Massachusetts Institute of Technology

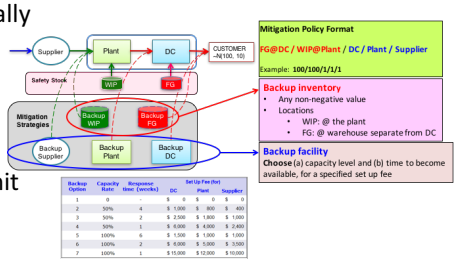
MIT Center for Transportation & Logistics

Supply Chain Resilience Evaluation And Mitigation: Analysis of Results

Shell Chemicals Best-in-Class SC1x
November 16-17, 2016
Rotterdam, The Netherlands

Game Details

- Objective:
  - Design a resilient risk mitigation strategy to minimize the total supply chain cost while maximizing the order fill rate over an uncertain future.
- Costs:
  - Holding Costs ~25% annually
  - Landed Product Costs
    - Finished Goods $100 /unit
    - WIP $80 /unit
    - Raw Materil $50 /unit
  - Selling Price $225 per unit
  - No Stockout Costs



- Service Level
  - Order Fill Rate (OFR) at customer location
  - Under normal conditions, order fill rate is ~99%

What is the most important for developing mitigation policy? Least? Why?

A. Supplier Disruption

B. Plant Disruption

C. DC Disruption

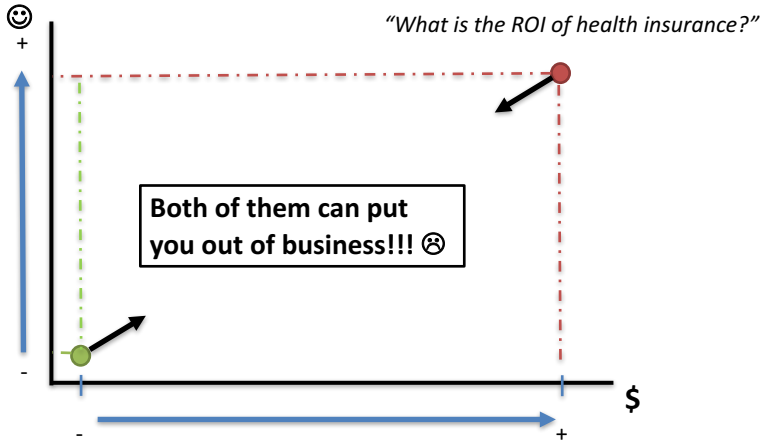
How to define a SC Risk Management Strategy?

Commonly any operations management policy/strategy aims at minimizing cost, maximizing ROI, etc…

Which risk management strategy is better?

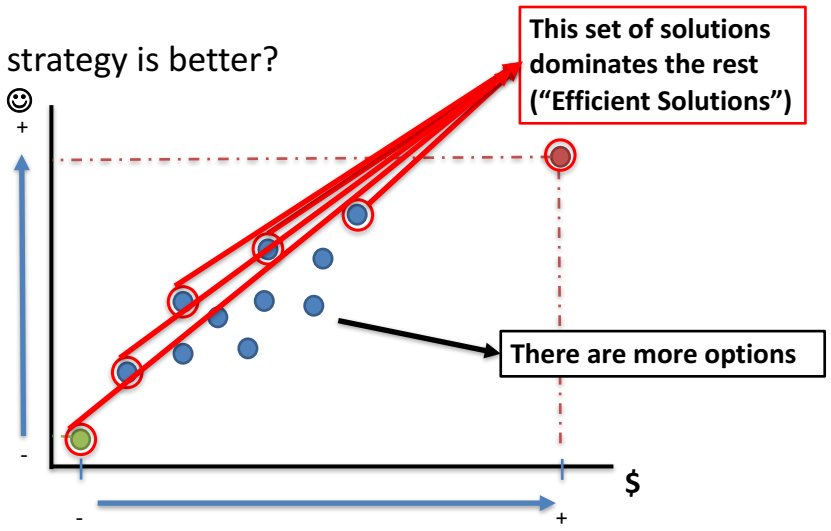
But…what about service level in case of a disruption?

Which strategy is better?

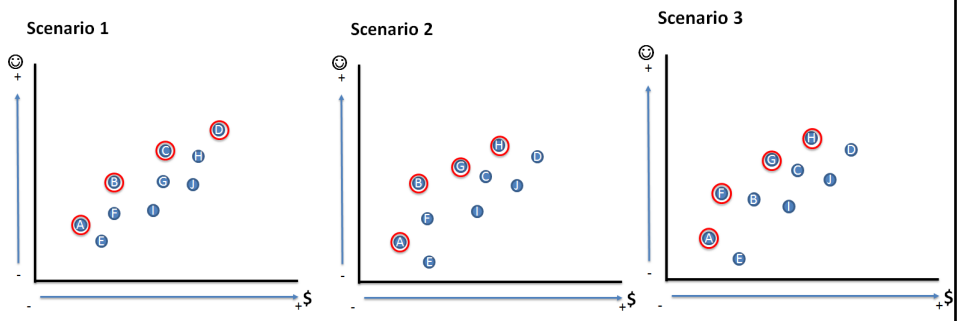


The Concept of Trade-Off

Which strategy is better?

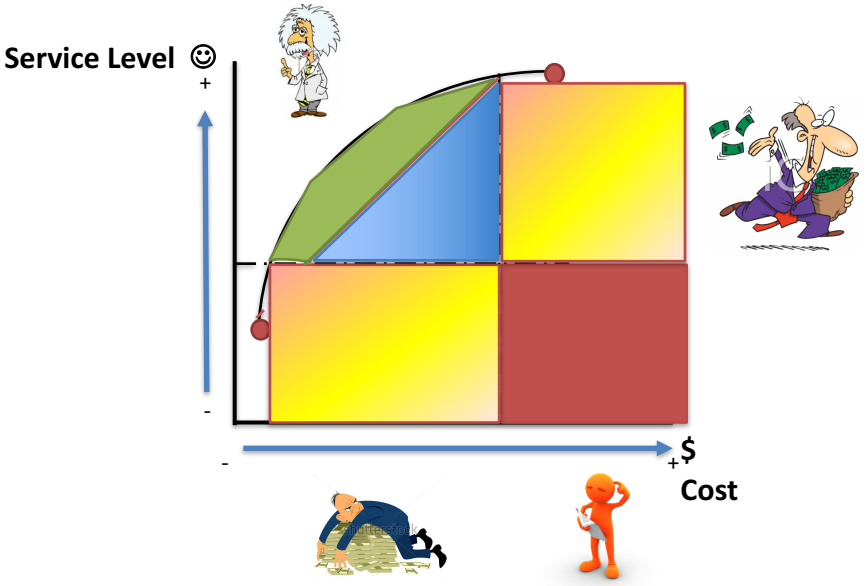


Examples of Effective Resilience Strategies



Since policy A belongs to the Efficient set in the three hypothetical scenarios, then we say that policy A is an effective resilience strategy

Assessment of mitigation strategies



Two Methods of Scoring

- Method 1
  - Scores on the basis of how many times a policy is dominated by another policy.
  - A Pareto frontier is identified and those teams are removed, 0 pts. Then another Pareto frontier is identified among the remaining teams, those teams get 1 pt and then they are removed. Repeat until there are no more teams.
  - Basically there are no constraints on this method of assessment, so you can be on the Pareto but have terrible service.
- Method 2
  - Assumes that there are minimum service and maximum cost constraints.
  - Scores 2 points in the green, 1 in the blue and 0 in the yellow or red zones (check graphs and results).

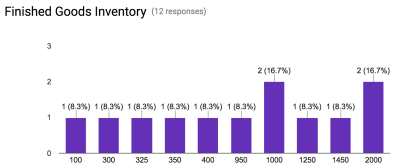
Ten Disruption Profiles at Ten Different Compositions

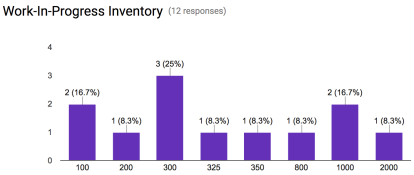
		DC disruption			Plant disruption			Supplier disruption		
Disruption Description	Sc #	Start	Duration	Normal in	Start	Duration	Normal in	Start	Duration	Normal in
No disruptions	1	1	0	1	1	0	1	1	0	1
Nightmare YearLong	2	1	12	13	14	12	26	27	12	39
Nightmare All At Once	3	26	12	38	26	12	38	26	12	38
Plant Down Long	4	1	0	1	12	36	48	1	0	1
DC Down Long	5	12	36	48	1	0	1	1	0	1
Supplier Down Long	6	1	0	1	1	0	1	12	36	48
Short Delays All Overlap	7	26	4	30	26	4	30	26	4	30
Short Delays No Overlap	8	40	4	44	15	4	19	1	4	5
DC Dead All Year	9	1	52	53	1	0	1	1	0	1
Plant Dead All Year	10	1	0	1	1	52	53	1	0	1

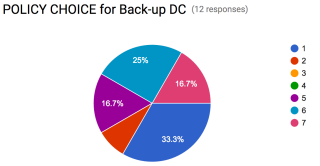
Scenarios -->	1	2	3	4	5	6	7	8	9	10
Sunny Day	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Partly Sunny	82%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Slightly Sunny	55%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Slightly Cloudy	37%	7%	7%	7%	7%	7%	7%	7%	7%	7%
Very Cloudy	19%	9%	9%	9%	9%	9%	9%	9%	9%	9%
Nightmare	0%	11%	11%	11%	11%	11%	11%	11%	11%	12%
Short Overlapping	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Supplier Down Longterm	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%
DC Down Longterm	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
Even Probability	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

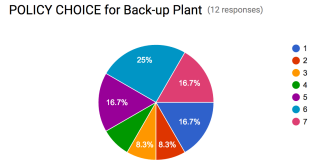
For example, Sunny Day is 100% scenario 1, 0% the rest. Even probability considers all scenarios with 10% of probability of occurrence, etc.

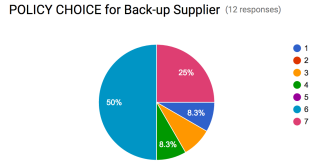
Collective Policy Selections





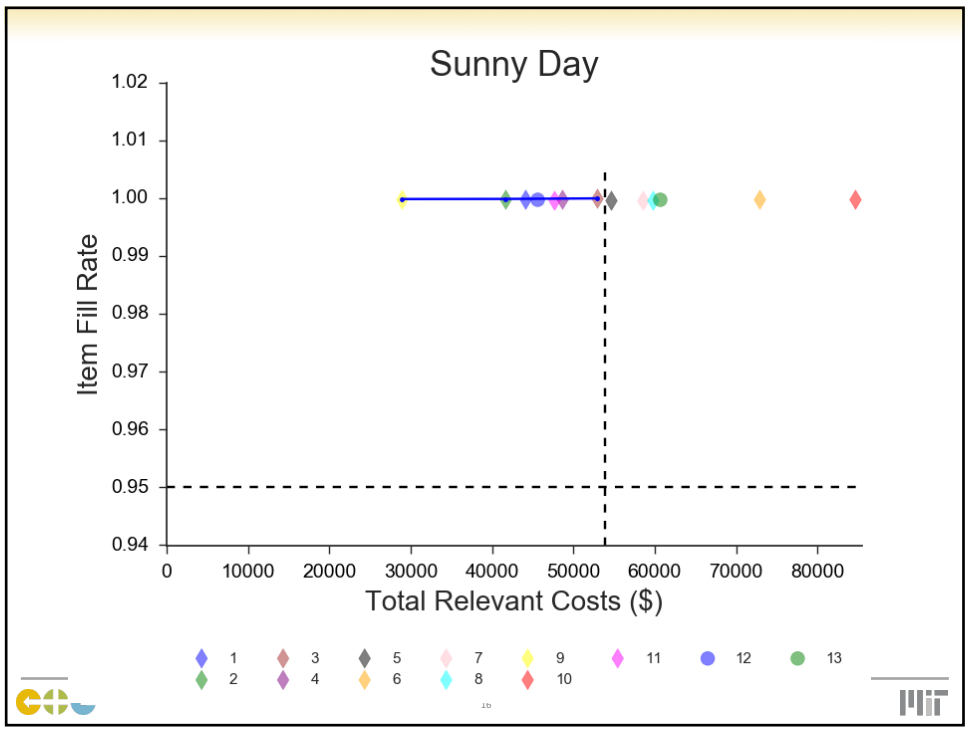


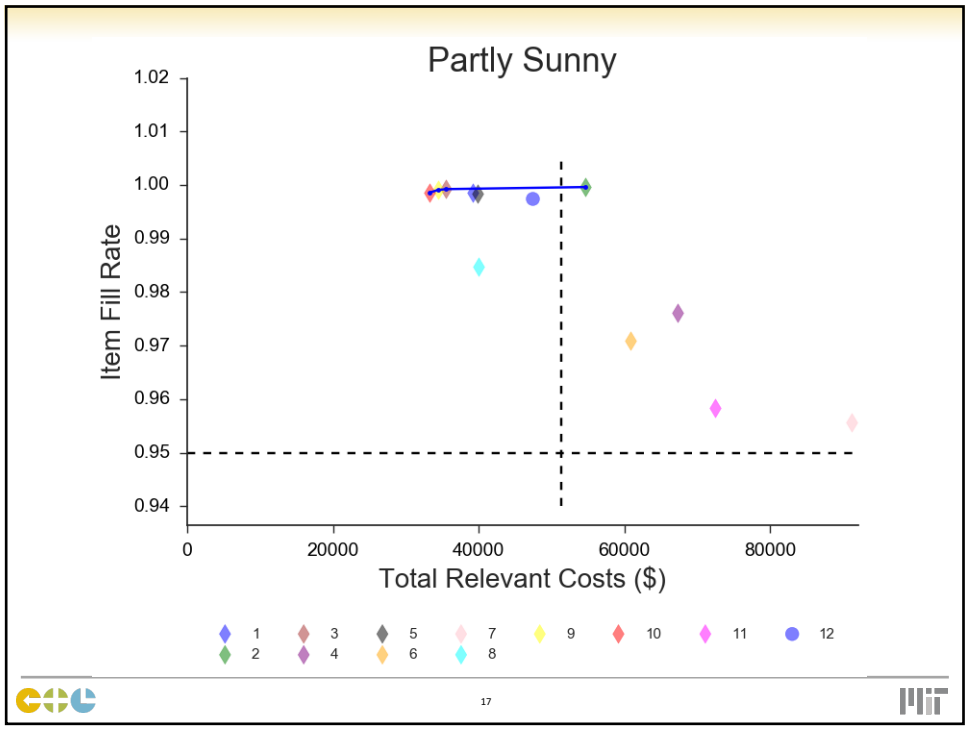


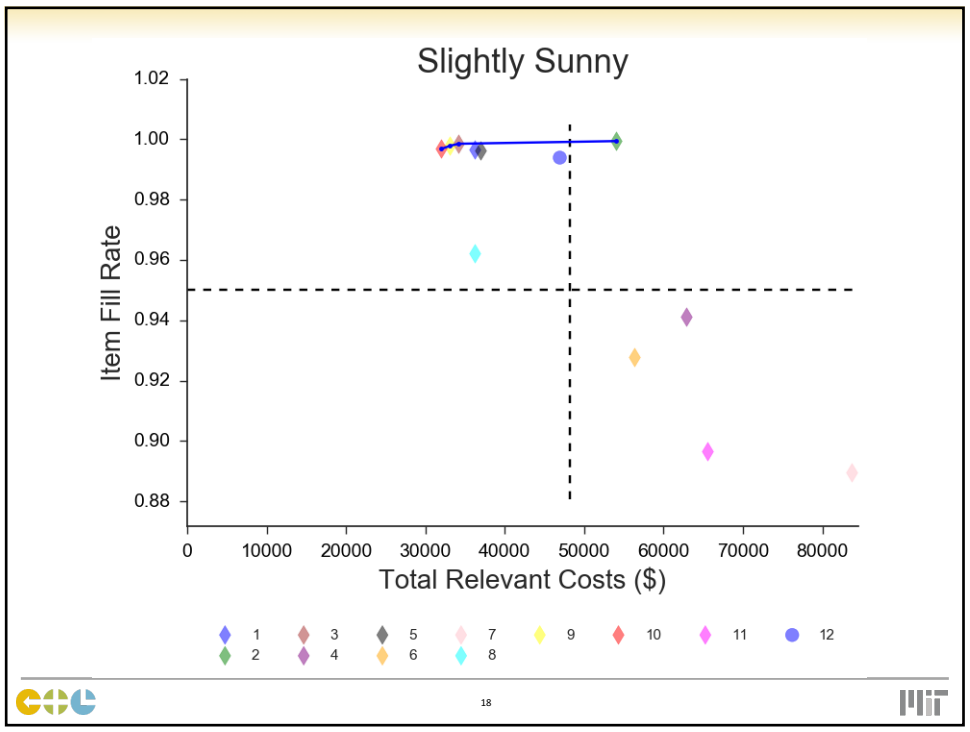


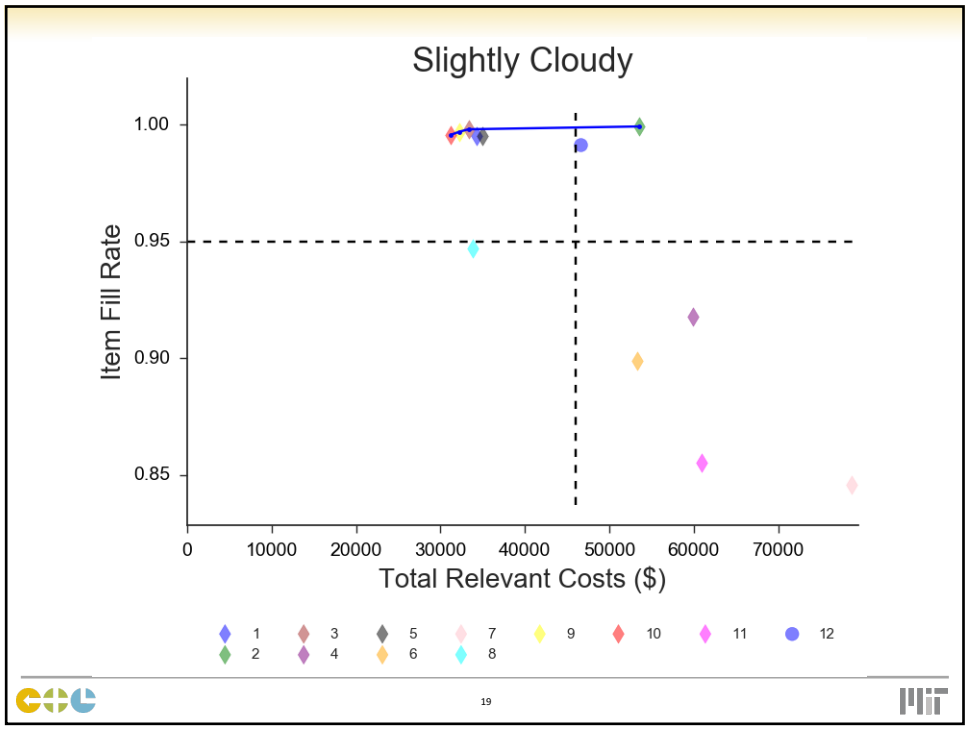
Policy Selections by Team

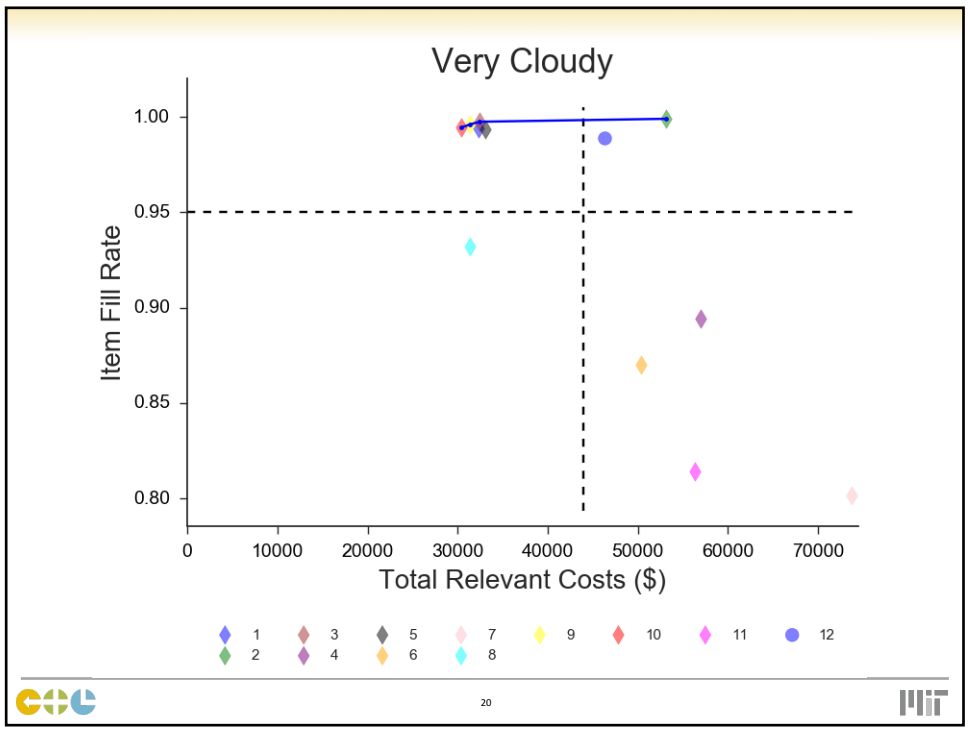
Team #	Group Name	FGI	WIP	Backup DC	Backup Plant	Backup Supplier
1	Super Supplers 'R Us	1000	200	5	5	6
2	Uwe and Rik	400	100	7	7	7
3	MO	350	350	6	6	6
4	YW	1450	800	1	3	7
5	Martijn	950	300	5	5	6
6	MarMina	1250	1000	1	4	4
7	TEAM TONANA	2000	2000	1	1	1
8	AgCo	1000	300	2	2	6
9	JF	325	325	6	6	6
10	Martin & Sophie	300	300	6	6	6
11	Nazireldil	2000	1000	1	1	3
12	TEAM TONANA 1	100	100	7	7	7

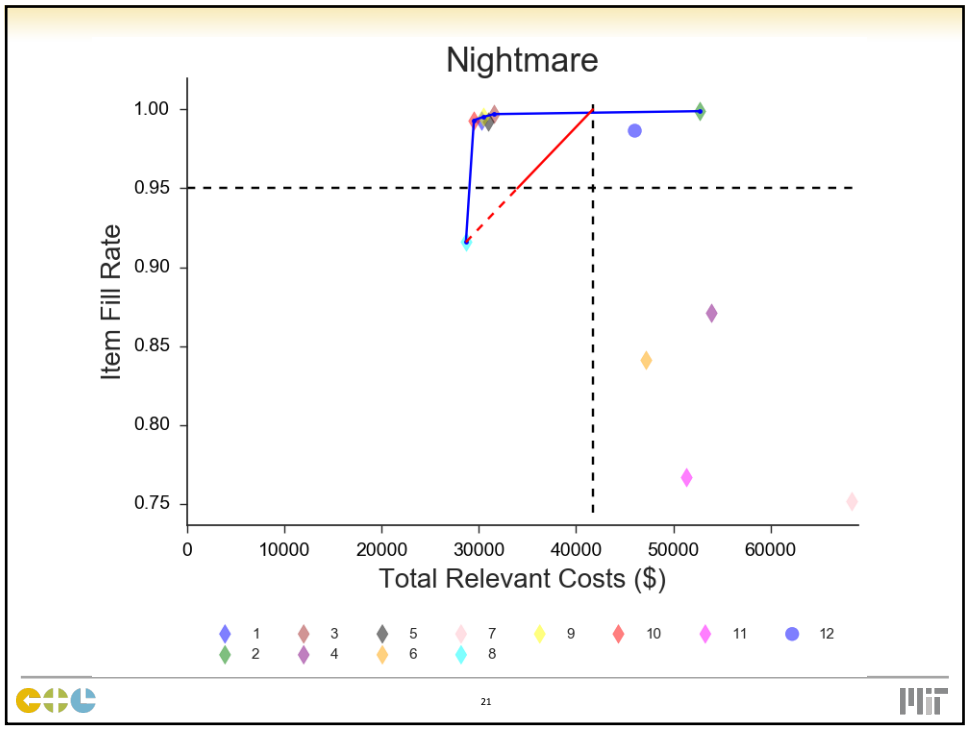

Sunny Day
Item Fill Rate
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0
10000
20000
30000
40000
50000
60000
70000
80000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
13

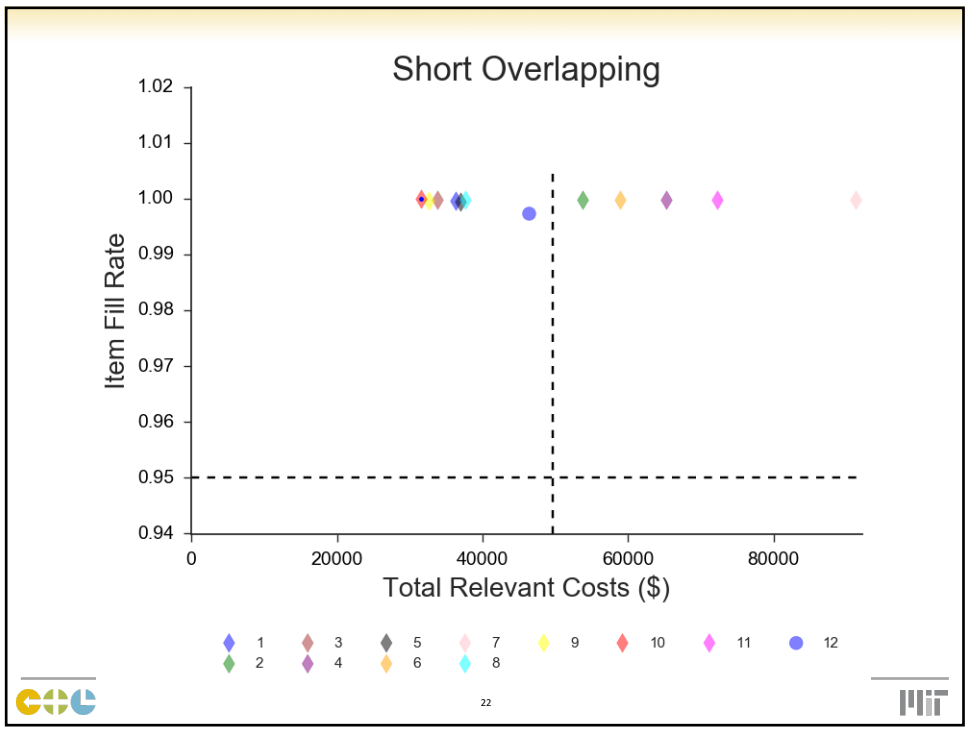

Partly Sunny
Item Fill Rate
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0
20000
40000
60000
80000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
17

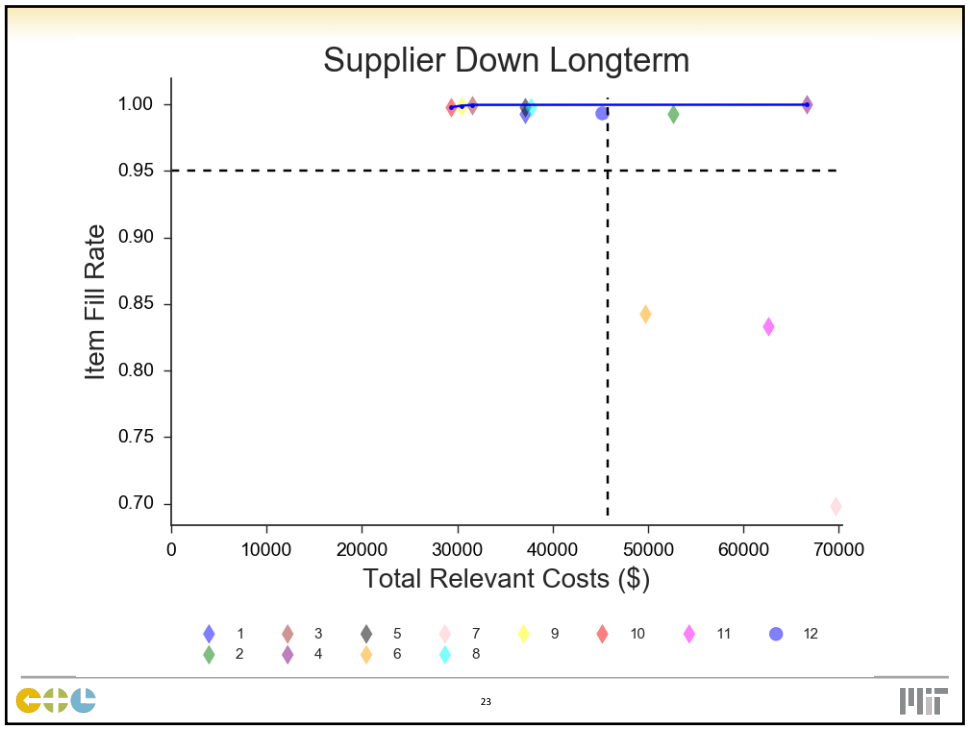

Slightly Sunny
Item Fill Rate
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0
10000
20000
30000
40000
50000
60000
70000
80000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
18

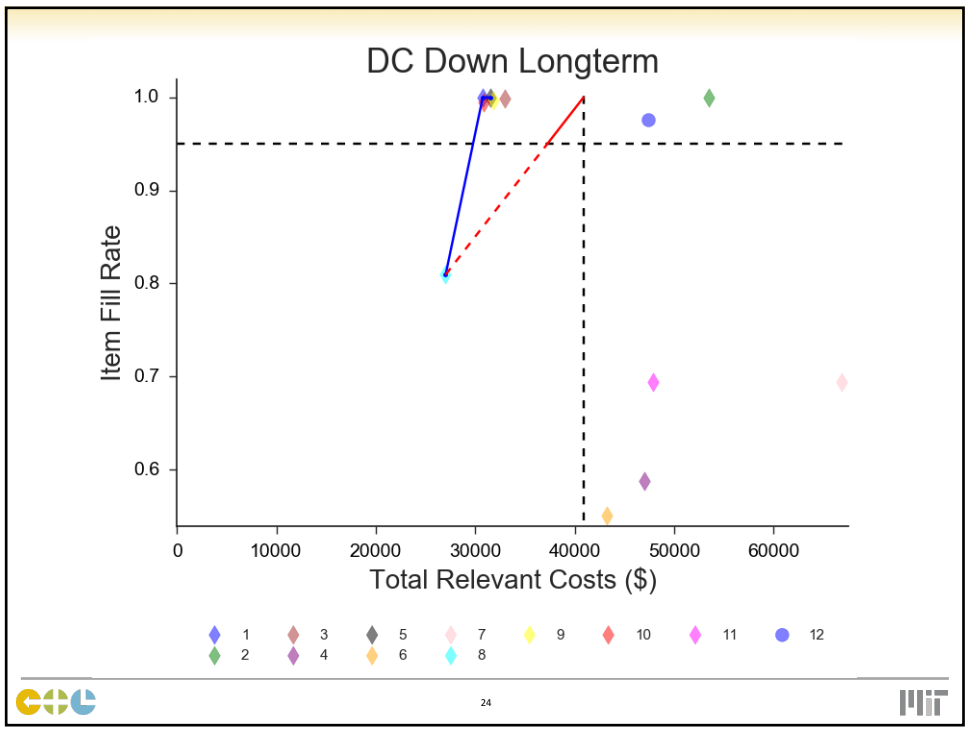

Slightly Cloudy
Item Fill Rate
1.00
0.95
0.90
0.85
0
10000
20000
30000
40000
50000
60000
70000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
19

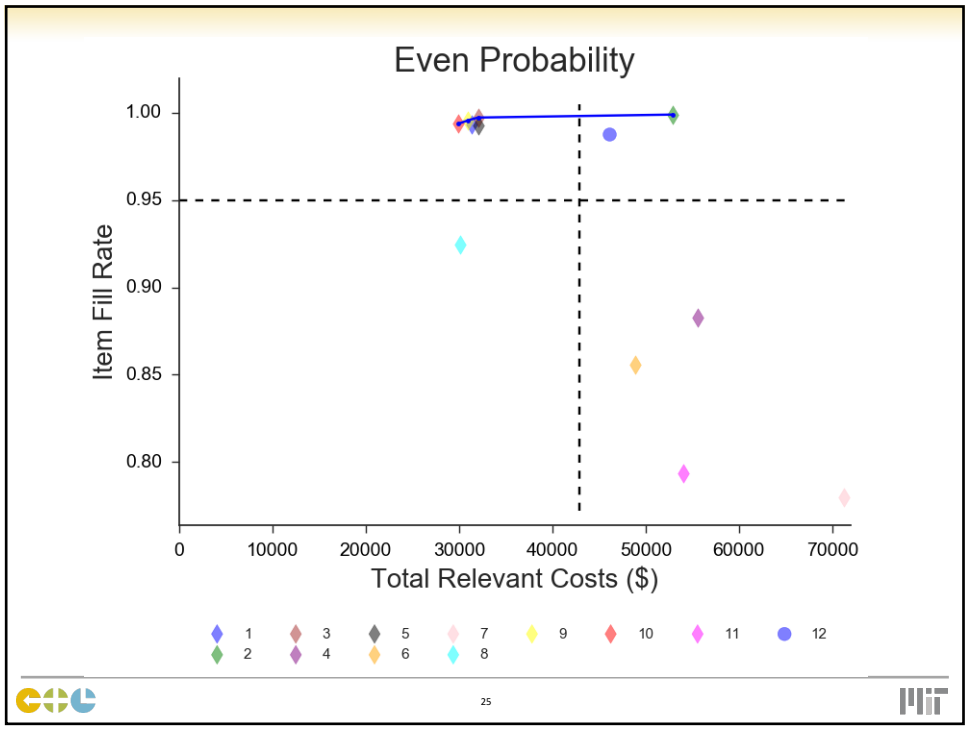

Very Cloudy
Item Fill Rate
1.00
0.95
0.90
0.85
0.80
0
10000
20000
30000
40000
50000
60000
70000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
20


Nightmare
Item Fill Rate
1.00
0.95
0.90
0.85
0.80
0.75
0
10000
20000
30000
40000
50000
60000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
21


Short Overlapping
Item Fill Rate
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0
20000
40000
60000
80000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
22


Supplier Down Longterm
Item Fill Rate
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
10000
20000
30000
40000
50000
60000
70000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
23


DC Down Longterm
Item Fill Rate
1.0
0.9
0.8
0.7
0.6
0
10000
20000
30000
40000
50000
60000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
24


Even Probability
Item Fill Rate
1.00
0.95
0.90
0.85
0.80
0
10000
20000
30000
40000
50000
60000
70000
Total Relevant Costs ($)
1
2
3
4
5
6
7
8
9
10
11
12
25

Scoring Method 1 & 2

Group	Score	Green	Yellow	Red	Group	Score
10	**1**	**10**	**0**	**0**	**1**	**20**
9	2	**10**	**0**	**0**	**3**	**20**
3	3	**10**	**0**	**0**	**5**	**20**
2	8	**10**	**0**	**0**	**9**	**20**
1	11	**10**	**0**	**0**	**10**	**20**
8	12	5	0	5	8	10
5	17	5	0	5	12	10
12	27	0	0	10	2	0
4	32	0	0	10	4	0
6	35	0	0	10	6	0
11	41	0	0	10	7	0
7	51	0	0	10	11	0

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Policy Selections by Team: Relative Policy Assessment

Team #	Group Name	FGI	WIP	Back-up DC	Back-up Plant	Back-up Supplier	Redundancy	Flexibility
1	Super Supplers 'R Us	1000	200	5	5	6	Mix	Med-H
2	Uwe and Rik	400	100	7	7	7	Med	Highest
3	MO	350	350	6	6	6	Med	High
4	YW	1450	800	1	3	7	High	Mix
5	Martijn	950	300	5	5	6	Med-H	Med-H
6	MarMina	1250	1000	1	4	4	High	Low-M
7	TEAM TONANA	2000	2000	1	1	1	Highest	Lowest
8	AgCo	1000	300	2	2	6	Med-H	Low-M
9	JF	325	325	6	6	6	Med	High
10	Martin & Sophie	300	300	6	6	6	Low-M	High
11	NazireIdil	2000	1000	1	1	3	High	Low
12	TEAM TONANA 1	100	100	7	7	7	Lowest	Highest

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Winners

Team #	Group Name	FGI	WIP	Back-up DC	Back-up Plant	Back-up Supplier	Redundancy	Flexibility
1	Super Supplers 'R Us	1000	200	5	5	6	Mix	Med-H
3	MO	350	350	6	6	6	Med	High
5	Martijn	950	300	5	5	6	Med-H	Med-H
9	JF	325	325	6	6	6	Med	High
10	Martin & Sophie	300	300	6	6	6	Low-M	High

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Some Observations

- No ROI on an investment that, when successful, nothing happens
  - More like calculus for an insurance investment, but identify the trade-off
- Multiple ways to protect – at different costs
  - Different policies do well under different scenarios
  - Consider the portfolio of potential outcome scenarios
- Scenario creation is an informed process
  - Consider the vulnerabilities of your supply chain
- Downstream matters more than Upstream
  - …for this supply chain but it is not necessarily universally true
  - DC protection more important because it protects the customer where sales are won/lost; it also adds time for Plant and Supplier response
- Combination of Redundancy & Flexibility necessary
  - Redundant inventory covers before backup capacity available
  - Options for additional capacity (flexibility) covers for longer term

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