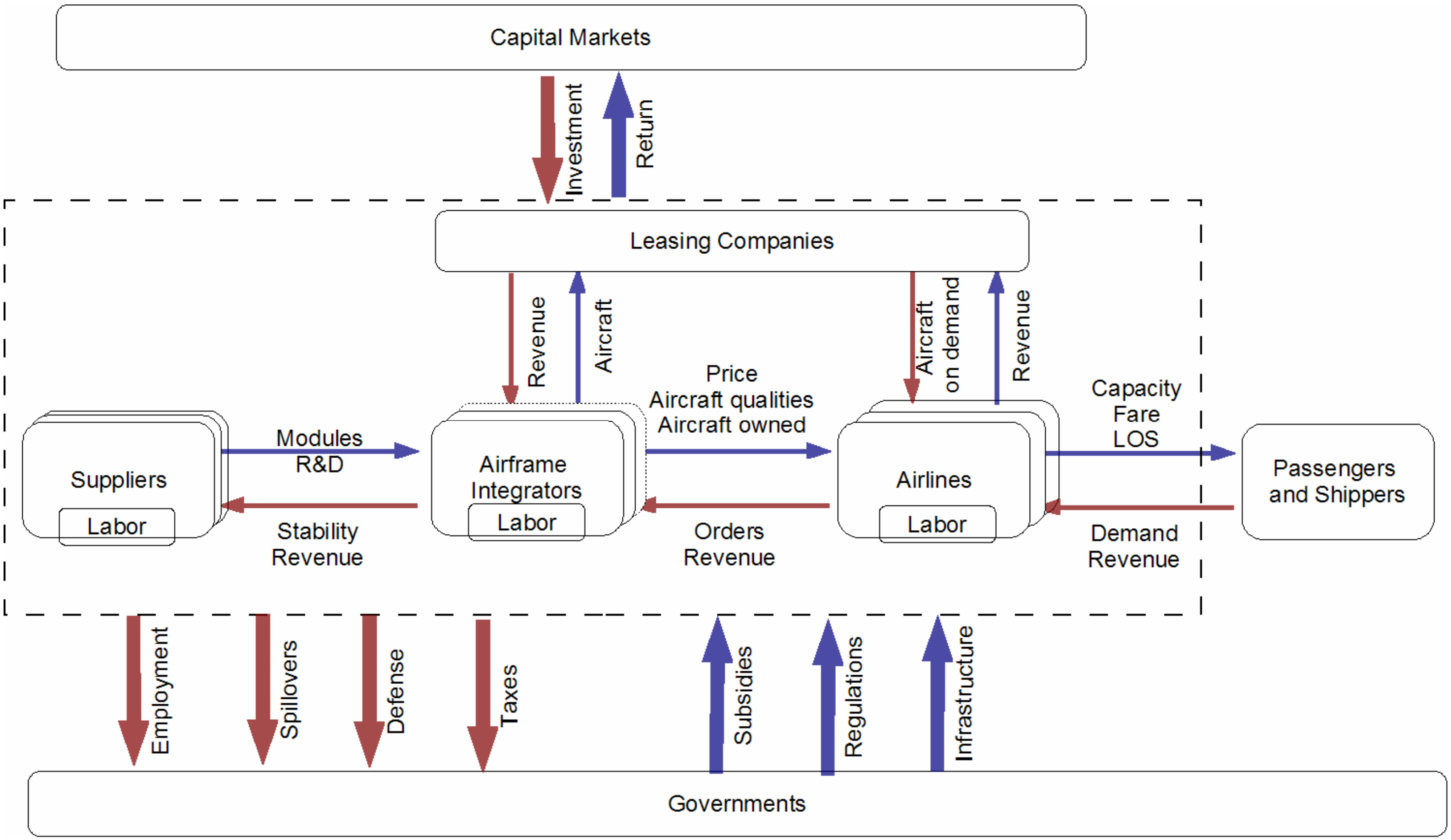
3.2. Define the Solution Space

4. Model the EoE

5. Experiment Using the EoE Model

6. Consider implementability of strategic alternatives

CA as an EoE (I)



→ **Abstraction of the CA EoE interfaces, primary constituent enterprises and non-enterprise stakeholders**

CA as an EoE (II)

Constituent Enterprise/ Stakeholder	Values	Metrics
Passengers/ Shippers	Availability of air travel	ASK / year
	Affordability of air travel	Average fares
	Level of Service	Frequency, reliability, amenities (load factors as proxy)
Carriers	Economic Return	Economic Value Added (EVA: Op. Profit – Taxes – Cost of Capital) Discounted to NPV
	Stability of Return	Coefficient of variation (CV)
	Downturn time	Average time with negative returns
Airframe Manufacturers	Economic Return	Economic Value Added (EVA: Op. Profit – Taxes – Cost of Capital) Discounted to NPV
	Stability of Aircraft Deliveries	Coefficient of variation (CV)
	Downturn time	Average time with negative returns
Capital Markets	Return on investment	Combination of airlines and airframe manufacturers returns
	Defaults avoidance	Economic losses due to defaults
Governments	Availability of air travel	ASK/year
	Returns of domestic industries	EVA
	Min. subsidies	Amount of assistance in support of airlines and aircraft manufacturers
	Employment stability	Employment numbers

- → **Representation of constituent enterprise and stakeholder *value functions***
- → **Used to evaluate and compare effects of strategic alternatives**

Modeling EoEs

1. Define EoE Study Objectives:

2. Qualitatively Describe the EoE

3.1. Define Plausible Futures: Create scenarios that represent realistic outcomes

3.2. Define the Solution Space: Identify strategic alternatives towards the desired EoE state

4. Model the EoE

5. Experiment Using the EoE Model

6. Consider implementability of strategic alternatives

Strategic areas for reducing cyclicality

- **Flexibility in airline operations:**
  - *Fixed vs. variable costs*
    - Profit sharing and outsourcing
    - Leasing
  - *Aircraft fleet management*
    - Flexibility in Aircraft Fleet Utilization
    - Aircraft retirement
    - Aircraft ordering
      - *Supply chain visibility*
      - *Demand Forecasting*
      - *Effect of Profitability on Orders*

- **Airline competitive environment**
  - *Yield management*
  - *Effect of Airline Entry and Exit* on Pricing

- **Aircraft manufacturers competitive environment**
  - *Aircraft pricing*
  - *Manufacturing*
    - Production rate adjustments
    - Production costs

Modeling EoEs

1. Define EoE Study Objectives:

2. Qualitatively Describe the EoE

3.1. Define the Plausible Futures

3.2. Define the Solution Space

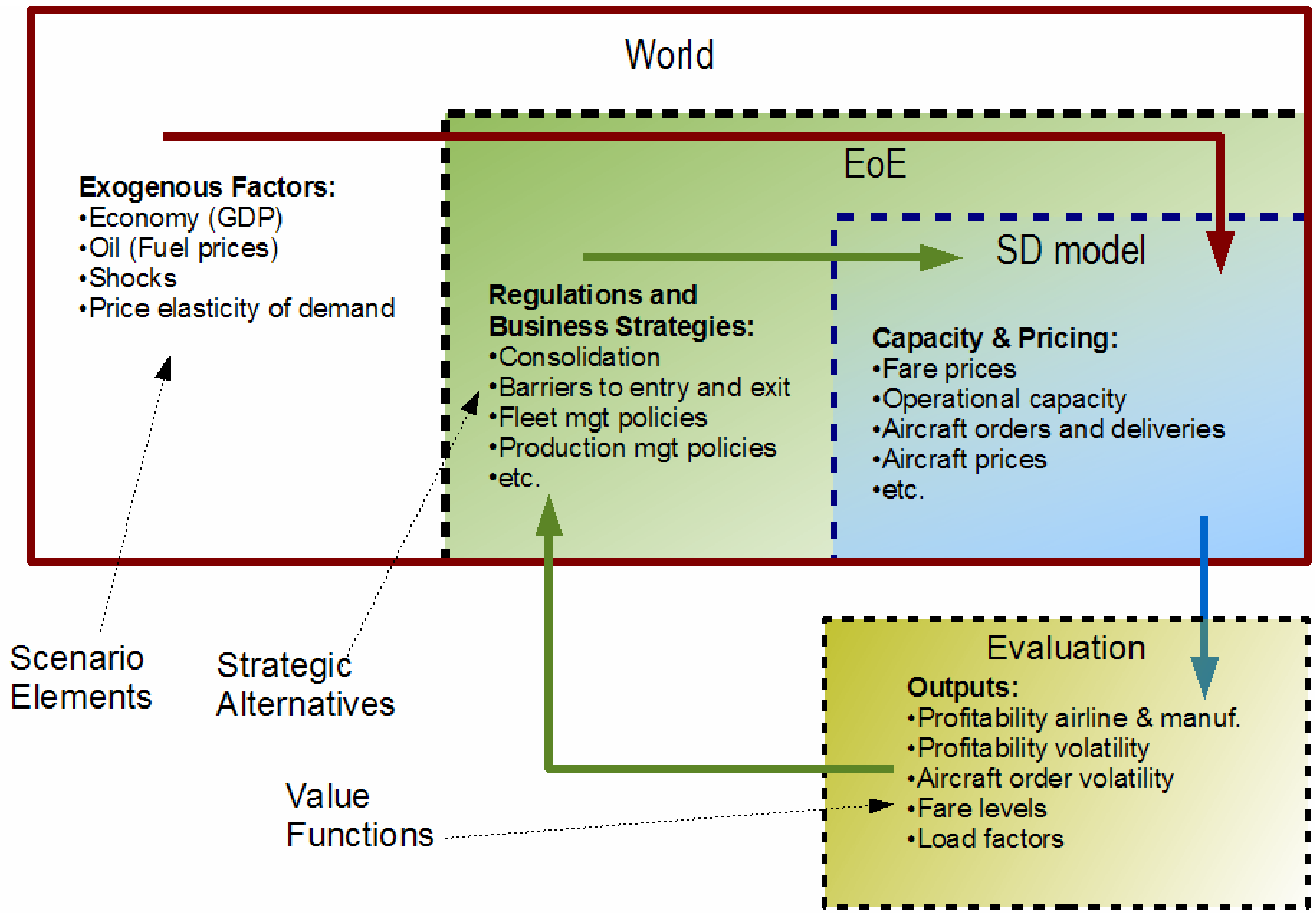
4. Model the EoE:

- Identify appropriate modeling method(s)
- Quantify the value functions of constituent enterprises,
- Quantify and model the interfaces between constituents,
- Calibrate, validate and verify the resulting model

5. Experiment Using the EoE Model

6. Consider implementability of strategic alternatives

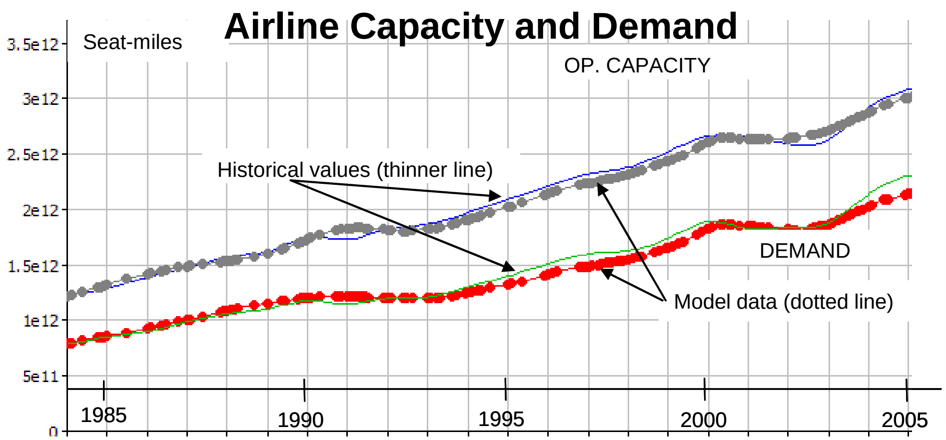
CA EoE Modeling

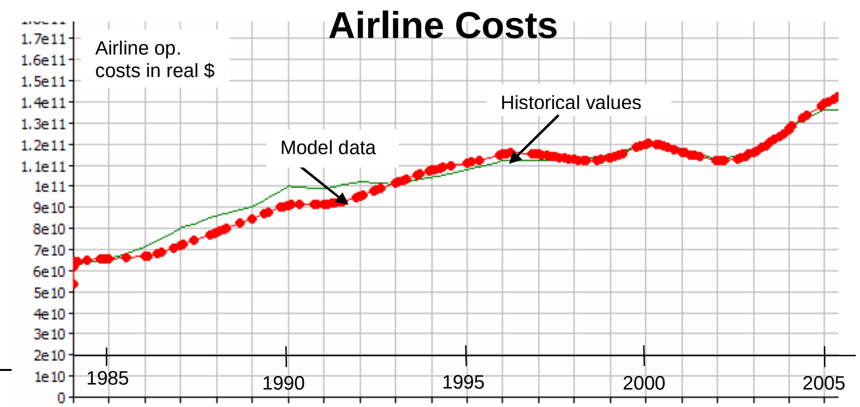


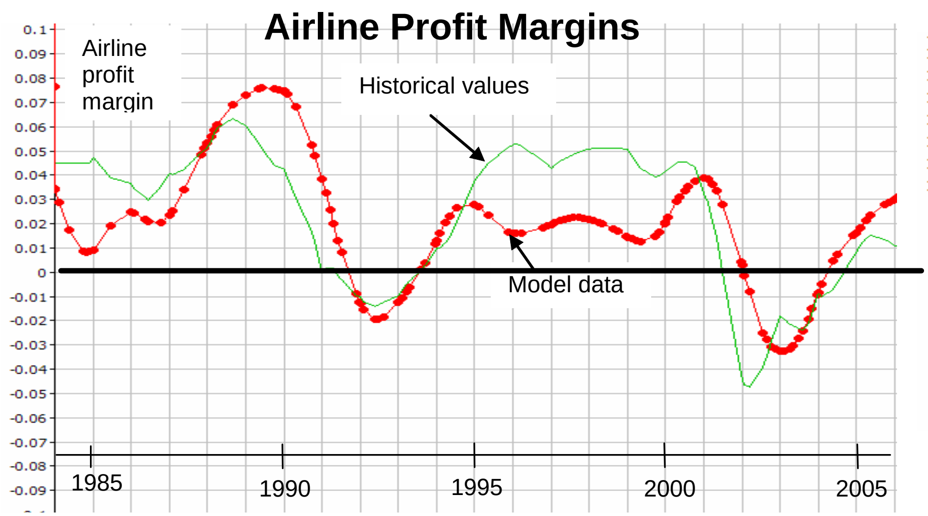
→ **SD Model: captures critical aspects of the EoE**

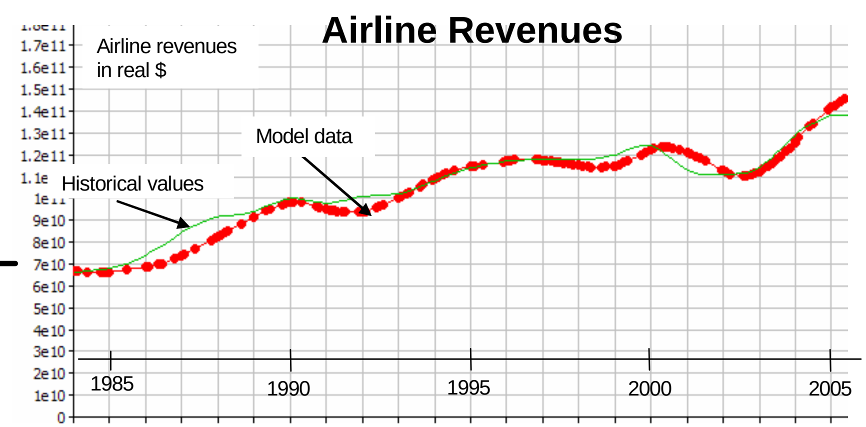
→ **Integration of scenarios, strategies and value functions**

CA EoE SD Model Validation: Airlines





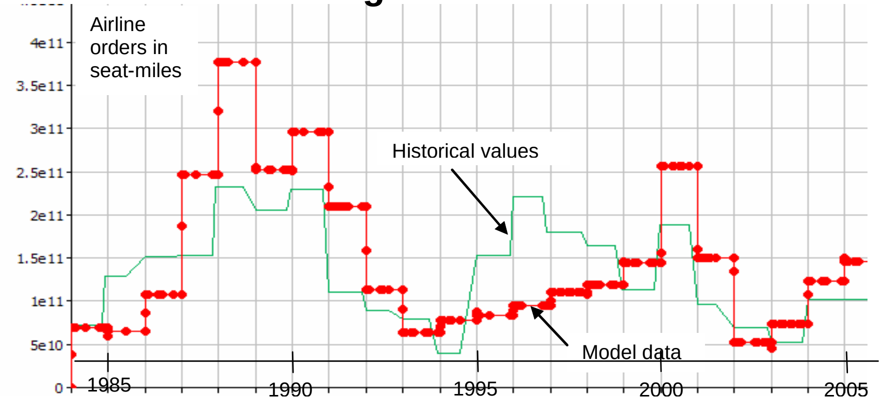




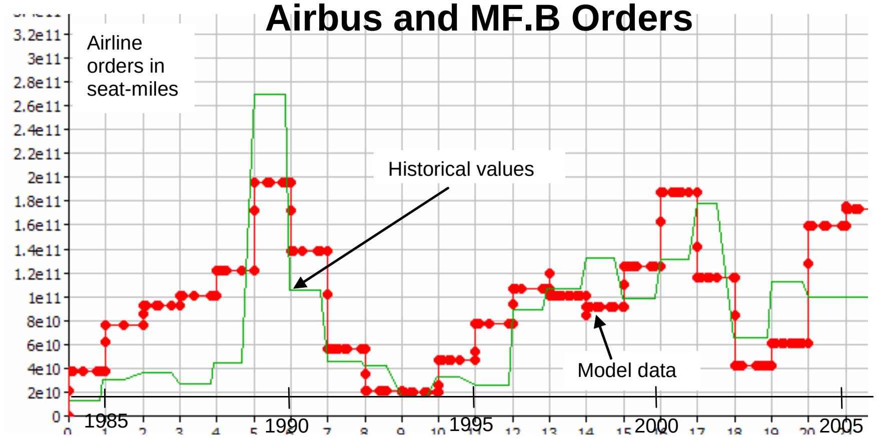
→ **Visual inspection and statistical analysis indicate matching**

CA EoE SD Model Validation: Manufacturers

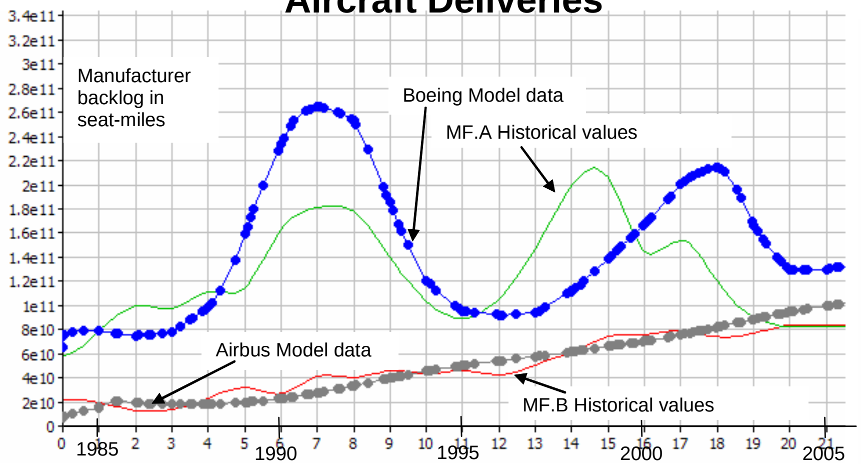
Boeing and MF.A Orders



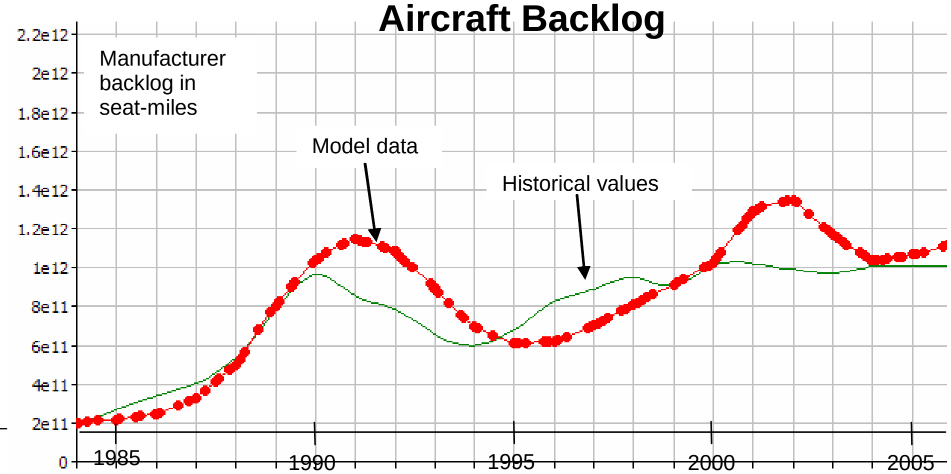
Airbus and MF.B Orders



Aircraft Deliveries



Aircraft Backlog



→ **Visual inspection and statistical analysis indicate matching**

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Modeling EoEs

1. Define EoE Study Objectives:

2. Qualitatively Describe the EoE

3.1. Define the Plausible Futures

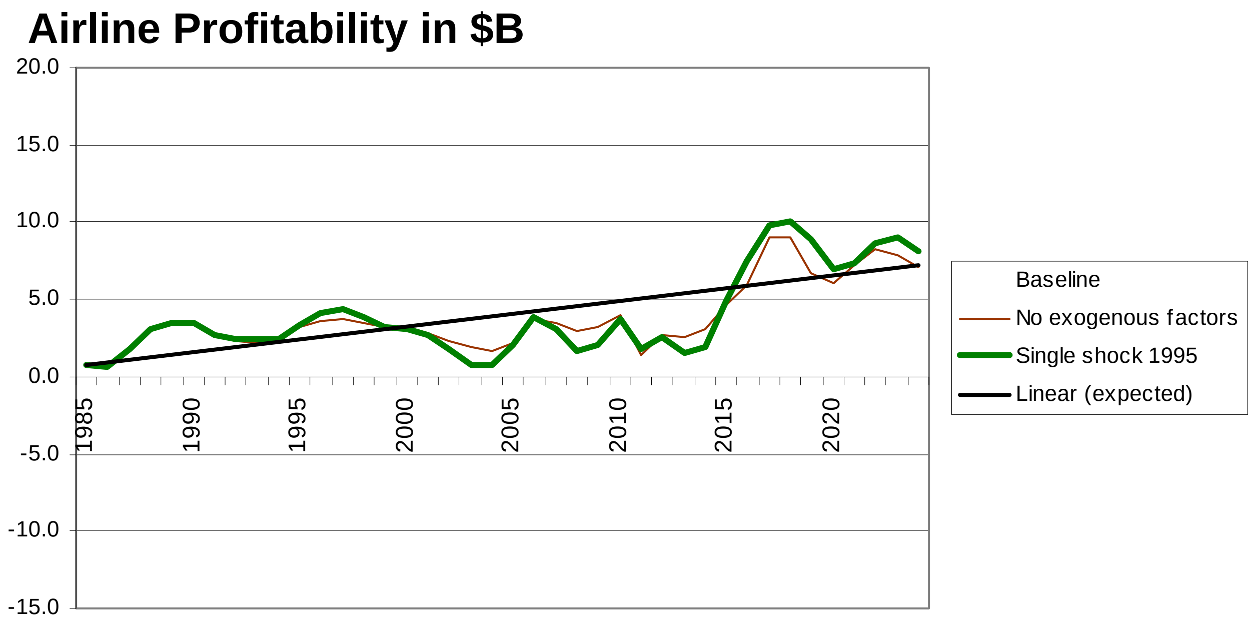
3.2. Define the Solution Space

4. Model the EoE

5. Experiment Using the EoE Model:
- Quantify strategic alternatives (SA)
- Design experiments that cover interactions across (SA)
- Run experiments across scenarios
- Compare and identify the promising SA

6. Consider implementability of strategic alternatives:
- Design implementation strategy based on institutional/regulatory aspects of the EoE
- Game theory and compensation schemes for non-Pareto optimal strategic alternatives

Exogenous vs. Endogenous Dynamics



→ **There *is* cyclical behavior even in the absence of exogenous factors**

Relative effect on cyclicality of exogenous factors:

1. **Fuel (CV : 1.12)**
2. **GDP (CV : 0.87)**
3. **External shocks (CV : 0.46)**

From Strategic areas to Strategic Alternatives: 2 examples

- **Flexibility in airline operations:**
  - *Fixed vs. variable costs*
    - Profit sharing and outsourcing
    - Leasing
  - *Aircraft fleet management*
    - Flexibility in Aircraft Fleet Utilization
    - Aircraft retirement
    - Aircraft ordering
      - ***Supply chain visibility***
      - *Demand Forecasting*
      - *Effect of Profitability on Orders*

•25% SC Visibility

•50% SC Visibility

•75% SC Visibility

- **Airline competitive environment**
  - *Yield management*
  - *Effect of Airline Entry and Exit* on Pricing
- **Aircraft manufacturers competitive environment**
  - *Aircraft pricing*
  - *Manufacturing*
    - **Production rate adjustments**
    - Production costs

•Slow production rate adjustment

•Faster production rate adjustment

•Just-in-time (JIT) delivery

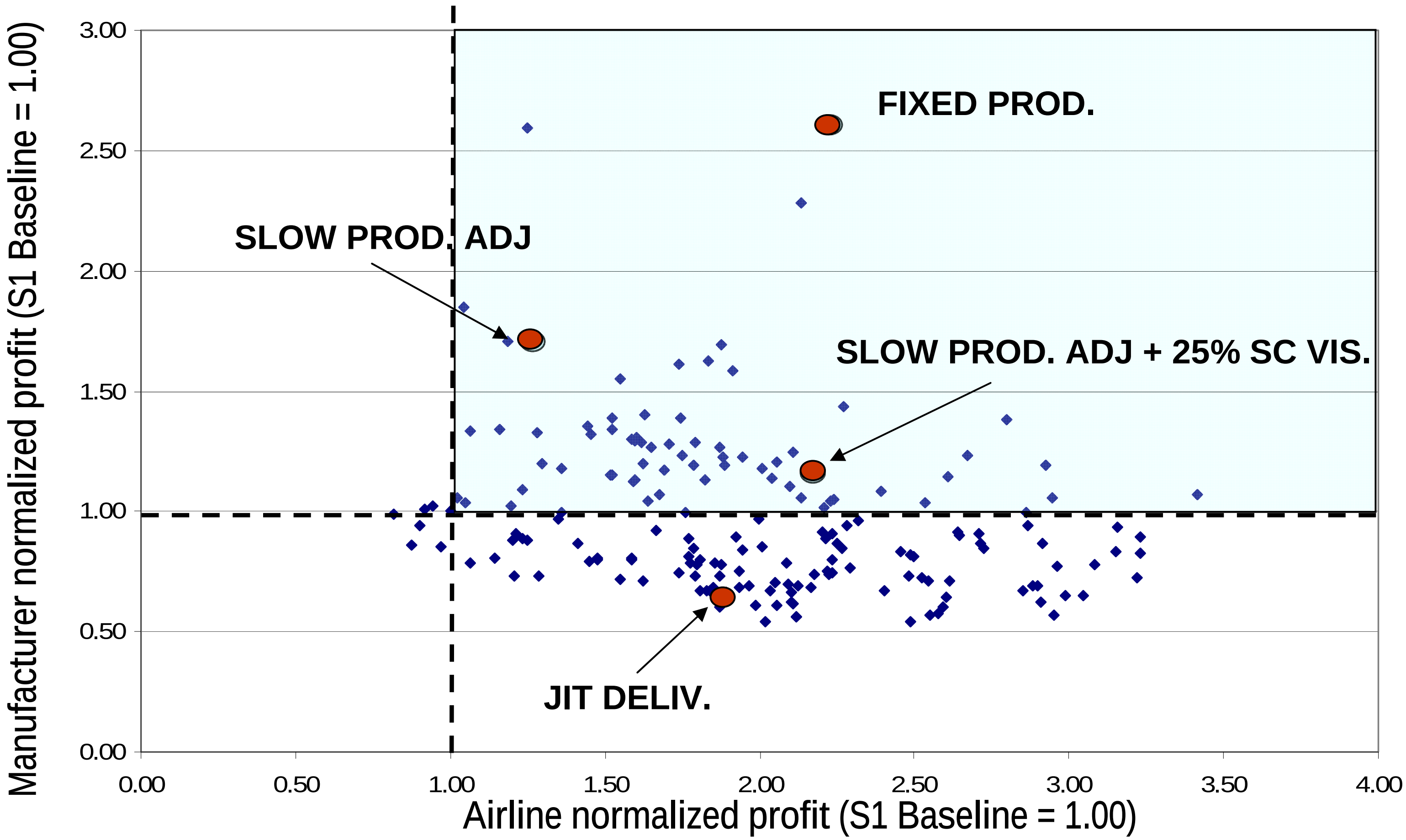
•Fixed schedule production rate

Results: Individual Strategic Alternatives Performance (average across scenarios)

	Airline		Manufacturers		Passengers	
	NPV Change	CV change	NPV Change	Order CV Change	Fare Change	LF change
75% SC visibility	**256.4%**	**54.0%**	**-45.6%**	**41.8%**	**2.6%**	**13.8%**
50% SC visibility	**168.7%**	**47.3%**	**-38.9%**	**31.5%**	**2.7%**	**9.5%**
MF fixed prod. Rate	**49.6%**	**-23.4%**	**123.3%**	**N/A**	**-0.3%**	**2.8%**
Slow prod rate change	**25.6%**	**-2.6%**	**63.7%**	**-43.5%**	**-0.8%**	**1.3%**
Slow prod rate change + 25%SC visibility	**142.2%**	**50.5%**	**4.3%**	**5.3%**	**2.2%**	**7.4%**
MF JIT+ lean + 25% SC visibility	**90.6%**	**41.9%**	**-40.2%**	**25.4%**	**3.6%**	**5.2%**

→ **Control of Capacity is key**

Symbiotic Quadrant –
Optimization search for strategic alternative bundles



→Control of capacity leads to symbiotic strategies close to the Pareto front

→There are benefits to be gained from bundling strategic alternatives

Conclusions

→ Strong endogenous dynamics in commercial aviation structure that fuel cyclicality

→ Non-collusive slowing of production rate adjustment provides strong symbiotic benefits to both manufacturers and airlines while passengers are not negatively impacted

→ No synergistic advantage found if MF.A pursues JIT and MF.B maintains its slow-to-adapt production strategy (*)

→ Other interesting strategic alternatives were shown:

- Airline industry consolidation
  - In pricing (*)
  - In ordering (reducing 'supply chain discounting')
- Increasing fleet flexibility (higher level of short term op. leases) (*)

→ Bundling of alternatives can provide improvements but production control (in the extreme) is on the Pareto front

→ Commercial Aviation as an EoE: a useful perspective

Thank you for your attention!

Questions?

Back-up

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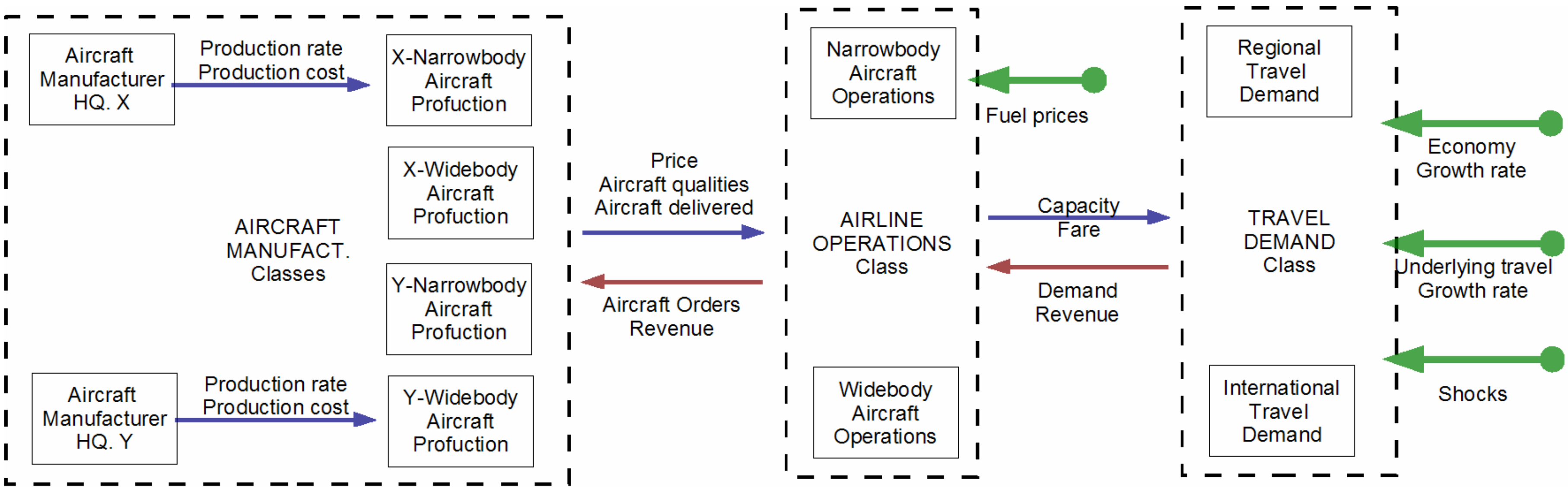
Contributions

- **Integrating disparate literature strands:**
  - **Extensive coverage of commercial aviation**
  - **Synthesis of the literature on business cycles in economics and supply chain**
  - **Modeling approaches for enterprises (Ch. 8)**
- **Formalizing the Enterprise of Enterprises concept**
- **Creating an SD model of the CA EoE with duopolist manufacturer dynamics and separate narrow-, wide- body market segments**
- **Identifying and comparing CA EoE specific symbiotic strategic alternatives**

Future Work

- Use agents to model airline behavior and specifically the evolution of Airline – Manufacturer partnerships
- Model manufacturer new entrants
- Extend competition on aircraft market beyond only price: introduce endogenous dynamic decisions for technological aircraft change
- Calibrate the manufacturer module of the model with proprietary industry data
- Adapt the EoE view and methodology to other cyclical industries and seek generalizations on mechanisms for cyclical dynamics

CA EoE Model Structural View



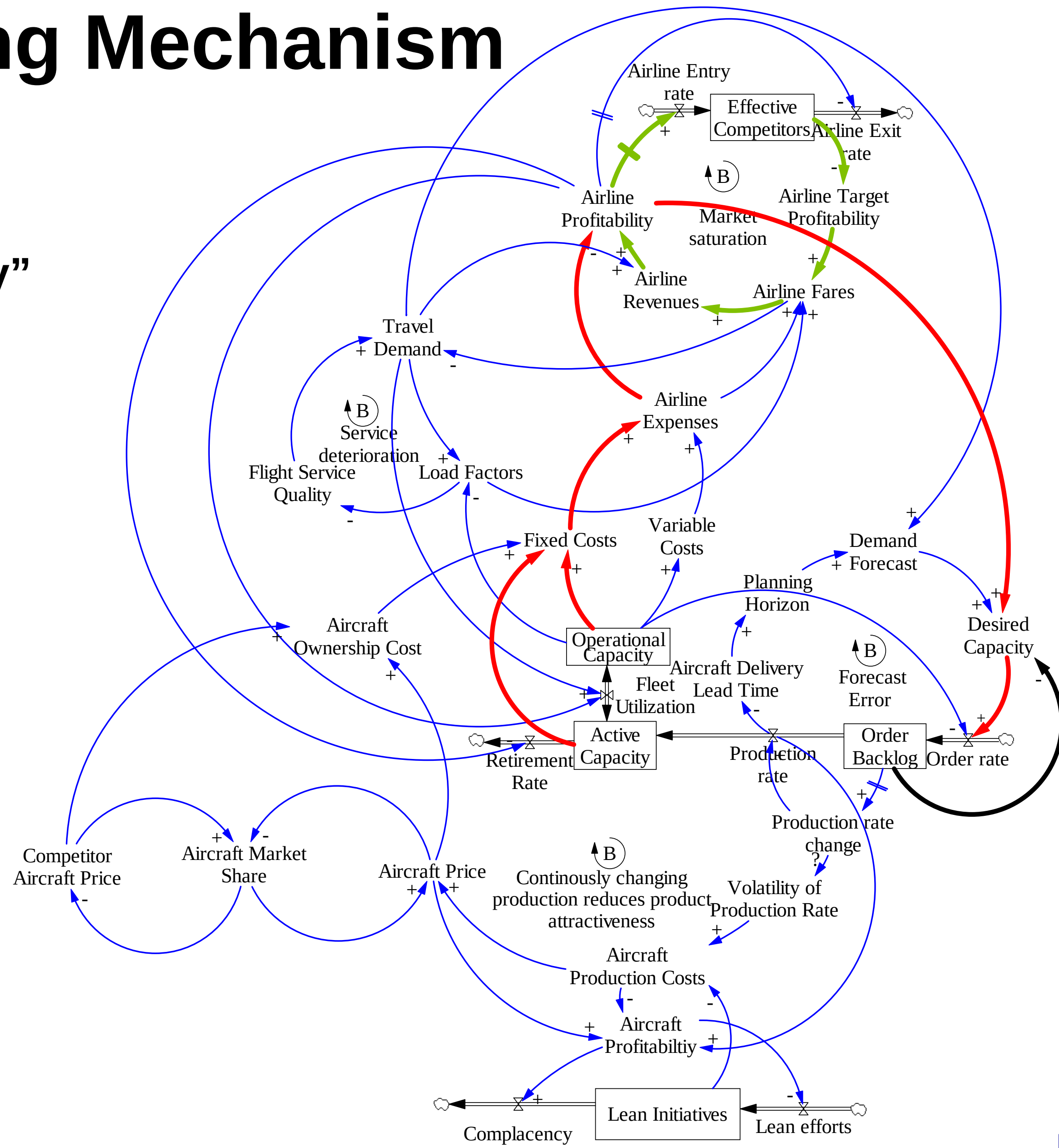
- Based on and extended H. Weil's airline industry model (1996)
- Partly developed in collaboration with J. Lin and J. McConnell.
- Implemented using Anylogic

Dampening Mechanism

For the

"supply chain visibility"

strategic alternative



Competitive Dynamics for S1 (I)

	Exp 1		Exp 2		Exp 3		Exp 4		Exp 5		Exp 6		Exp 7	
Strategic Alternatives	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**
Production scheduling														
JIT delivery	*		*		*		*		*		*		*	
Slow production rate change		*		*		*		*		*		*		*
Quick production rate change														
Fixed production schedule														
Production costs														
Lean manufacturing	*		*		*	*	*		*		*	*	*	*
Adaptive production (costs)			*		*									
Industry relations and pricing														
Vertical integration (50%)							*			*		*	*	*
Aggressive Competition													*	*

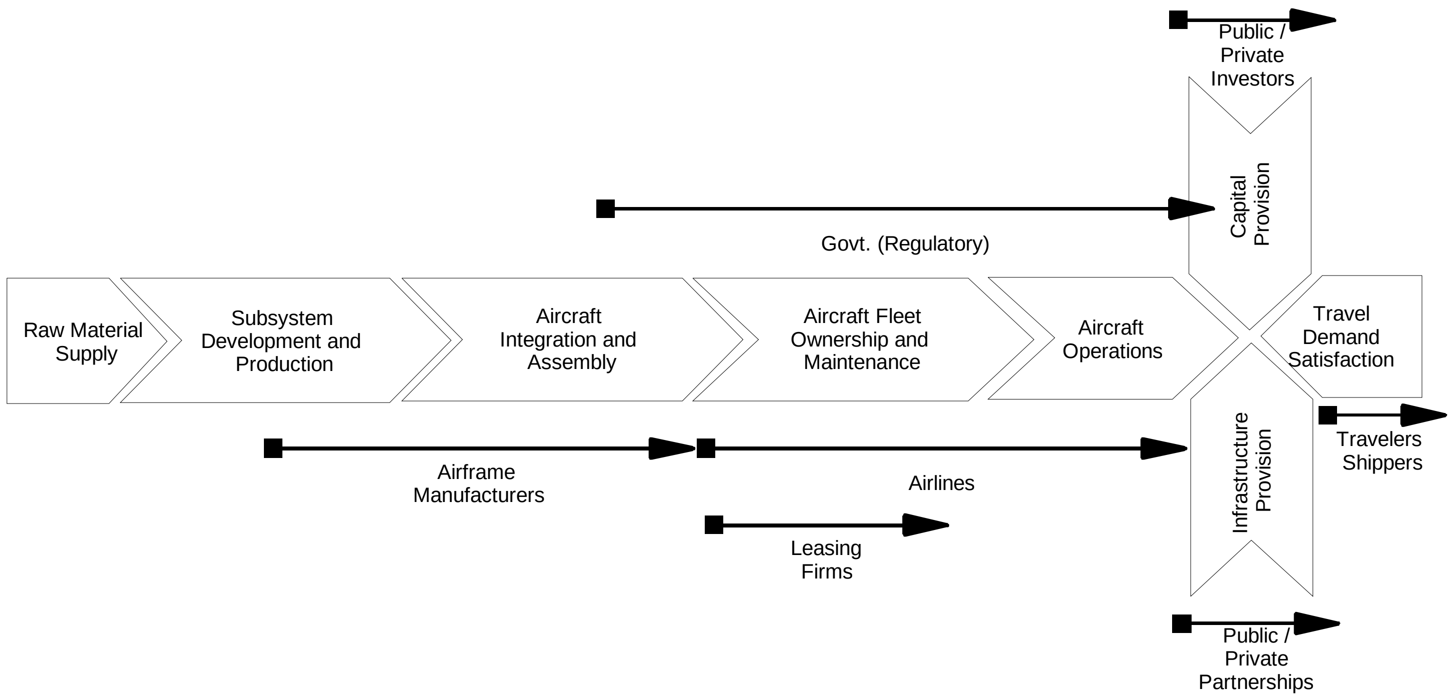
	Exp1	**Exp2**	**Exp3**	**Exp4**	**Exp5**	**Exp6**	**Exp7**
Airlines							
NPV Change	0.2%	3.0%	2.6%	0.6%	0.6%	0.1%	1.8%
Coef. Var. Change	21.6%	19.1%	21.7%	25.1%	24.0%	28.6%	12.6%
Mf. A							
NPV Change	-21.4%	32.5%	48.1%	-16.3%	-22.4%	-5.3%	-98.2%
Total order change	-2.1%	1.5%	2.7%	-0.1%	-0.4%	8.8%	-1.6%
Order coef. Of Var. change	10.5%	10.6%	9.7%	13.2%	13.4%	19.7%	4.3%
Mf. B							
NPV Change	-9.1%	-3.3%	-15.2%	-13.2%	-11.6%	-20.6%	-49.1%
Total order change	1.2%	3.8%	2.0%	-0.9%	-0.3%	-5.7%	9.9%
Order coef. Of Var. change	21.3%	18.1%	22.4%	23.0%	23.6%	19.4%	21.1%
Pax							
Fare change	-0.2%	-0.1%	0.0%	-0.2%	-0.2%	-0.1%	-1.5%
LF change	-0.2%	-0.1%	-0.2%	-0.3%	-0.3%	-0.5%	0.3%
Total Return							
Universal owner view	93	108	108	93	92	93	65
Rank							
Universal owner view	**12**	**6**	**5**	**11**	**13**	**10**	**15**

Competitive Dynamics for S1 (II)

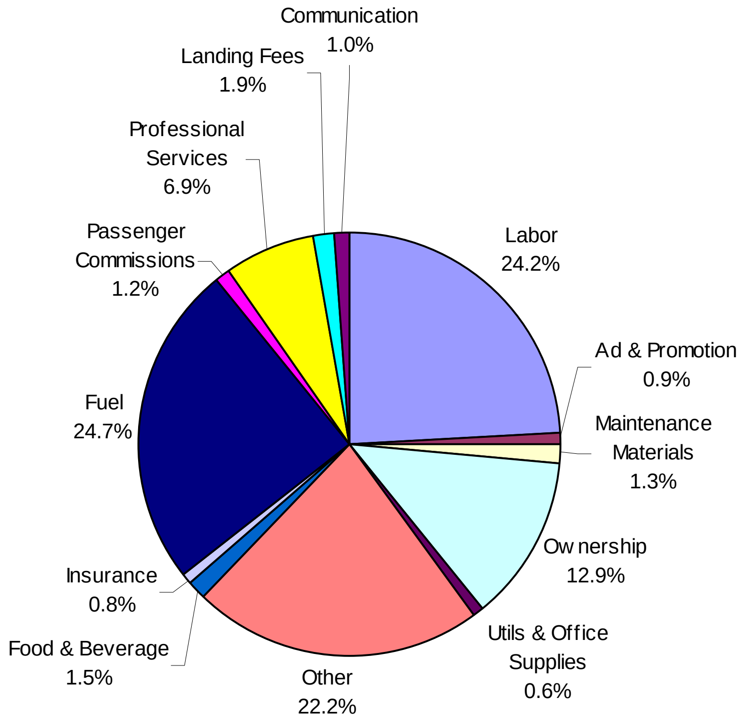
	Exp 8		Exp 9		Exp 10		Exp 11		Exp 12		Exp 13		Exp 14		Exp 15	
Strategic Alternatives	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**	**Mf. A**	**Mf. B**
Production scheduling																
JIT delivery	*		*		*	*										
Slow production rate change		*						*				*	*	*	*	*
Quick production rate change							*		*	*	*					
Fixed production schedule				*												
Production costs																
Lean manufacturing	*	*	*	*	*	*	*	*	*		*	*	*		**	**
Adaptive production (costs)	*	*			*	*	*	*				*			*	*
Industry relations and pricing																
Vertical integration (15%)	*	*										*			*	*
Aggressive Competition																

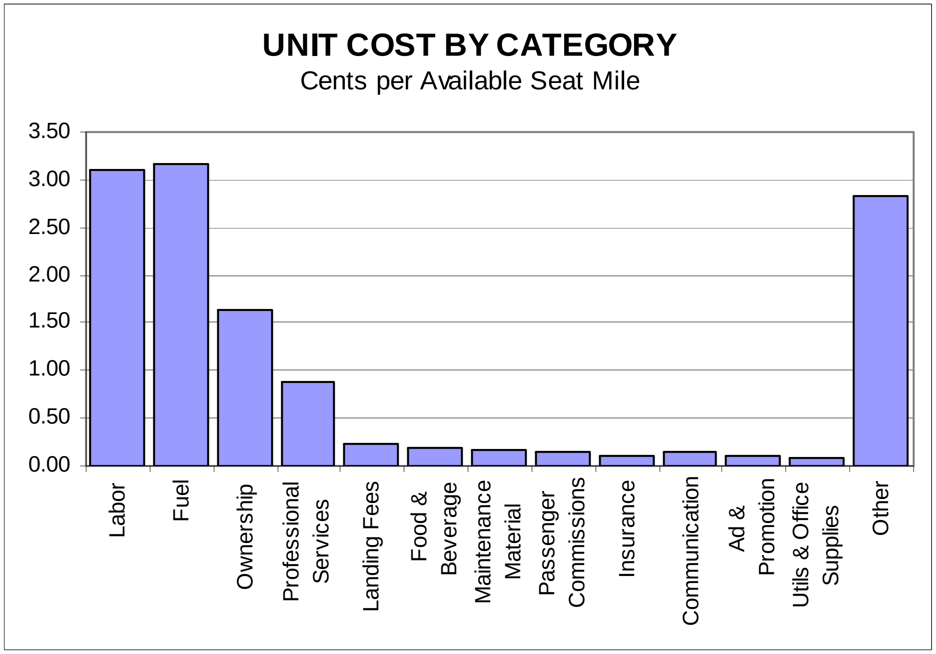
	Exp8	Exp9	Exp10	Exp11	Exp12	Exp13	Exp14	Exp15
Airlines								
NPV Change	1.2%	12.4%	55.9%	0.7%	11.1%	-0.1%	20.5%	17.7%
Coef. Var. Change	22.2%	6.4%	-11.4%	3.0%	-2.1%	3.2%	2.5%	5.7%
Mf. A								
NPV Change	32.0%	-51.5%	-26.7%	46.8%	-10.0%	5.3%	87.1%	119.6%
Total order change	2.4%	-6.8%	-44.1%	-3.0%	-23.0%	-1.8%	15.0%	22.6%
Order coef. Of Var. change	18.9%	28.7%	-6.1%	1.7%	-6.2%	5.2%	-11.9%	-11.2%
Mf. B								
NPV Change	-13.6%	-18.0%	-21.1%	0.3%	-27.3%	-5.0%	55.8%	35.5%
Total order change	-1.2%	3.8%	-20.9%	3.2%	-0.6%	0.2%	53.0%	49.3%
Order coef. Of Var. change	19.7%	21.8%	9.2%	5.5%	13.8%	4.1%	10.3%	10.1%
Pax								
Fare change	0.0%	-1.2%	-3.1%	0.3%	-1.5%	0.2%	0.4%	-2.6%
LF change	-0.2%	0.9%	3.9%	0.0%	1.3%	-0.1%	1.6%	1.4%
Total Return								
Universal owner view	104	90	116	111	96	100	145	146
Rank								
Universal owner view	**7**	**14**	**3**	**4**	**9**	**8**	**2**	**1**

CA Value Chain

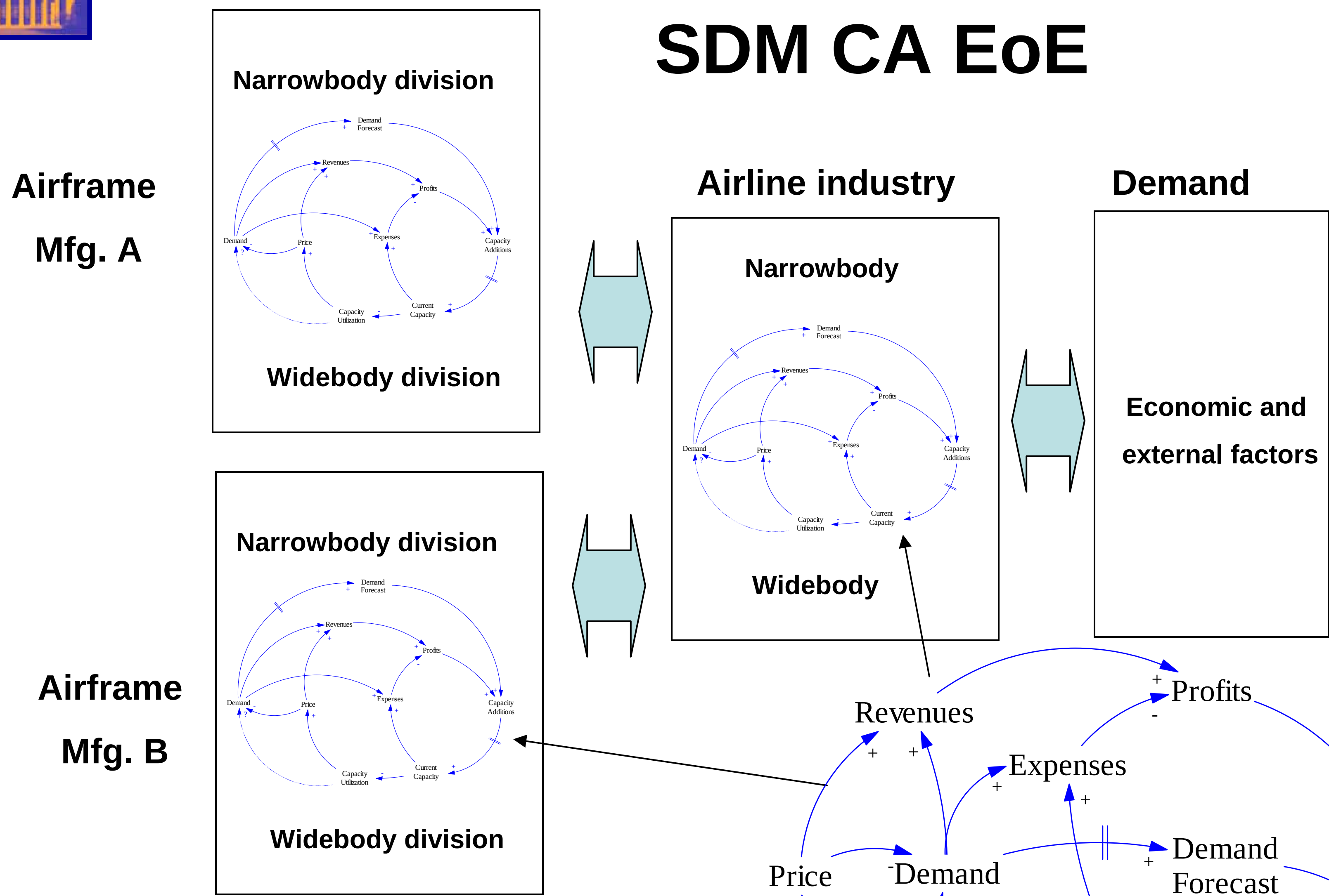


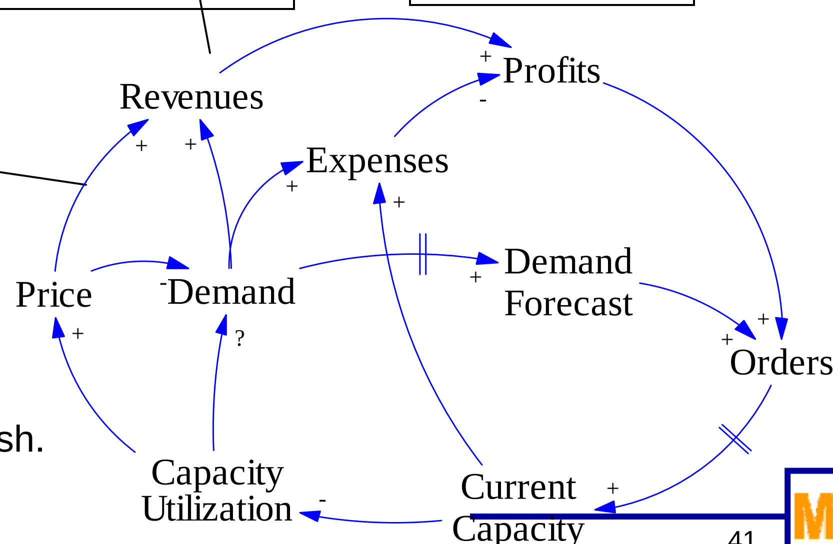
Airline Costs





SDM CA EoE



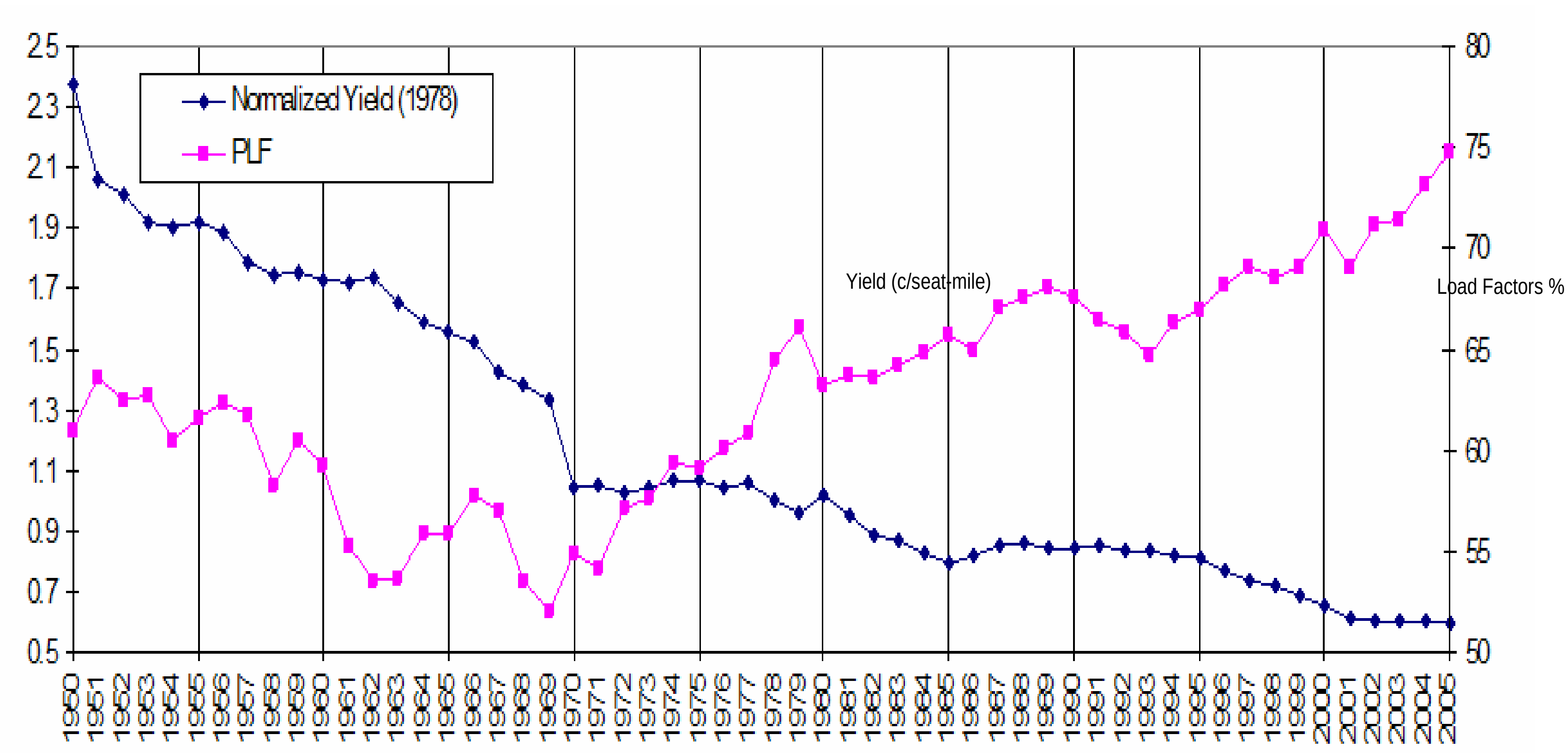


- Based on H.B. Weil's airline industry model (1996)
- Developed further in collaboration with Jijun and Josh.
- Using Anylogic

Statistical Tests

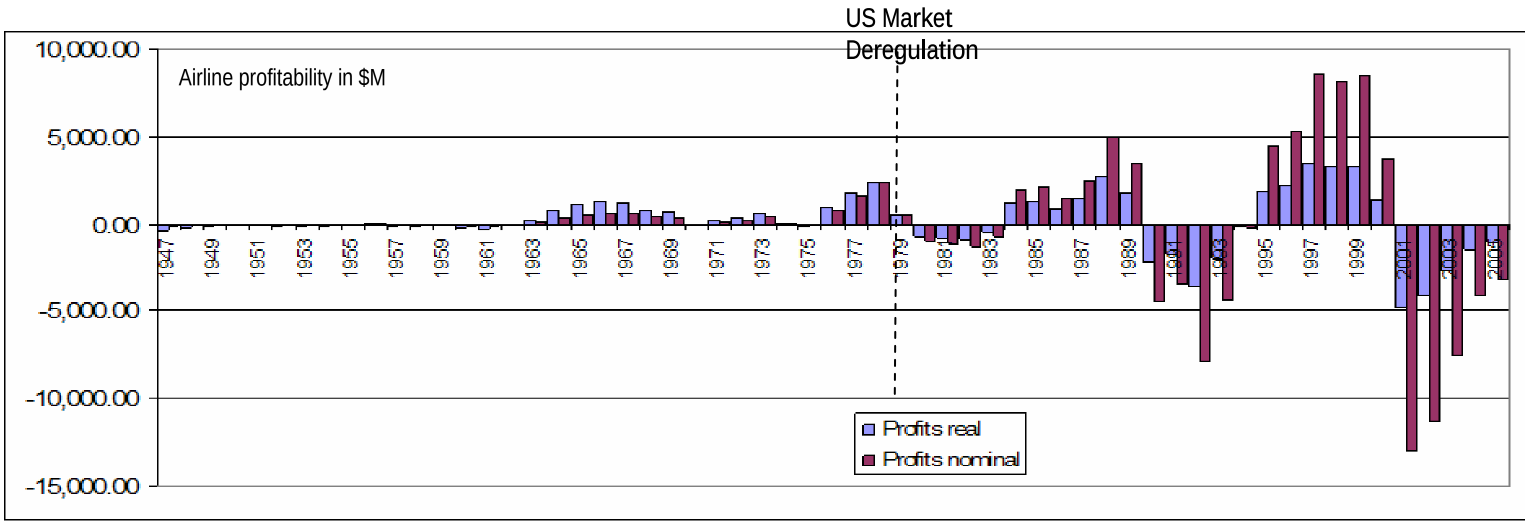
Variable	Mean d	Mean m	Sqrt (MSE)	R sq.	Theil statistics			P(T<=t) two-tail	Statistically significant difference at 0.05
					Um	Us	Uc		
Capacity (in trillion op. ASM)	2.03	2.03	0.077	0.981	0.001	0.153	0.845	0.986	No
Demand (in trillion RPM)	1.39	1.39	0.061	0.975	0.004	0.007	0.989	0.976	No
Load factors	0.68	0.68	0.02	0.430	0.019	0.002	0.979	0.718	No
Airline costs in ($B)	101	98.9	5	0.959	0.172	0.246	0.582	0.730	No
Airline revenues	103	101.1	5.2	0.949	0.152	0.185	0.663	0.735	No
Airline profit margins	0.026	0.027	0.018	0.663	0.003	0.000	0.997	0.916	No
Aircraft orders (in trillion ASM)	0.21	0.19	0.067	0.628	0.081	0.095	0.824	0.531	No
Aircraft backlog (in trillion ASM)	0.61	0.63	0.164	0.636	0.019	0.111	0.871	0.771	No

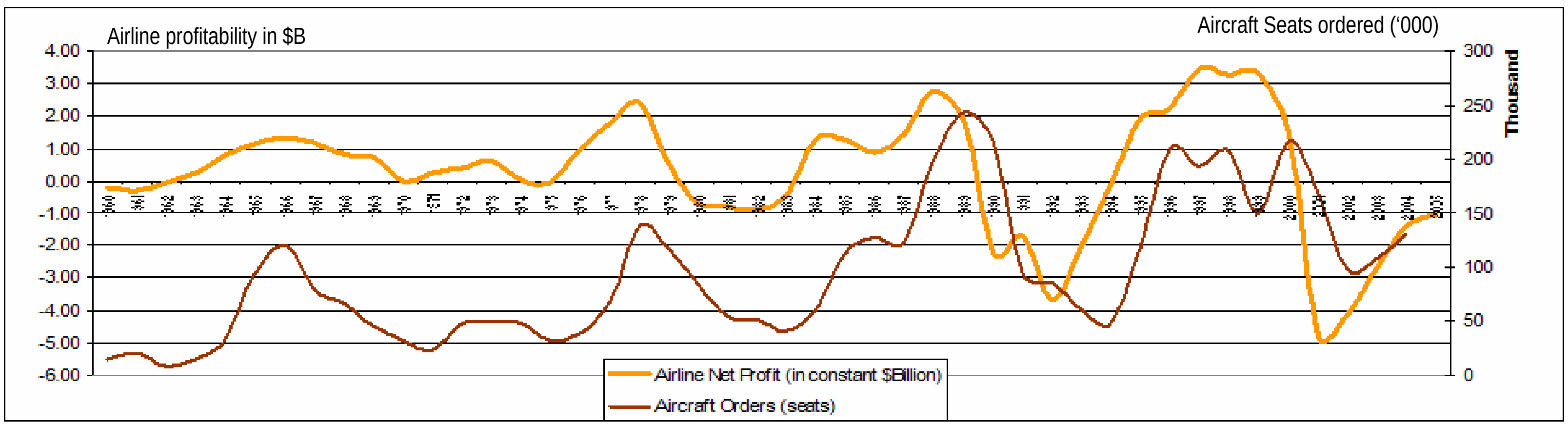
Manifestations of Cycles in CA



Global Airline Data – Data Source ATA (2006)

Manifestations of Cycles in CA



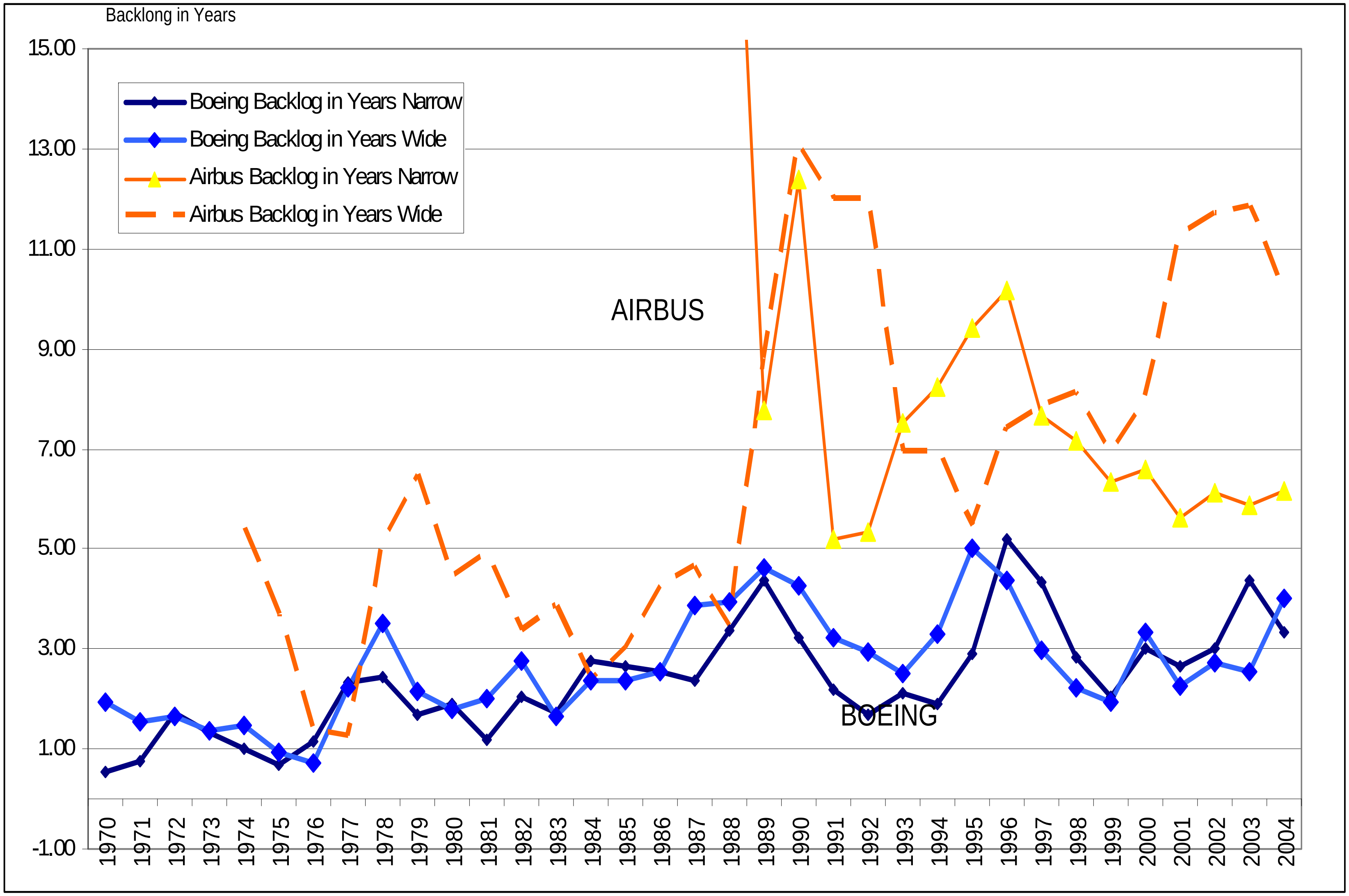


Global Data – Data Sources: ATA (2006), Boeing and Airbus order and delivery history

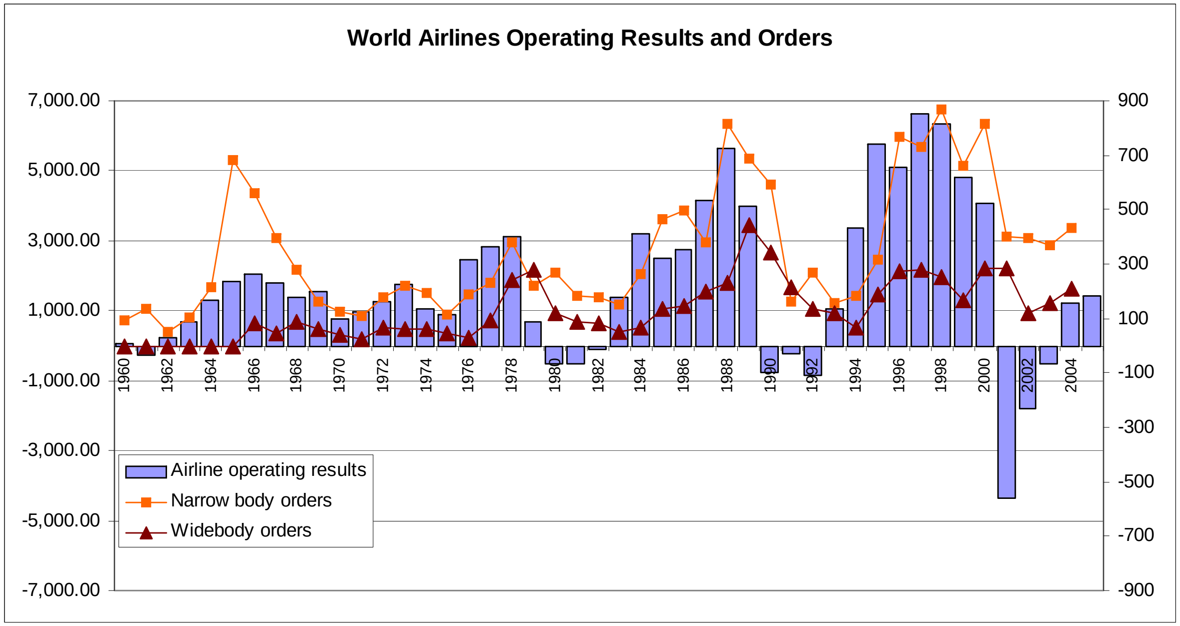
SD Model Basic Assumptions

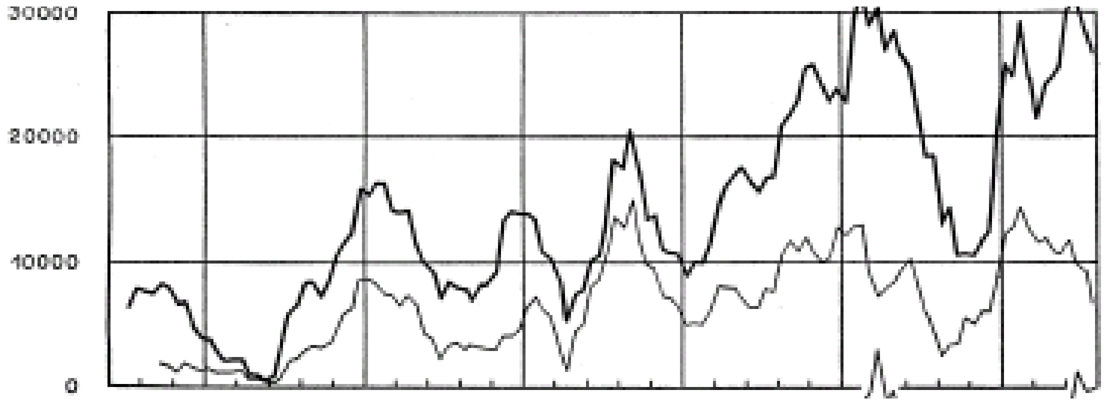
- Manufacturers produce equivalent models compete on price (can be relaxed)
- There are no manufacturer entrants

Manufacturer Response to Cycles



Business Cycles?





Shipbuilding in tons for Norwegian Ship Owners (1883-1913) [Source: Einarsen 1938]

Airframe manufacturers due to their central position in the value chain have the potential power to enhance system stability.

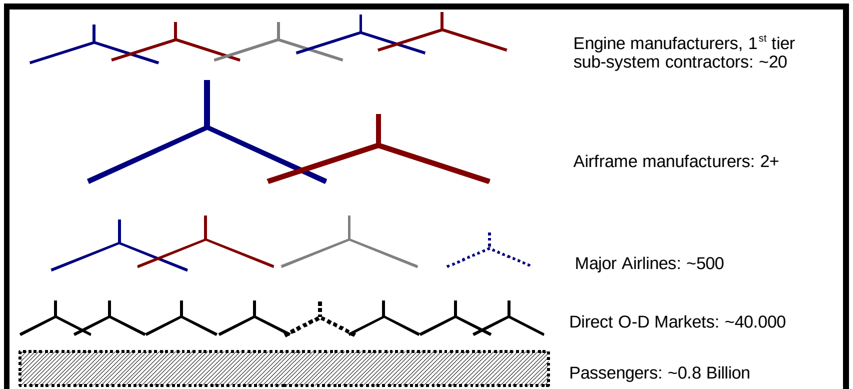
Objective:

Symbiotic strategies that can enhance long term value by supplanting zero-sum games with value adding propositions. They can be cooperative but not necessarily so.

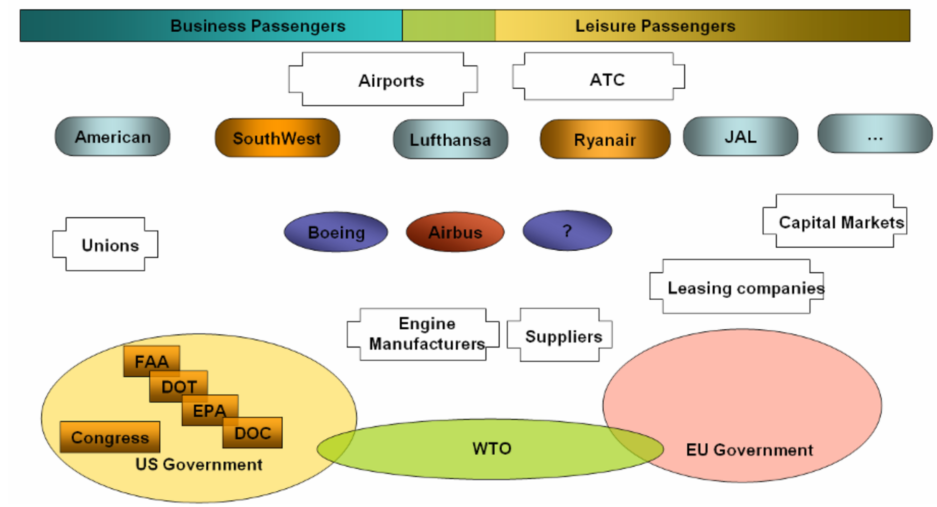
Value Functions: CA as an EoE

	Value function	Symbols
Passengers	$P_{VF} = \begin{cases} \max \sum_t \sum_i Q_{ti} \\ \min \sum_t \sum_i D_{ti} F_{ti} (1+r_p)^t, \quad r_p = 0 \\ \min \frac{\sum_i D_{ti}}{\sum_i Q_{ti}}, \forall t \end{cases}$	
Carriers	$Car_{VF} = \begin{cases} \max \left(\sum_t \underbrace{(F_{it} D_{it} - C_{it} Q_{it})}_{EVA} \cdot (1+r_i)^t \right) \\ \min \left(std(EVA) \right) \\ \min(\, t, EVA < 0) \end{cases}$	t: unit of time i: carrier j: airframe manufacturer r: discount rate Q_i: Available Seat Kilometers (ASK) D_i: Realized demand in Revenue Passenger Kilometer (RPK) F_i: Yield (Revenue / RPK) C_i: Unit cost (Expenses/ASK) including cost of capital P_j: Manufacturer revenue per aircraft QP_j: Aircraft delivered CP_j: Production costs per aircraft including cost of capital
Airframe Manuf.	$Mfg_{VF} = \begin{cases} \max \left(\sum_t (P_{jt} - CP_{jt}) QP_{jt} \cdot (1+r_j)^t \right) \\ \min \left(std(QP_{jt}) \right) \end{cases}$	
Government	$Gov_{VF} = \begin{cases} \sum_i Q_{ti} > q_t, \forall \; domestic \quad i \\ and \\ \sum_j QP_{ti} > qp_t, \forall \; domestic \quad j \end{cases}$	
Capital Markets	$Cap_{VF} = \begin{cases} \max \left(\sum_t (F_{it} D_{it} - C_{it} Q_{it}) \cdot (1+r_m)^t + \sum_t (P_{jt} - CP_{jt}) QP_{jt} \cdot (1+r_m)^t \right) \\ or \\ \max \left((F_i D_i - C_i Q_i) + (P_j - CP_j) QP_j \right), \forall t \end{cases}$	

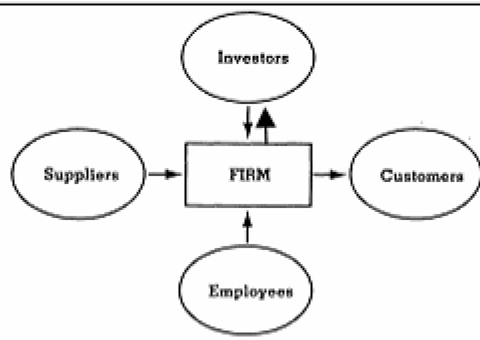
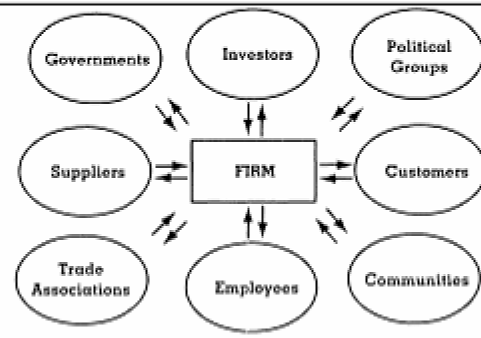
Views of Commercial Aviation



	U.S. Data (Source: Campbell)		Global Data (extrapolation)	
	Direct Output in $B	Employees ('000)	Direct Output in $B	Employees ('000)
Air transportation	154	691*	~405	~2000
Airport services	18	121	~47	~345
Commercial Aircraft manufacturing	75	241	~180	~640

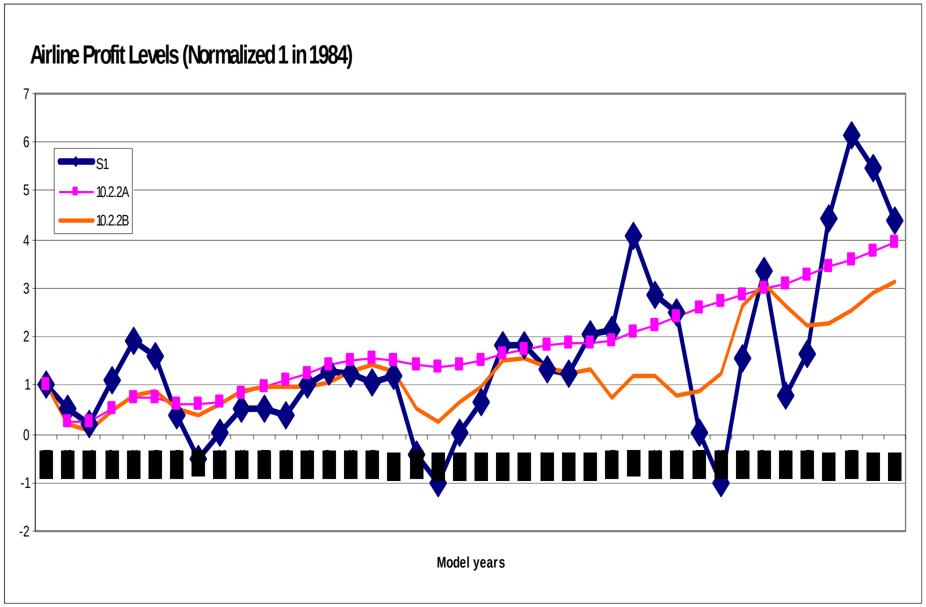


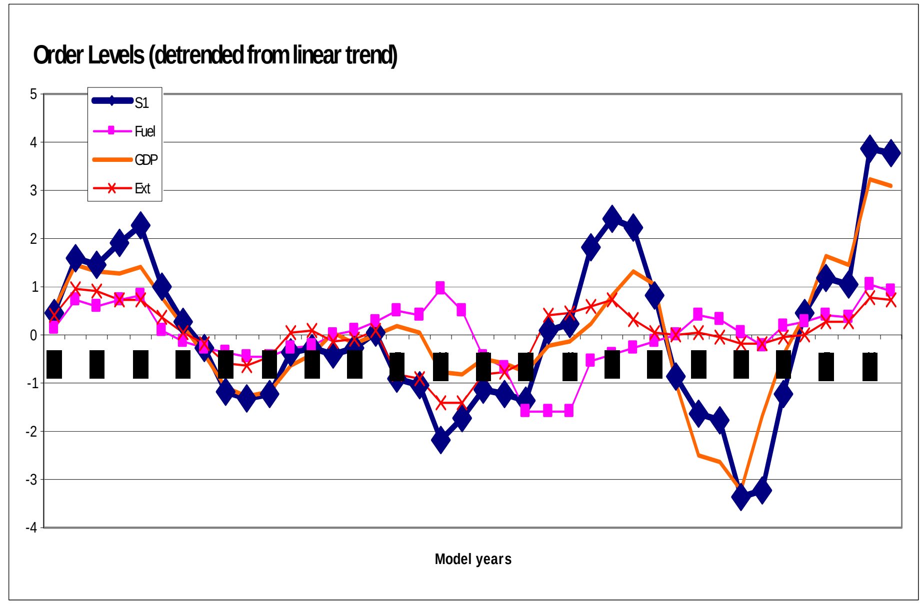
Two enterprise models

<table>
<tr><th></th><th>Shareholder-centric/modular Enterprise</th><th>Stakeholder-centric/integral Enterprise</th></tr>
<tr><td>View</td><td>
</td><td>
</td></tr>
<tr><td>Goals</td><td>Maximize shareholder wealth</td><td>Pursue multiple objectives of parties with different interests</td></tr>
<tr><td>Governance</td><td>Principal-Agent Model: Managers are agents of stakeholders. Control is the key task.</td><td>Team production model: Coordination, cooperation, & conflict resolution are the key tasks.</td></tr>
<tr><td>Performance metrics</td><td>Shareholder value</td><td>Fair distribution of value</td></tr>
</table>

Based on: Donaldson and Preston (1995), Kochan and Rubinstein (2000) , Piepenbrock (2005)

Results: Endogenous Dynamics





Cyclical behavior in the absence of exogenous factors

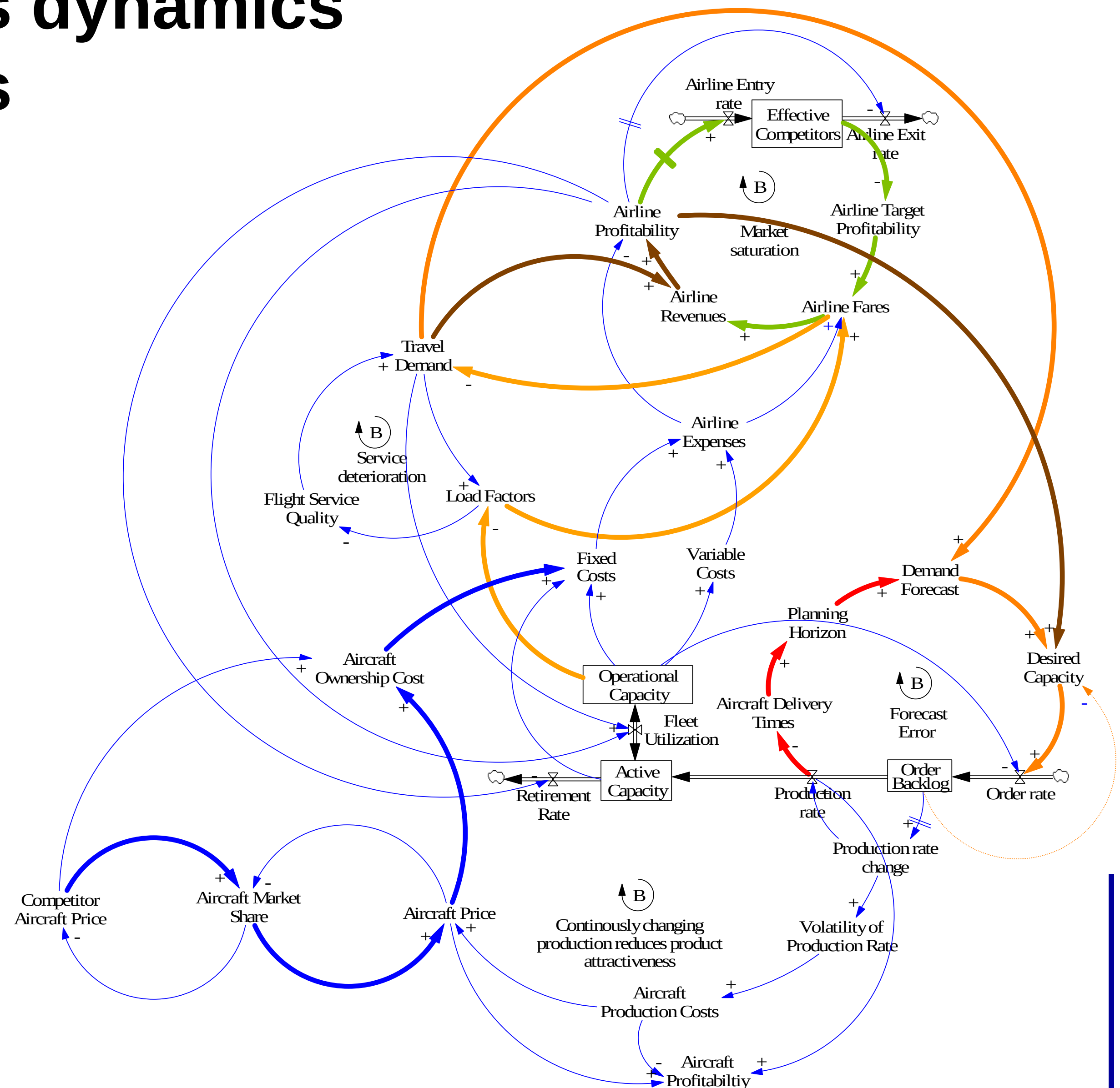
Effect of exogenous factors in order of importance:

1. **Fuel**
2. **GDP**
3. **External shocks**

Model Key Assumptions

- Equivalent aircraft
- Freight market represented by passengers

Endogenous dynamics mechanisms



What are the salient causal mechanisms that induce the cyclical behavior? CA-specific factors

Disruptive technologies	**Jets, 2-pilot cockpit, fuel efficient designs, product families etc.**
Technical regulations	**Noise abatement, stage 2,3,4 aircraft**
Exogenous factors	**Macroeconomic cycles, fuel prices, materials, interest rates**
Demand shocks	**Iraq war I, 9/11, SARS etc.**
Reinvestment cycle **Intertemporal substitution**	**Aircraft as large capital investment with limited but adjustable lifetime**
Bullwhip in supply chains, labor, and inventory	**Long lead times for both labor and capital. Irreversibility.**
Industry characteristics	**Scale economies and large investment in upfront R&D incentivize airframe mfg. to promote their wares aggressively in short term** **Low marginal costs for airlines**
Market regulations	**Deregulation combined with imperfect financing allows multiple entrants.** **Subsidies, bankruptcy protections, and national pride policies retain players in weak markets**
Decision-making	**Bounded rationality and strategic optimism create overreaction by multiple entrants.** **Large number of decision makers.**
Financing volatility	**Debt and equity financing available in economic upturns lowers barriers to entry BUT dries quickly in downturns increasing risk of price wars.** **Short-term returns can be overemphasized over long-term stability.**

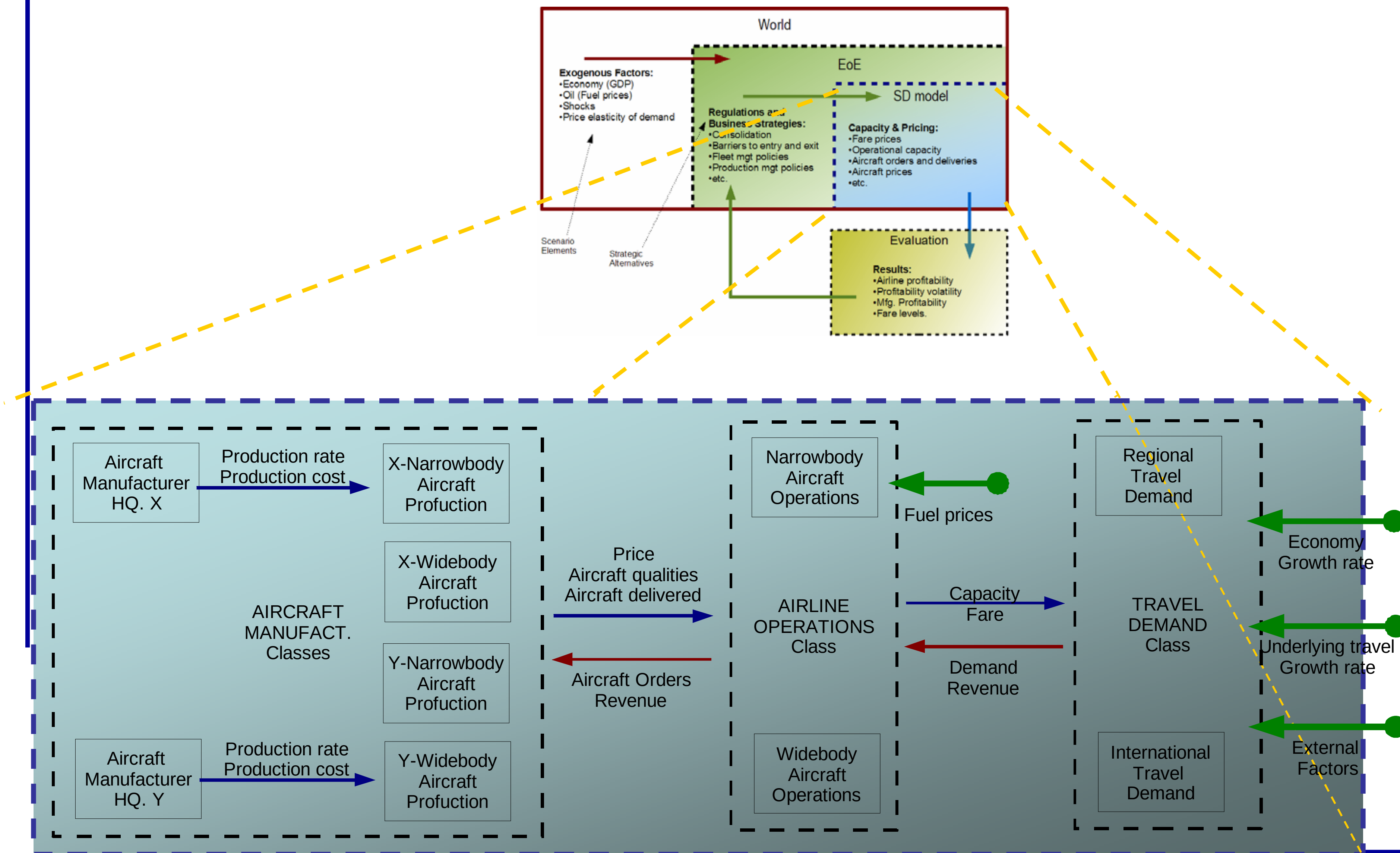
Airline Strategic Areas

Strategic Area	Desired effect
Pr	Flexibility. Reduces fixed capacity costs.
Profit-sharing programs	Flexibility. Reduces labor costs during hard times.
Good mix of ages in the fleet	Flexibility. Old amortized aircraft can be retired or parked without penalty on fixed costs.
Off-cyclical behavior (buy low, sell high)	Bullwhip reduction. Individual airline bottom line boost.
Steady ordering and flexible retirement	Bullwhip reduction.
Long-term profit-based planning	Bullwhip reduction. Compared to short-term profit-based vs. market-share based planning.
Less aggressive revenue management	Bullwhip reduction. Marginal costs of seats are not zero – holding off price wars.
Mergers	Number of players. Consolidating capacity will increase market power and reduce excessive capacity.
Tempered expectations	Decision making. Reducing irrational exuberance.

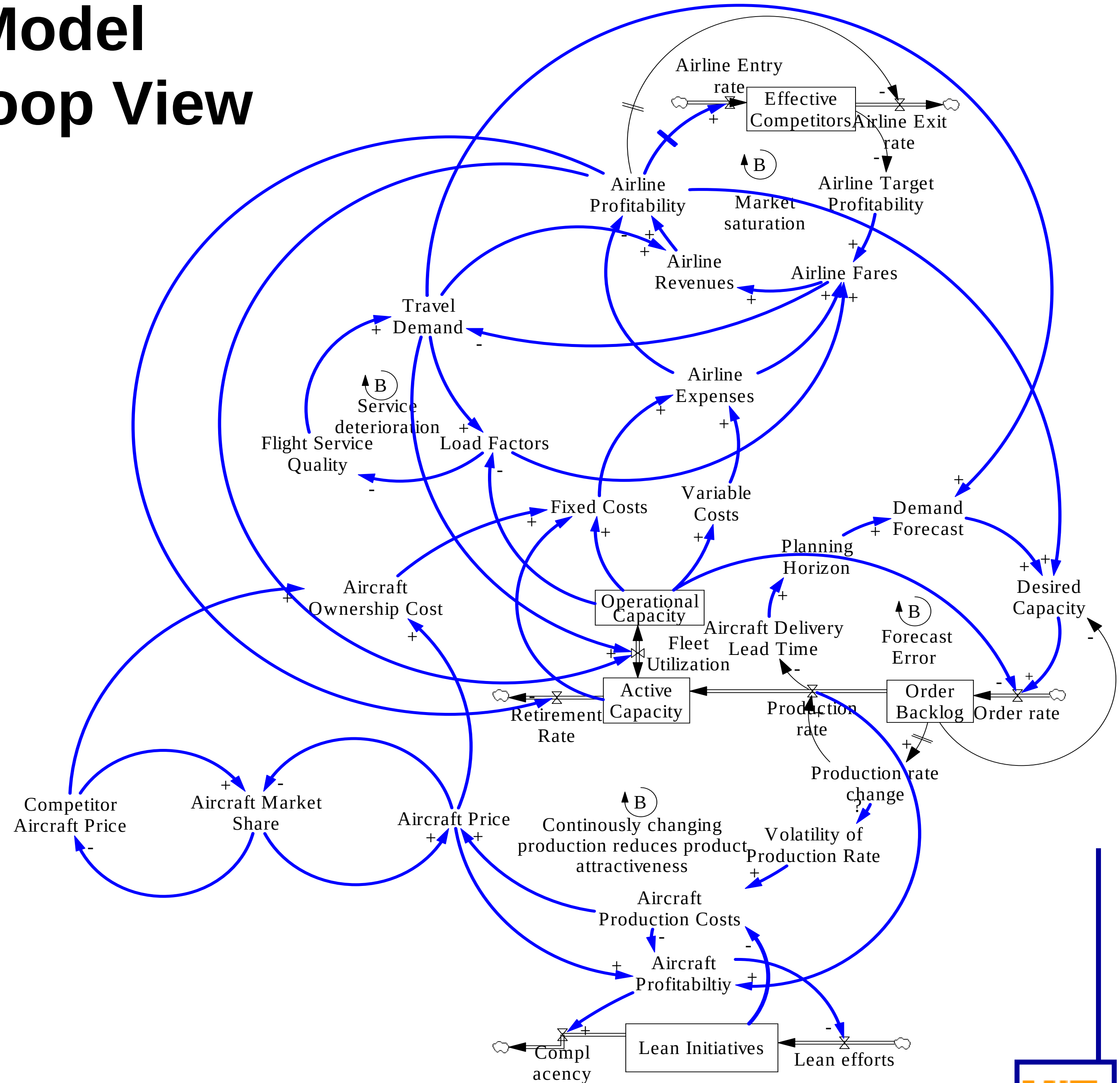
Airframe Manufacturers Strategic Areas

Strategic Area	Desired Effect
Pricing	Bullwhip reduction. Pro-cyclical pricing vs. stable pricing. Need based delivery: Auctioning production slots.
Ordering	Flexibility. Allowing family orders with specification of size later in time. Order cancellation policies Order vetting.
Standardize aircraft design	Flexibility. Stronger second hand and leasing markets. Facilitate quick post-manufacture customization (custom color schemes).
From aircraft manufacturer to service provider	Fly-by-the-hour aircraft services. Capacity decisions made with a system wide view.
New aircraft family release timing.	Cycle dampening. Follow the reinvestment cycle.
Production capacity management.	Cycle dampening. Allow backlogs to build before new production facility is established.
Lean mfg. Capacity delivery lead times.	Bullwhip reduction. Capacity effects are felt faster. Capacity inflow is more stable. Flexible production.
Production and development costs (lean improvements)	Bullwhip reduction. Lower capacity costs and higher profit margins.

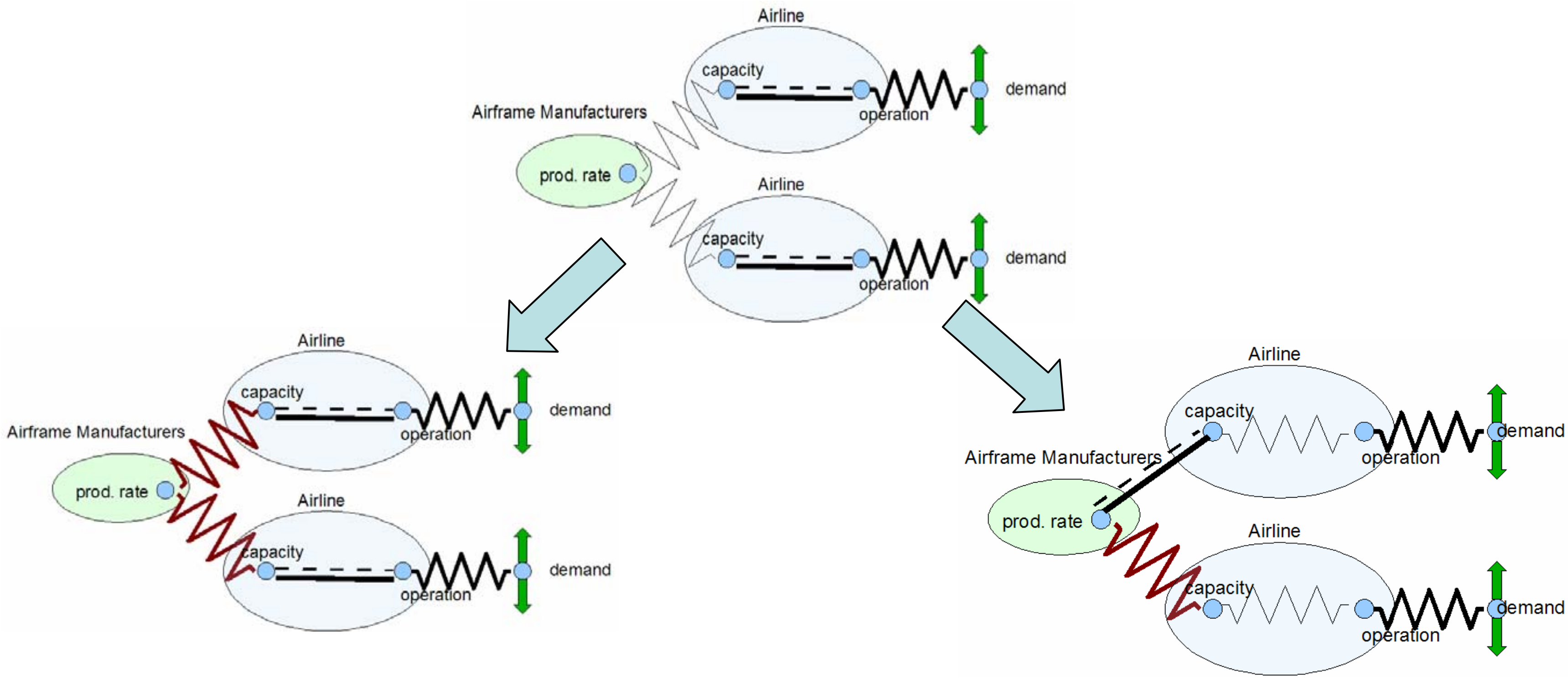
CA EoE Model Structural View



CA EoE Model Causal Loop View



Two conceptual ways to dampen the CA EoE based on Manufacturer Constituents



JIT Delivery:

+ No requirement for collusion

+ Increasing barriers to entry

-Depends on technical feasibility

-Provides comparatively less ROIC

Decoupling Capacity:

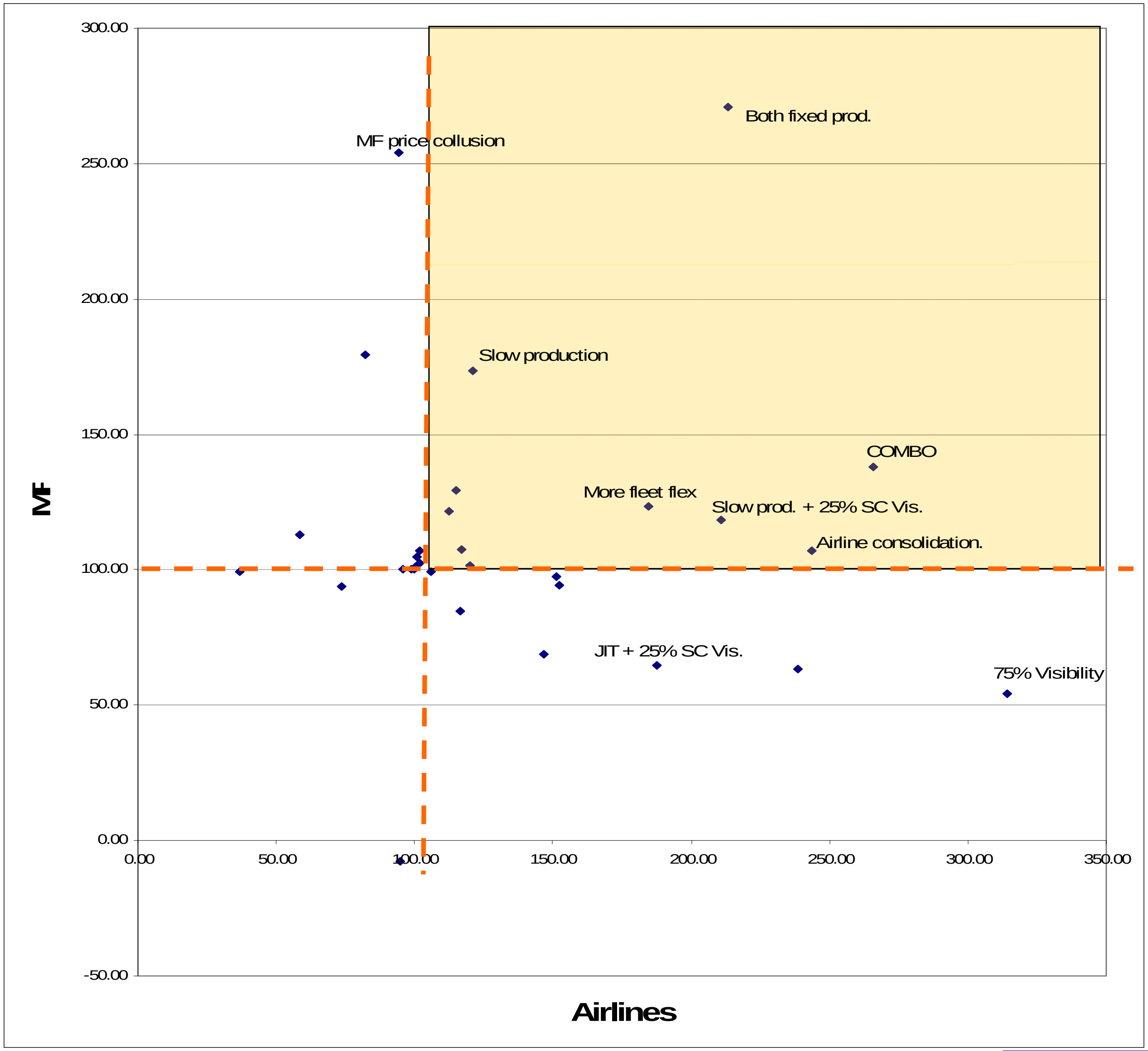
+ No requirement for collusion

+ Provides very high ROIC

- Attracts entrants

- Depending on implementation, may increase fares

Results: Symbiotic Quadrants



Definitions

EoE is a conceptual abstraction of an enterprise ecosystem

Strategic alternative is a specified action

Symbiotic strategic alternative is an action that improves total system performance by

(a) increasing the probability of survival for a majority of the EoE constituents; and

(b) without significantly compromising the long-term value delivered to any single constituent

Systems and Enterprises

Layers of systems (based on Hitchins 1994):

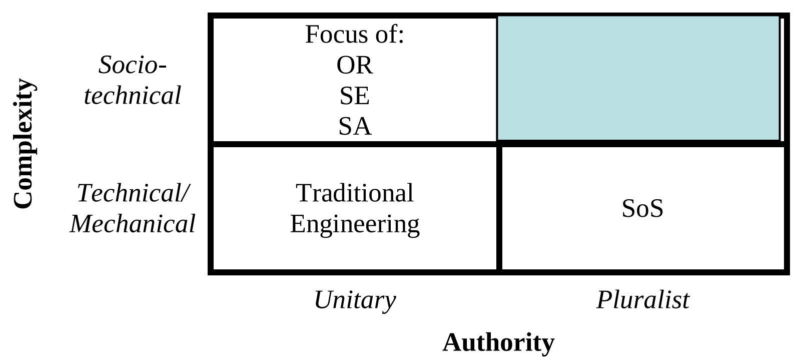
Layer 5 - *Socio-economic*. Principal lever of control is regulation.

Layer 4 - *Industry*. Complete and *competitive* supply chains.

Layer 3 - *Business*. Controlled optimization independent of competitor/partner performance.

Layer 2 - *Project*. The making of complex artifacts.

Layer 1 - *Product*. The making of tangible artifacts.



Classification based on Jackson and Keys (1984)

From SoS to Enterprise of Enterprises

"organizations are purposeful systems which contain purposeful parts and which are themselves part of larger purposeful systems.

Hence organizations have responsibilities to their own purposes, to the purposes of their parts, and to the purposes of the larger systems of which they are part." (Jackson and Keys 1984)

Characteristics of EoEs (based on SoS -- Maier 1998, Sage and Cuppan 2001)***:***

- **Operational Independence of the Constituent enterprises**
- **Managerial Independence of the Constituent enterprises**
- **Evolutionary Development**
- **Emergent Behavior**
- **Diversity of Interfaces**

Distinct value functions of constituents from emergent global value

No obvious architect or point of leverage

Large system inertia

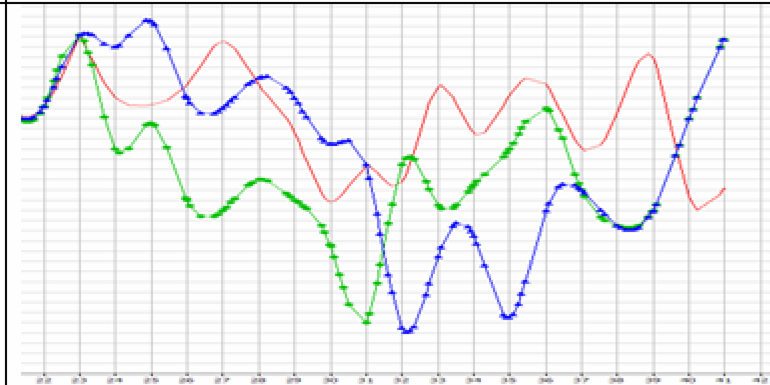
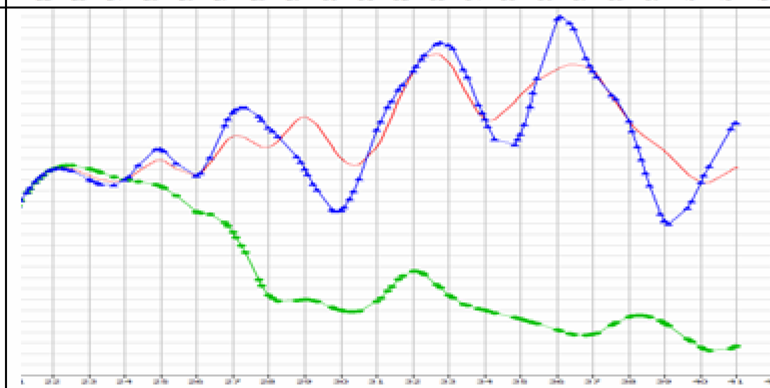
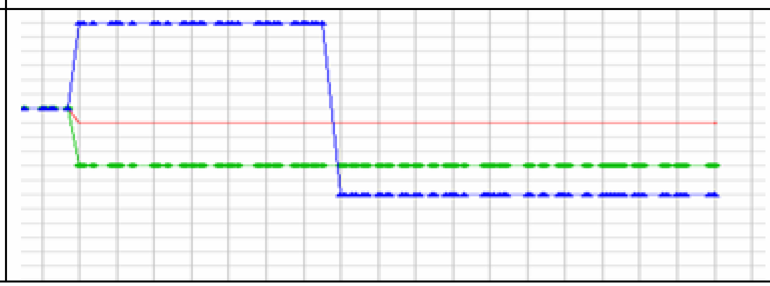
Loose coupling at interfaces

(tighter coupling EoE → Extended Enterprise (Nightingale 2004))

Loose coupling vs. Tight coupling

Scenarios

- S1: Global Village
- S2: Islands of Sufficiency
- S3: Growth and overshoot

	Scenarios for years 2006-2024
GDP (growth rates)	
Fuel Prices (normalized and in real $)	
Other external factors	

S1: red line, S2: green line dotted with circles, S3: blue line dotted with triangles