

Flexibility in Large Commercial Aircraft Program Valuation

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ESD.71 Application Portfolio

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Motivation

- With the near completion of Airbus's A380 and Boeing's 787 programs, manufacturers are likely to update their single-aisle aircrafts next.
- New airframer competition and increased environmental pressure:
 - **Incumbents:** Airbus A320, Boeing 737
 - **New Entrants:** Bombardier CSeries, Comac C919
- **To make the right decision, managers need to understand how to unleash value in the aircraft program design.**
- **Purpose:** To evaluate the impact of incorporating flexibility in large commercial aircraft program design.



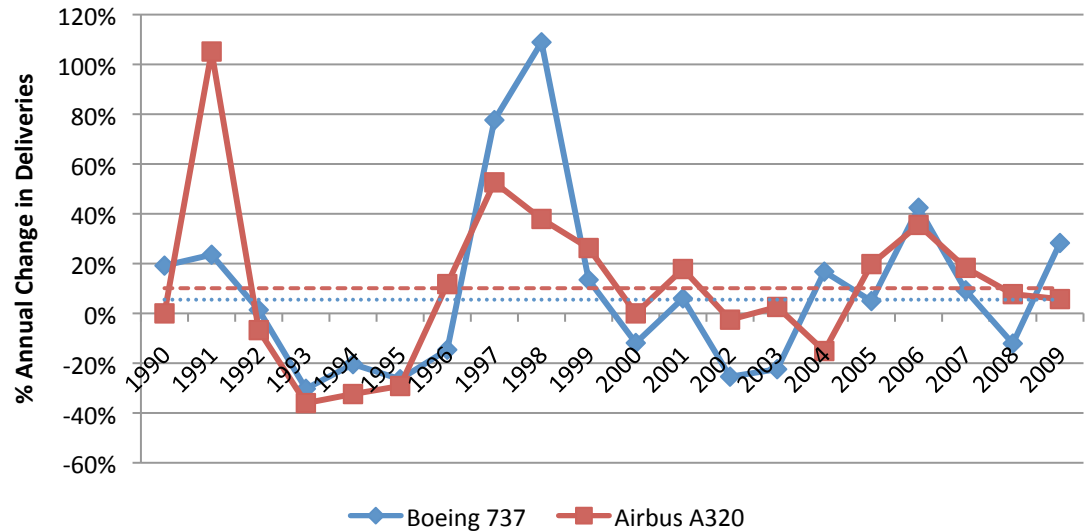
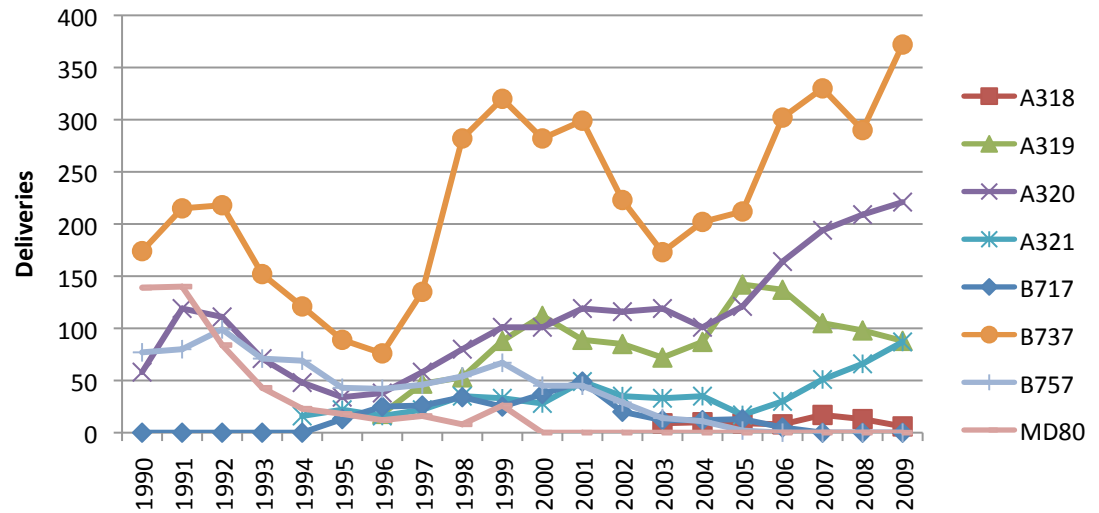
System Definition

- The development and production of a new single aisle aircraft in the 150-185 seat, short to medium-range market segment.
- **Deterministic:**
 - Build the production facility large with capacity to produce 600 aircraft / year
 - \$12 billion investment over first 6 years
- **Flexible:**
 - Build the production facility small with the capacity to produce 300 aircraft / year, but with the option to expand by 100 aircraft / year.
 - \$10 billion investment over the first 6 years
 - Option to exit the market if the program is unprofitable after for two consecutive years.
 - Two expansion rules:
 - **Rule 1 “Play it safe”:** If demand exceeds production capacity for two years in a row, invest \$2 billion to expand capacity by 100/aircraft/year.
 - **Rule 2 “Expand with the upswings”:** If the rate of increase in demand over the past year, projected forward one year using a linear interpolation, exceeds current capacity, invest \$2 billion to expand capacity by 100/aircraft/year.

Demand Uncertainty

- Volatile demand, as measured by narrow body aircraft deliveries.
- Use historical data to calibrate parameters of a mean reverting process:

$$X_{t+1} - X_t = \kappa(\mu - X_t) + \sigma \varepsilon_{t+1}$$



Stochastic Demand Model

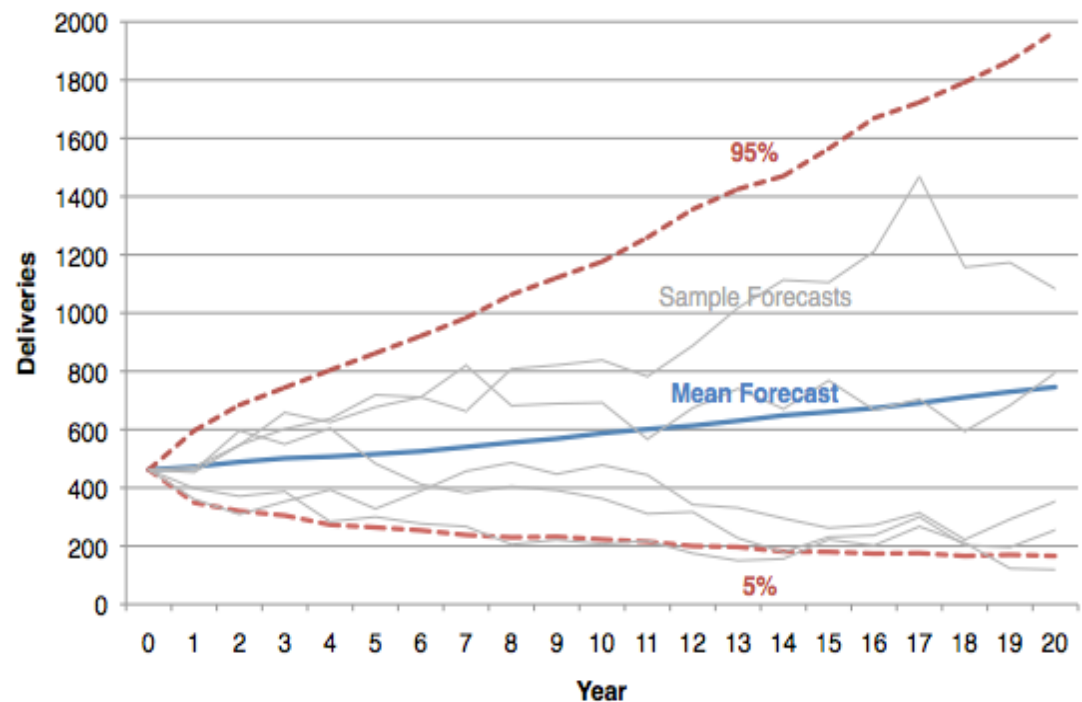
- From historical data:
 - Initial year demand from 2006-09 average deliveries
 - Speed of adjustment and volatility parameters from 2000-09 deliveries.

- From manufacturer forecasts:
 - Long run mean demand growth rate

20-year Deliveries	
Mean	12,527
S.D	5,926
95%	23,502
5%	5,668

Calibrated Parameter	Value	Standard Error
Initial Year Demand	462	30
Long Run Mean Demand Growth Rate (μ)	2.3%	3.9%
Speed of Adjustment Coefficient (κ)	0.94 years*	0.37 years
Demand Volatility (σ)	15.7%*	5.3%

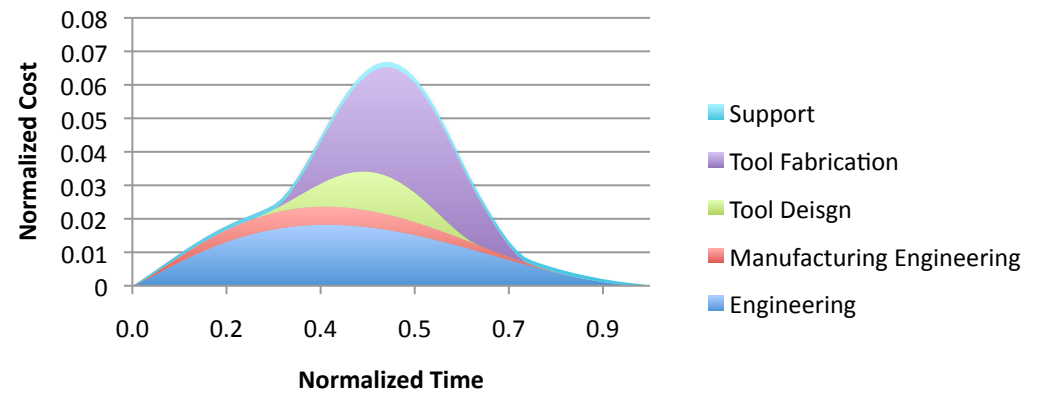
*Significant at the 95% confidence level



Program Valuation Model

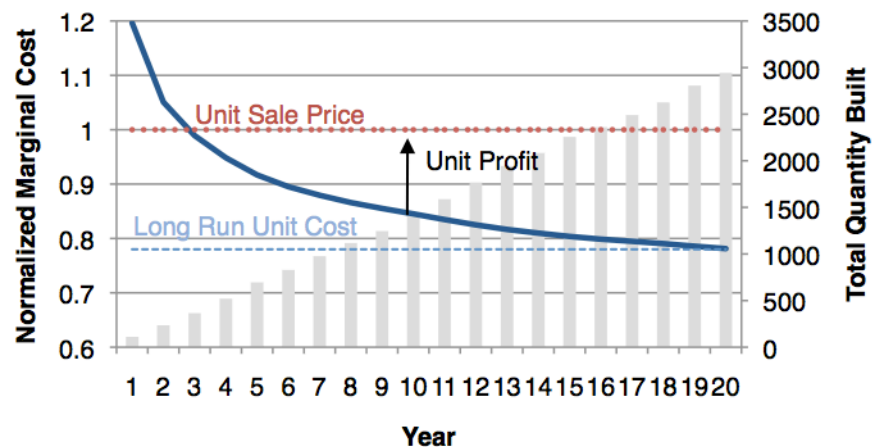
- Main components:

- Stochastic demand model
- Research, development, testing, and evaluation (RDT&E):
 - Distributed over the initial years of the program.



- Production learning curve:
 - Reduces the unit cost of production as more aircraft are produced.

$$UnitCost_i = TFUC \cdot Q_i^{\ln \beta / \ln 2}$$



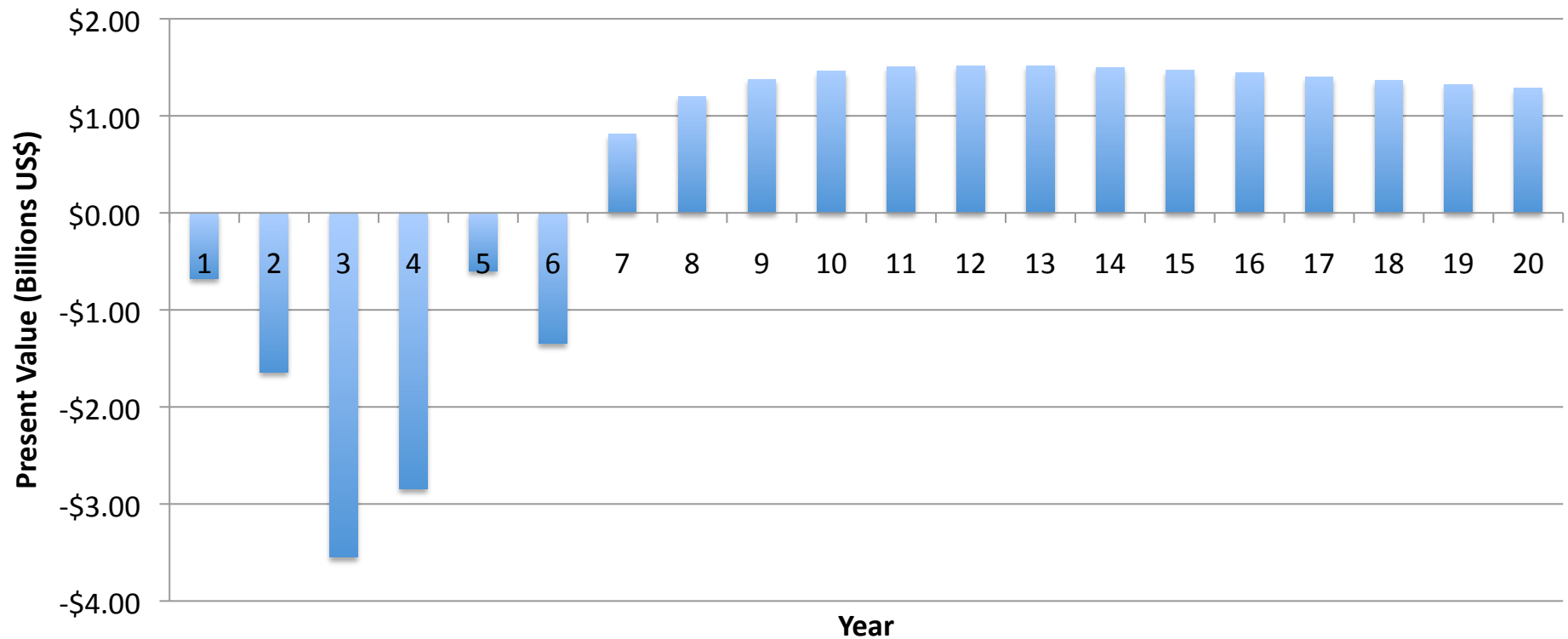
Program Valuation Model Assumptions

Variable	Assumptions	Source
Development Cost	Build Large= \$12 billion Flexible Options = \$10 billion	Bloomberg (2010)
Development Time	6 years	Markish (2002)
Aircraft Sale Price	\$50 million	Airline Monitor (2004)
Fixed Costs of Production	\$4 million/unit capacity/year	Assumed
Learning Curve Slope	Labor = 85% Other = 95%	Markish (2002)
% Production Costs	Labor = 41% Other = 59%	Markish (2002)
Theoretical First Unit Cost	\$75 million	DAPCA IV (1999), Raymer (2006)
Initial Production Capacity	Build Large = 600/year Flexible Options = 300/year	Assumed
Capacity Expansion Costs	\$2 billion / (100/year)	Assumed
Market Share	50%	Assumed
Initial year demand	462	2007-09 average
Long Run Mean Demand	2.3%	Manufacturer forecasts
Growth Rate		
Speed of Adjustment	0.94 years	Estimated from 2000- 2009 data
Coefficient		
Demand Volatility	15.7%	Estimated from 2000- 2009 data
Discount Rate	8%	IATA (2007)
Valuation Period	20 years	Assumed

Sample Cash Flow

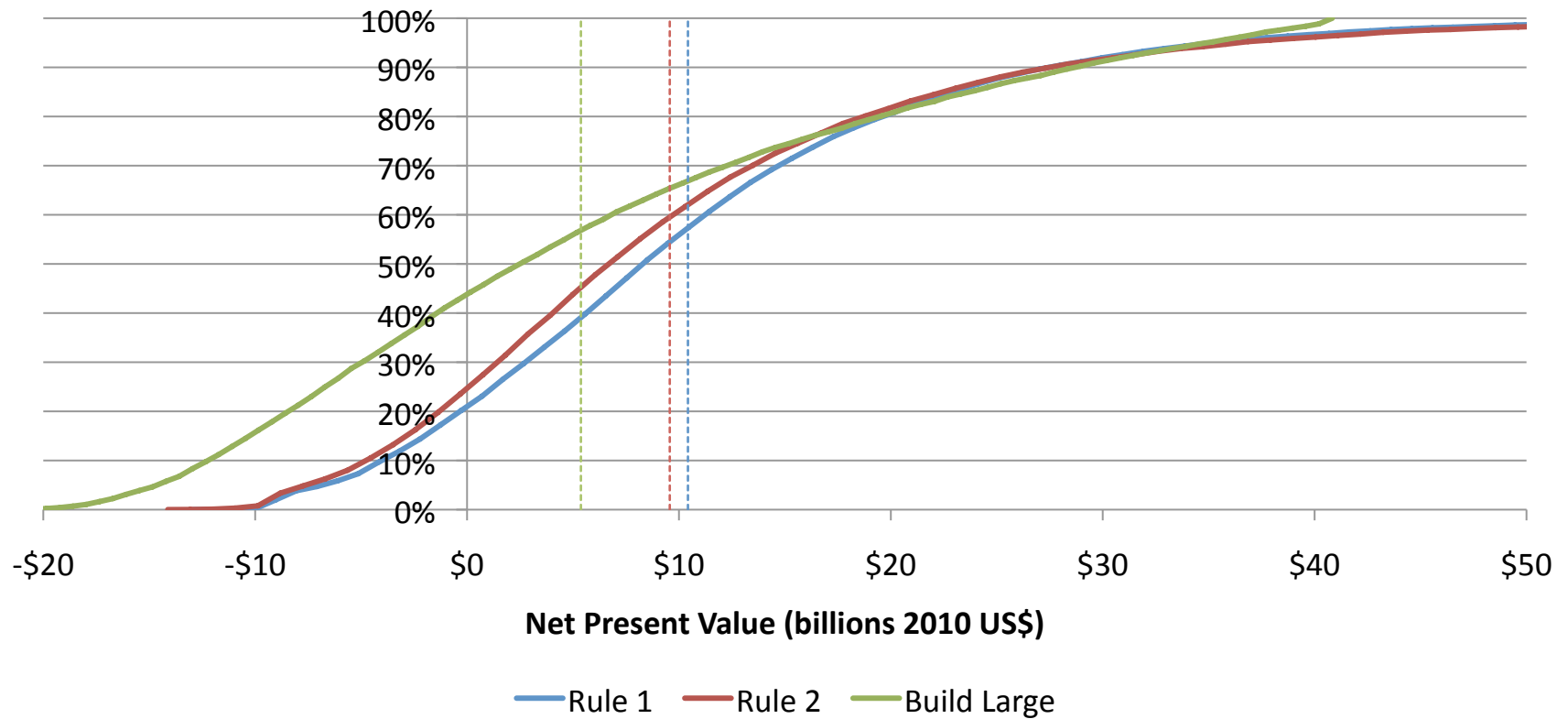
- **With constant demand:**

- RDT&E costs are expended in the first 6 years
- Fixed production costs begin in Year 6
- Learning curve effects present in Years 7-10
- Discounting reduces present value of future cash flows



System Performance

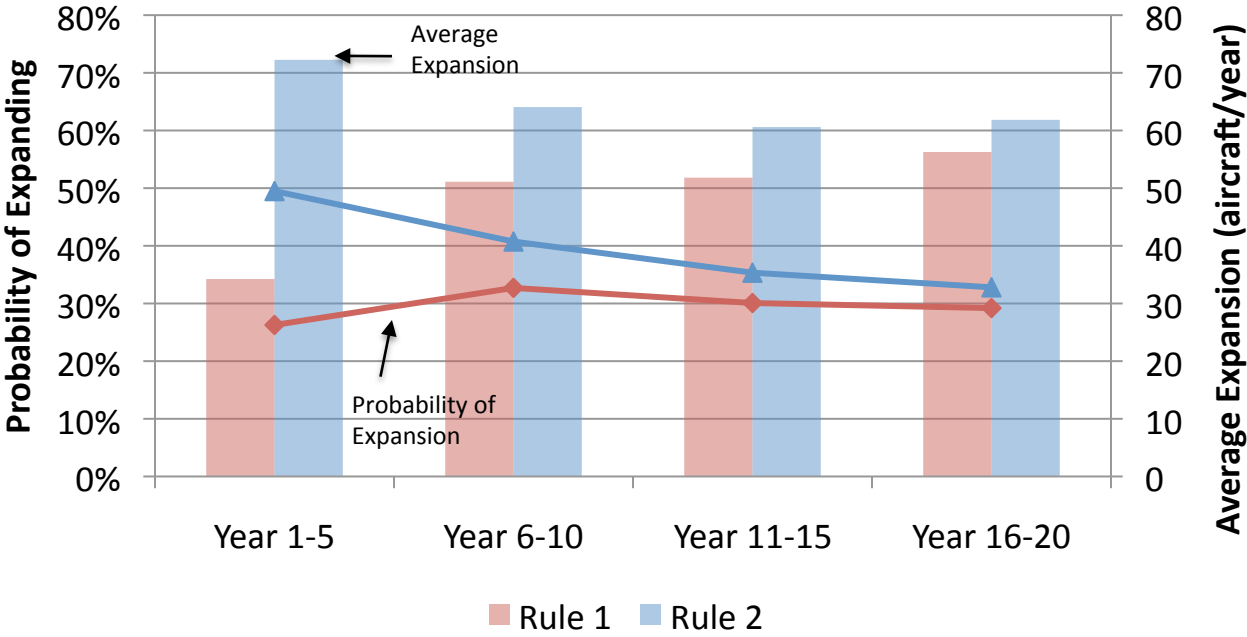
	Rule 1 <i>"Play it safe"</i>	Rule 2 <i>"Expand with the upswings"</i>	Build Large
E(NPV)	\$10.4	\$9.6	\$5.4
Std	\$13.0	\$13.8	\$15.1
5%	-\$6.9	-\$7.6	-\$14.6
95%	\$35.1	\$36.3	\$34.9



Capital Expenditures

- Build Large is 100+ units over capacity an average of 17.8 years!
- Flexible options are better able to match capacity to volatile demand

	Rule 1 <i>"Play it safe"</i>	Rule 2 <i>"Expand with the upswings"</i>	Build Large
E(PV(CapEx))	\$9.6	\$10.4	\$9.4
Std	\$2.1	\$2.5	\$0
5%	\$7.8	\$7.8	\$9.4
95%	\$13.8	\$15.2	\$9.4
Year 1 Capacity	300 /year	300 /year	600 /year
E(Y ₂₀ Capacity)	483	547	600
Std	226	249	0
5%	300	300	600
95%	900	1000	600



Conclusions

- Uncertainty in demand for single aisle aircraft results in flexibility being valuable when designing production facilities.
- Rule 1 – “Play it safe” – was generally the best option, although Rule 2 had a slightly higher 95% E(NPV) and Build Large slightly lower CapEx:

	Rule 1 <i>“Play it safe”</i>	Rule 2 <i>“Expand with the upswings”</i>	Build Large
E(NPV)	\$10.4 billion	\$9.6 billion	\$5.4 billion
E(PV(CapEx))	\$9.6 billion	\$10.4 billion	\$9.4 billion
ROI	1.09	0.92	0.57

- Flexibility in design of the system adds \$5 billion to its expected net present value.