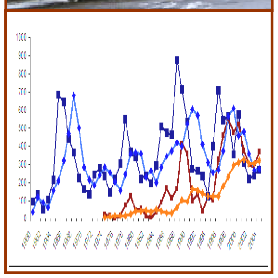
Strategies in Enterprise Ecology: Symbiotic Models for Commercial Aviation as an Enterprise of Enterprises



Sgouris Sgouridis and Prof. Joseph Sussman

Engineering Systems Division

Massachusetts Institute of Technology

Research Presentation

LAI Conference

Cambridge, MD

April, 19th 2007

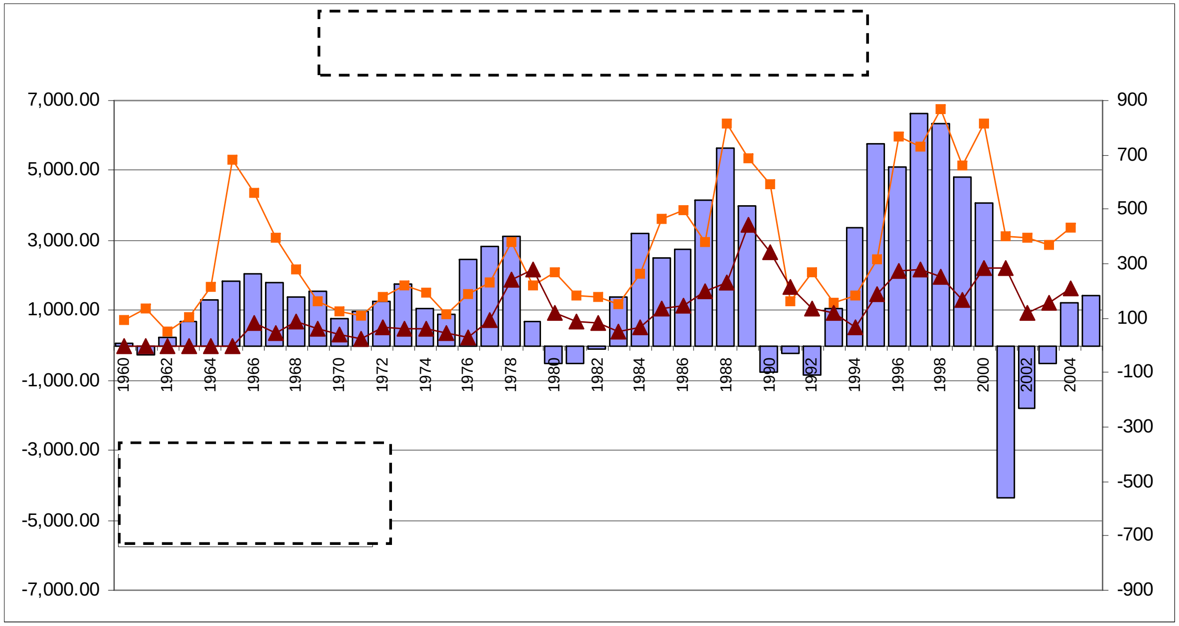
Agenda

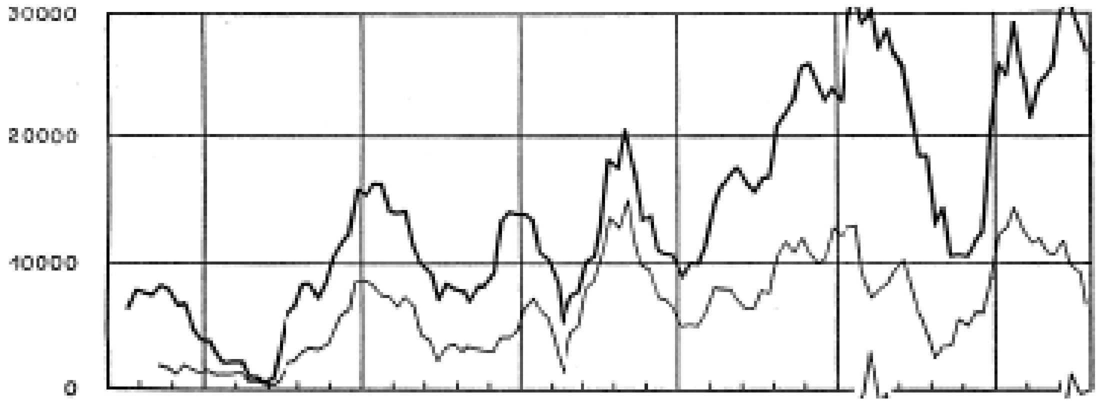
- Hypotheses
- Background
  - Commercial Aviation Cycles
  - Enterprises and business cycles
- A framework: Enterprise of Enterprises
- Modeling Enterprise of Enterprises
- Countercyclical strategies and symbiosis

Hypotheses

- Cyclical instability characterizes the Commercial Aviation EoE.
- Cyclicality is costly to the industries involved and society.
- There are feasible strategies that can dampen the cycles in a long-term Pareto efficient manner.

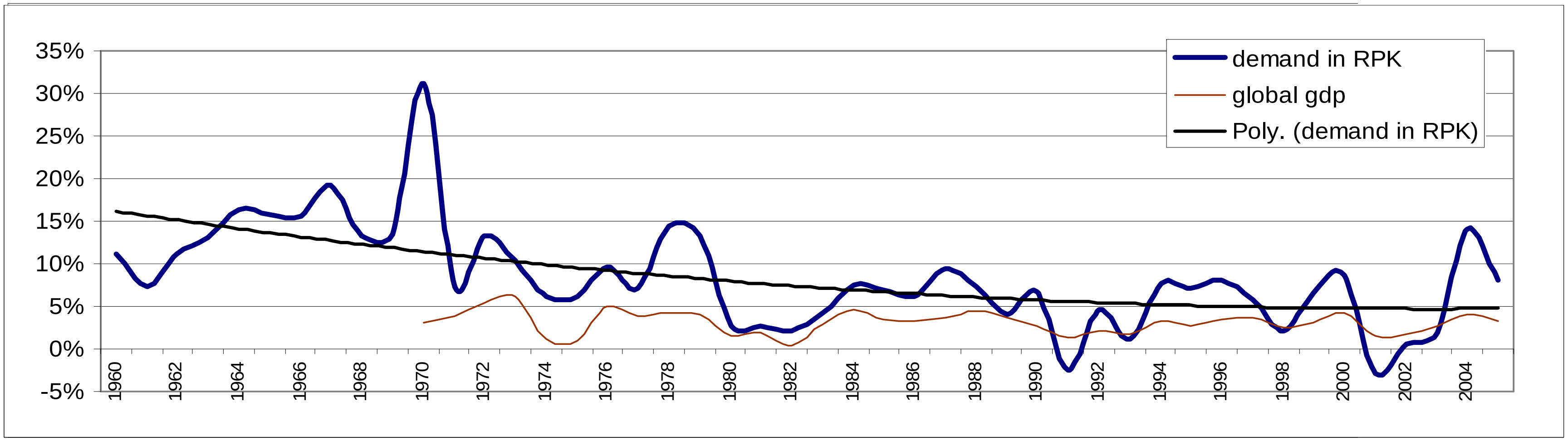
Business Cycles?

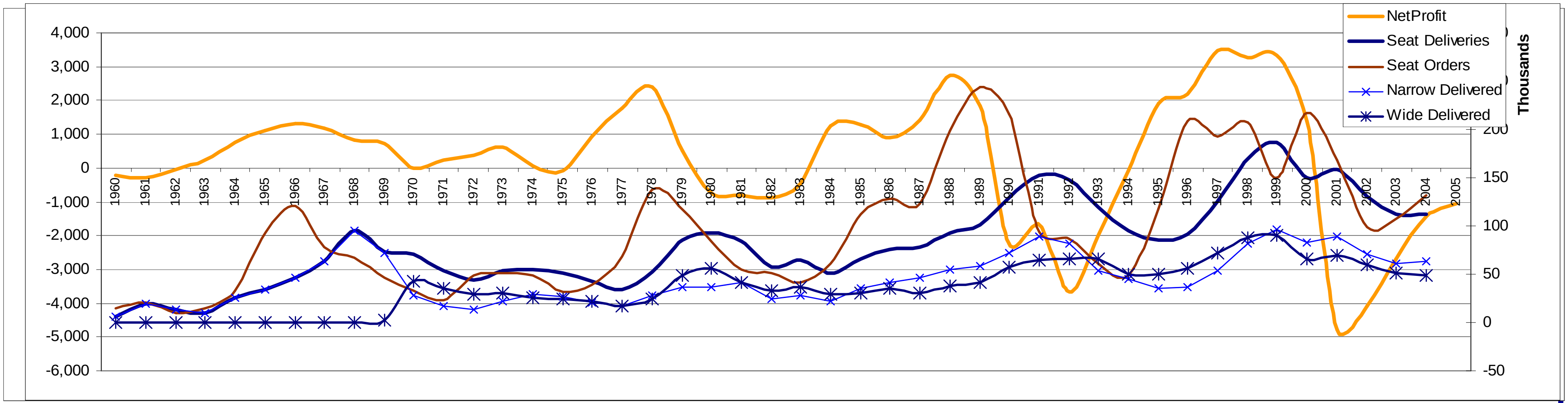




Shipbuilding in tons for Norwegian Ship Owners (1883-1913) [Source: Einarsen 1938]

Commercial Aviation Cyclicality (hi)Story

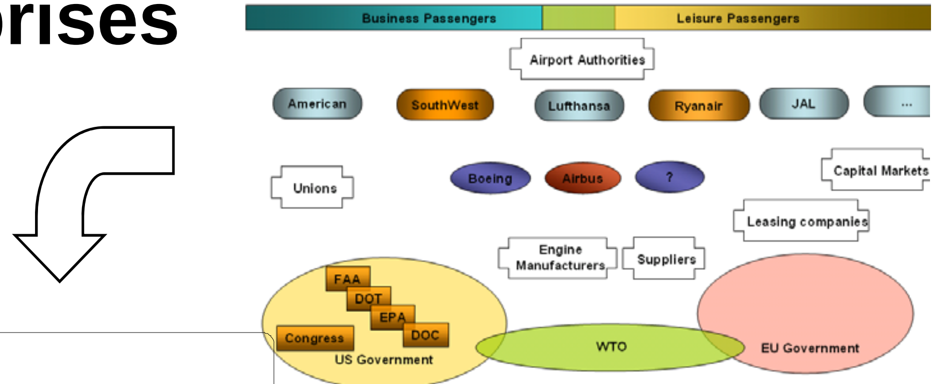


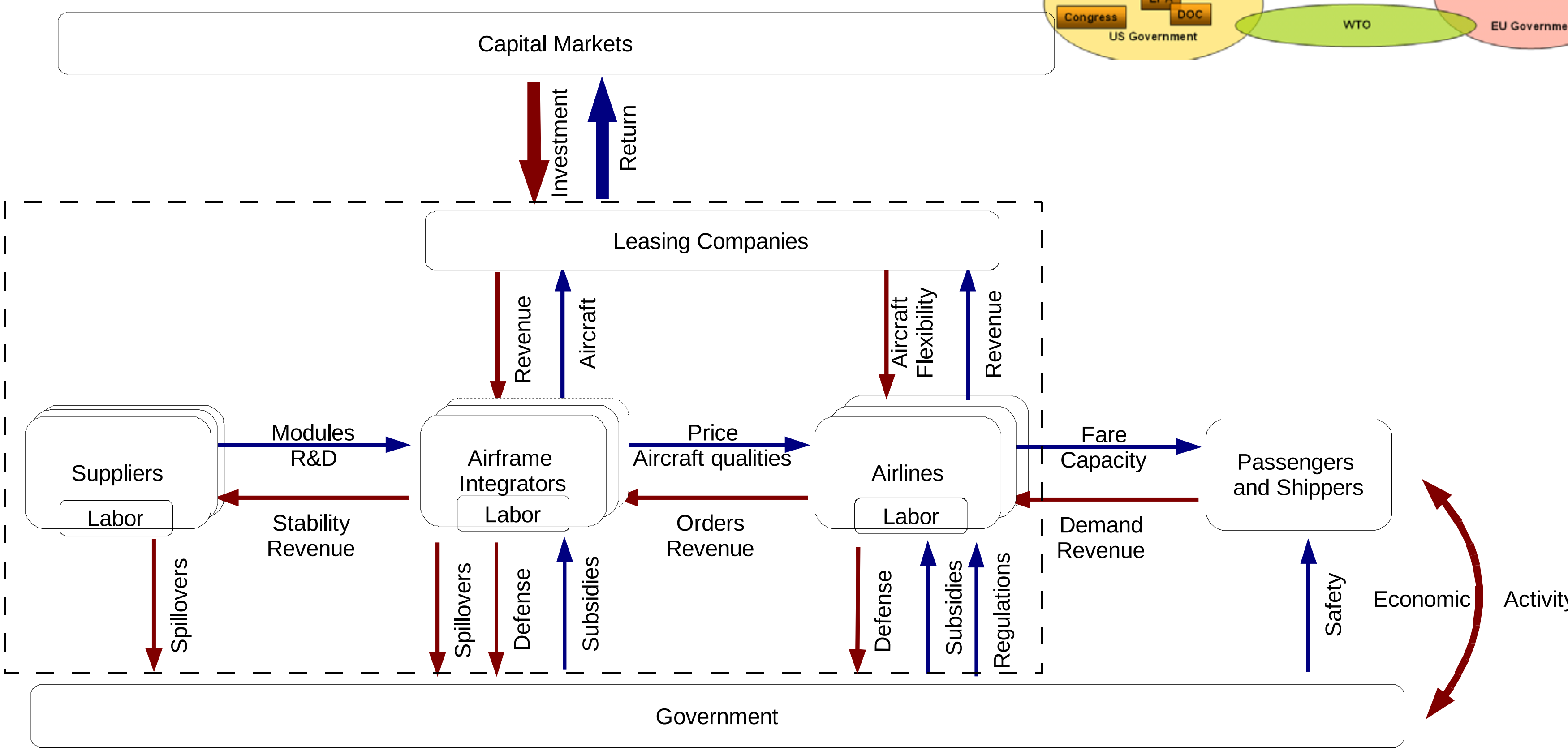


Enabling Factors for Cyclicality in CA

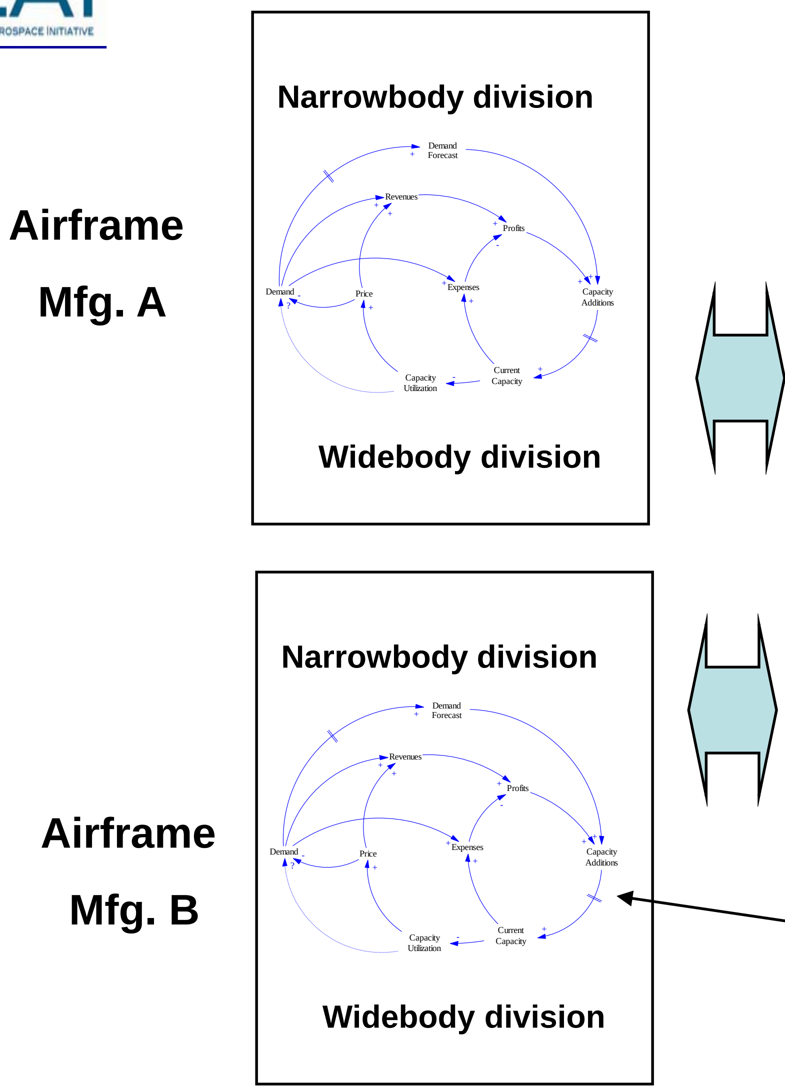
Triggers	Disruptive technologies	Jets, 2-pilot cockpit, fuel efficient designs, product families etc.
	Technical regulations	Noise abatement, stage 2,3,4 aircraft
	Input shocks	Fuel prices, materials, interest rates
	Demand shocks	Iraq war I, 9/11, SARS etc.
Endogenous	Reinvestment cycle Intertemporal 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

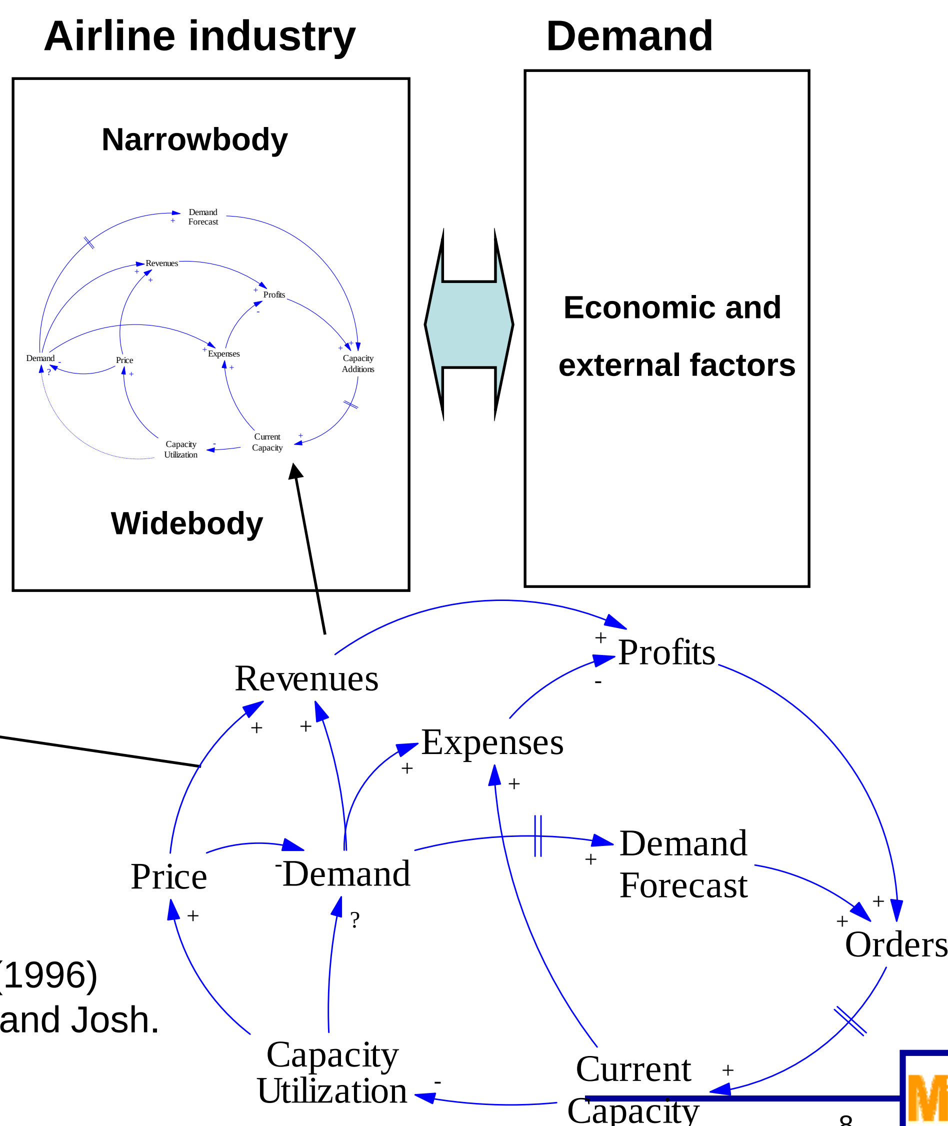
Framework: the Commercial Aviation Enterprise of Enterprises





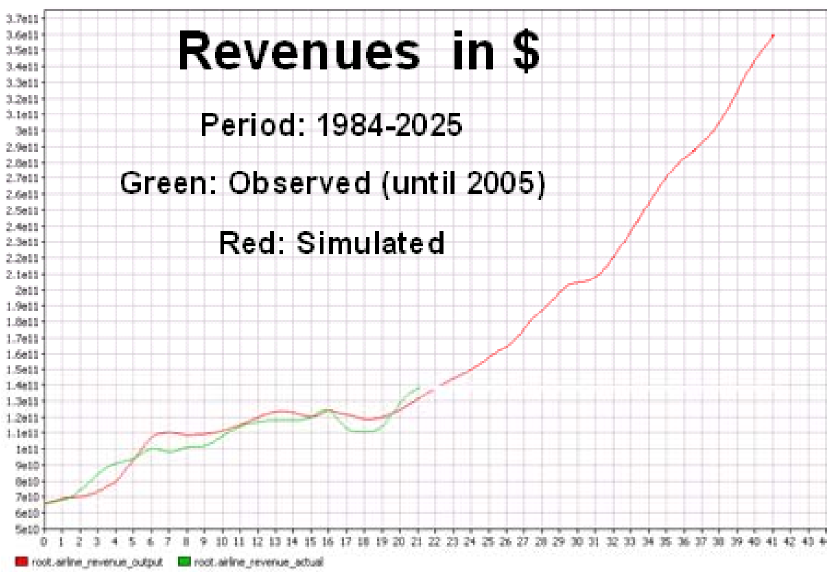
SDM CA EoE

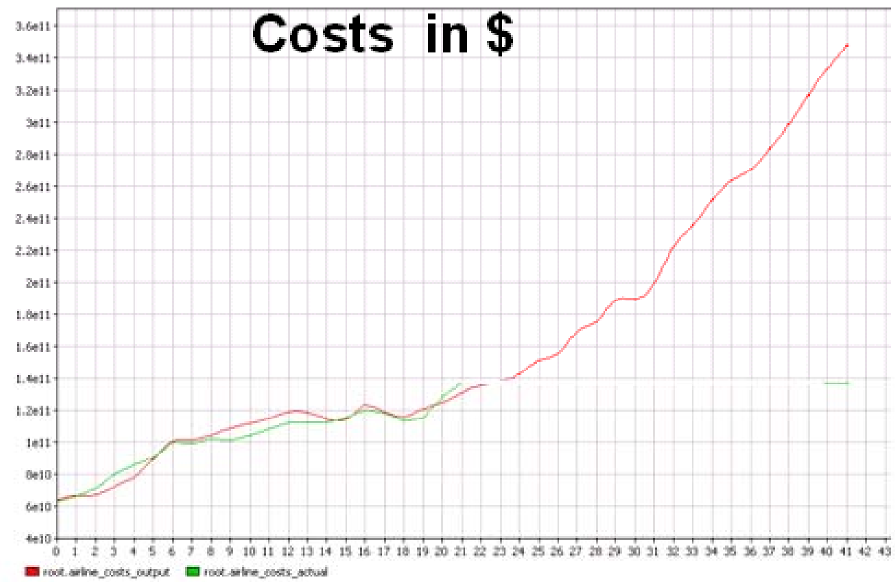


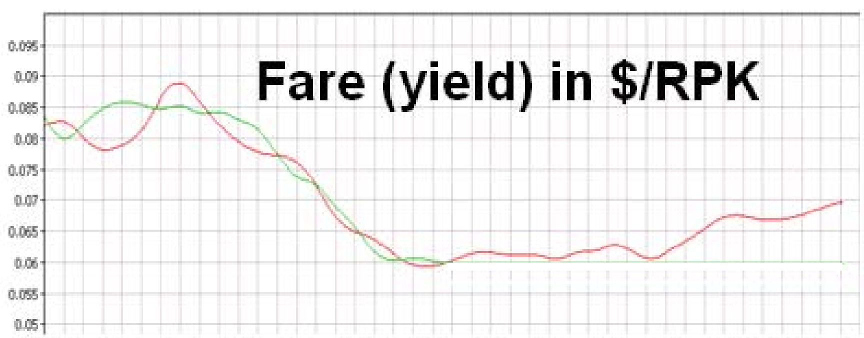


- Based on H.B. Weil's airline industry model (1996)
- Developed further in collaboration with Jijun and Josh.
- Using Anylogic

SDM Calibration: Demand and Capacity







Strategy Experiments

1. Identify value functions of stakeholders

2. Quantify and weight value functions.
Formulate as mutliobjective optimization

3. Identify strategic alternatives and strategic bundles

4. Identify future scenarios to establish parameter values

5. Execute the model by varying the strategic bundles (inputs) across scenarios

6. Compare the results and select the strategic bundles with robust performance

7. Qualitatively study the implementability of each bundle

1. Value propositions and Metrics

Stakeholder	Values	Metrics
Passenger/ Shipper	Availability of air travel	Average ASK/year
	Affordability of air travel	Undiscounted average fare
	Service of air travel	Frequency, amenities (load factors as proxy)
Carriers	Economic/investment return	Economic Value Added (EVA: Op. Profit – Taxes – Cost of Capital) Discounted to NPV
	Stability of return	Standard deviation from trend
	Minimum time in recession	Average time with return less than target
Airframe Mfgs.	*Same as carriers*	
Capital markets	Combination of carriers and airframe manufacturers returns maximized and stable	Metrics above
Governments	Availability of air travel	Metrics above
	Returns of domestic champions	Metrics above

2. Value Functions in the CA EoE as Multi-objective Optimization*

Stakeholder	Values
Passenger/ Shipper	Availability of air travel
	Affordability of air travel
	Service of air travel
Carriers	Economic/investment return
	Stability of return
	Minimum time in recession
Airframe Mfgs.	
Capital markets	Combination of carriers and airframe manufacturers returns maximized and stable
Governments	Availability of air travel
	Returns of domestic champions

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

*** Anylogic & OptQuest use tabu search algorithms to perform the optimization**

3. Airline Potential Strategic Areas

Strategic Area	Desired effect
Leasing	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.

3. 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).
Fly-by-the-hour aircraft services.	Transformation from aircraft manufacturer to service provider: Fly-by-the-hour aircraft services.
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.
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.

Next Steps

- Formulate experiments (DOE)
- Run experiments
- Draw conclusions and consider the implementability of the bundles of strategic alternatives