Portfolios of Counterterrorism Security Measures

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Why Consider Portfolios?

- Countermeasures are often most effective as systems of countermeasures
  - Layered defenses
- Evaluating countermeasures in isolation fails to take into account
  - Synergies
  - Redundancies
- Risk reduction is inherently nonadditive

Nonadditivity

- Suppose there are two countermeasures that work independently (perhaps at different points in the attack path)
- Each countermeasure has a 60% chance of thwarting an attack that is launched
- Total reduction in is risk is

$$\text{Risk reduction} = .6 + .6 - (.6)(.6) = .84$$

Combinations of Countermeasures

- Countermeasures that operate at different points in the attack path are apt to be less redundant
  - Threat
  - Vulnerability
  - Consequence
- Reduction in success probabilities for terrorists leads to deterrence (adaptation)

Modeling Deterrence and Adaptation

- Approaches
  - Mathematical programming allocation model
    - Stackleberg game
    - Security measures are selected knowing that terrorists will devise a strategy to circumvent security measures
  - Utility theoretic
    - Terrorists maximize expected utility by selecting strategies that take into account security measures

Modeling Vulnerabilities

- Security measures may be:
  - Independent (joint risk reduction)

$$q_{12} = 1-(1-p_1)(1-p_2) = p_1 + p_2 - p_1 p_2$$

  - Synergistic

$$q_{12} > 1-(1-p_1)(1-p_2) = p_1 + p_2 - p_1 p_2$$

  - Redundant

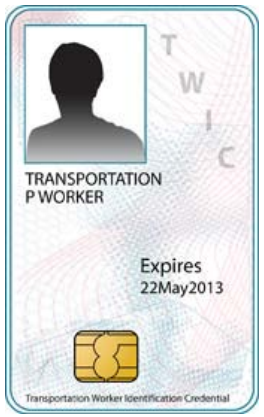
$$q_{12} < 1-(1-p_1)(1-p_2) = p_1 + p_2 - p_1 p_2$$

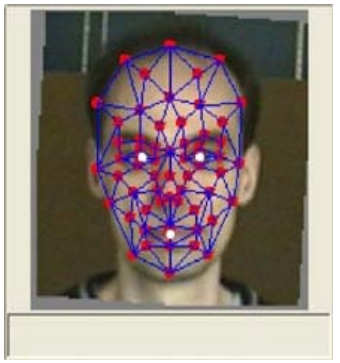
Model for Two Security Measures

$$q_{12}(p_1, p_2, a_{12}, a_{21}) = 1-(1-p_1)^{a_{12}}(1-p_2)^{a_{21}}$$

$$\text{Synergistic}: a_{12}, a_{21} > 1 \text{ then } q_{12} \uparrow$$

$$\text{Redundancy}: a_{12}, a_{21} < 1 \text{ then } q_{12} \downarrow$$





Approximation for Three Security Measures

$$q_3(p_1, p_2, p_3, a_{12}, a_{13}, a_{21}, a_{23}, a_{31}, a_{32})$$
$$= 1-(1-p_1)^{a_{12}a_{13}}(1-p_2)^{a_{21}a_{23}}(1-p_3)^{a_{31}a_{32}}$$

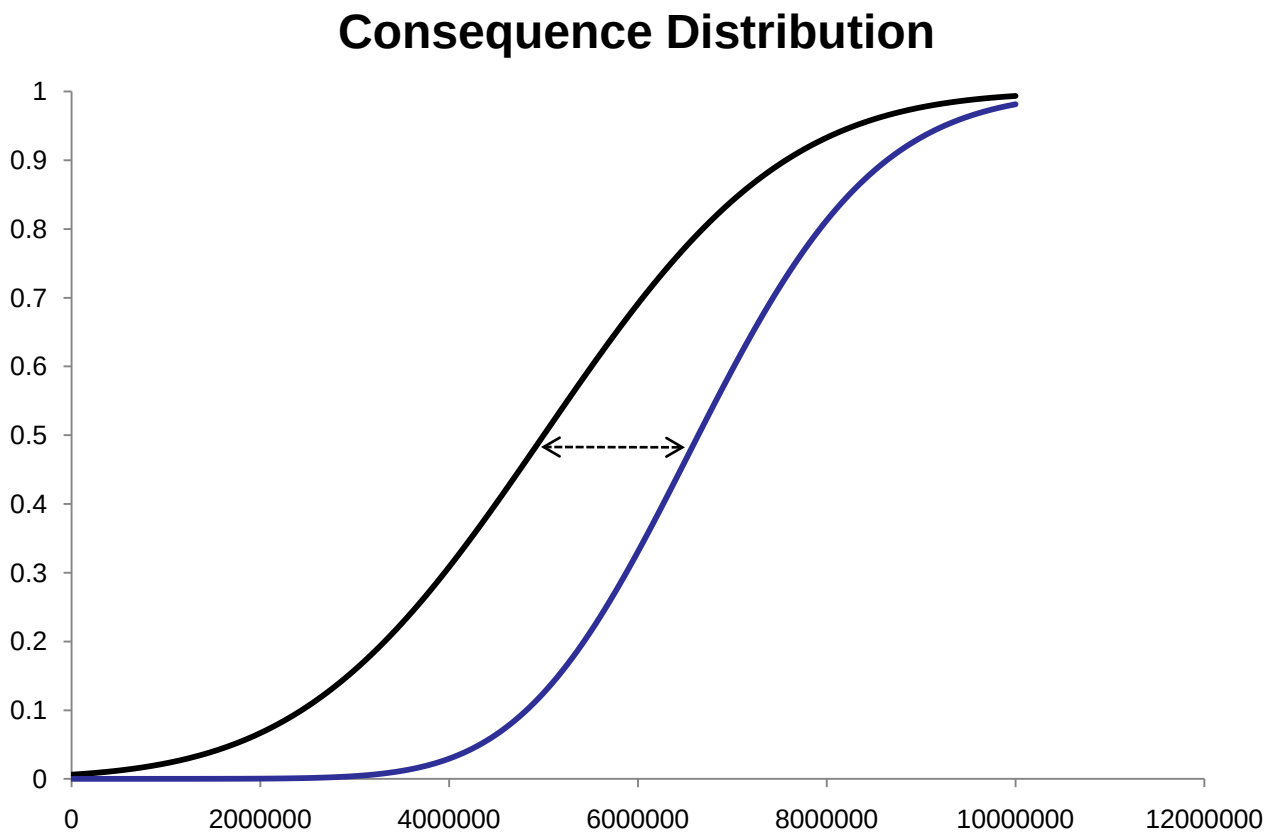
Modeling Mitigation

- Mitigation reduces potential consequences
- Model for mitigation

$$\text{Consequence distribution} : F(x)$$

$$\text{Mitigated distribution} : [F(x)]^{\alpha_1}$$

$$\alpha_p = \alpha_1 + (1-\alpha_1)\alpha_2 + (1-\alpha_1)(1-\alpha_2)\alpha_3 + \ldots\ldots + \prod_{i=1}^{m-1}(1-\alpha_i)\alpha_m$$

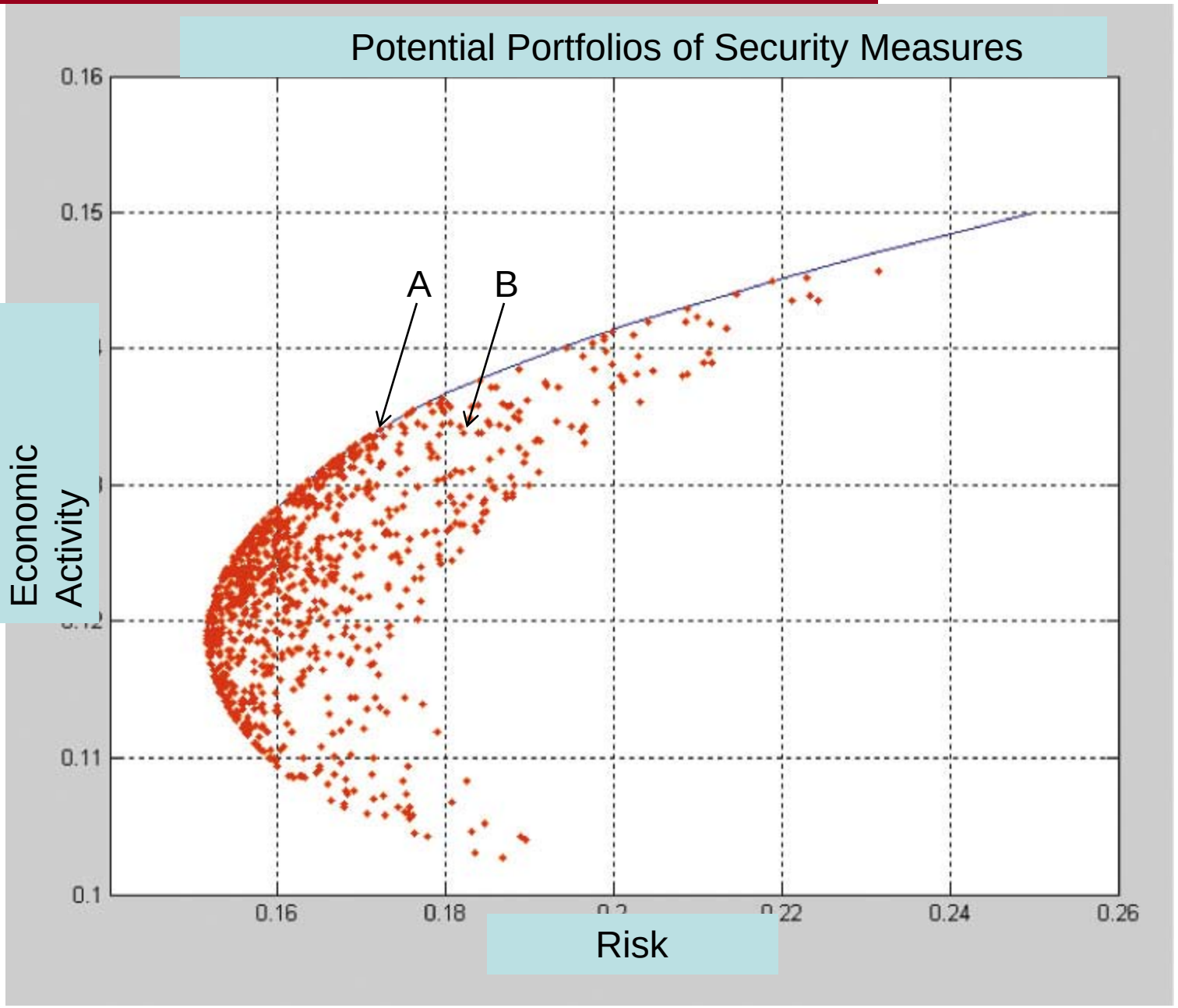

Consequence Distribution
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2000000
4000000
6000000
8000000
10000000
12000000

Evaluating Portfolios

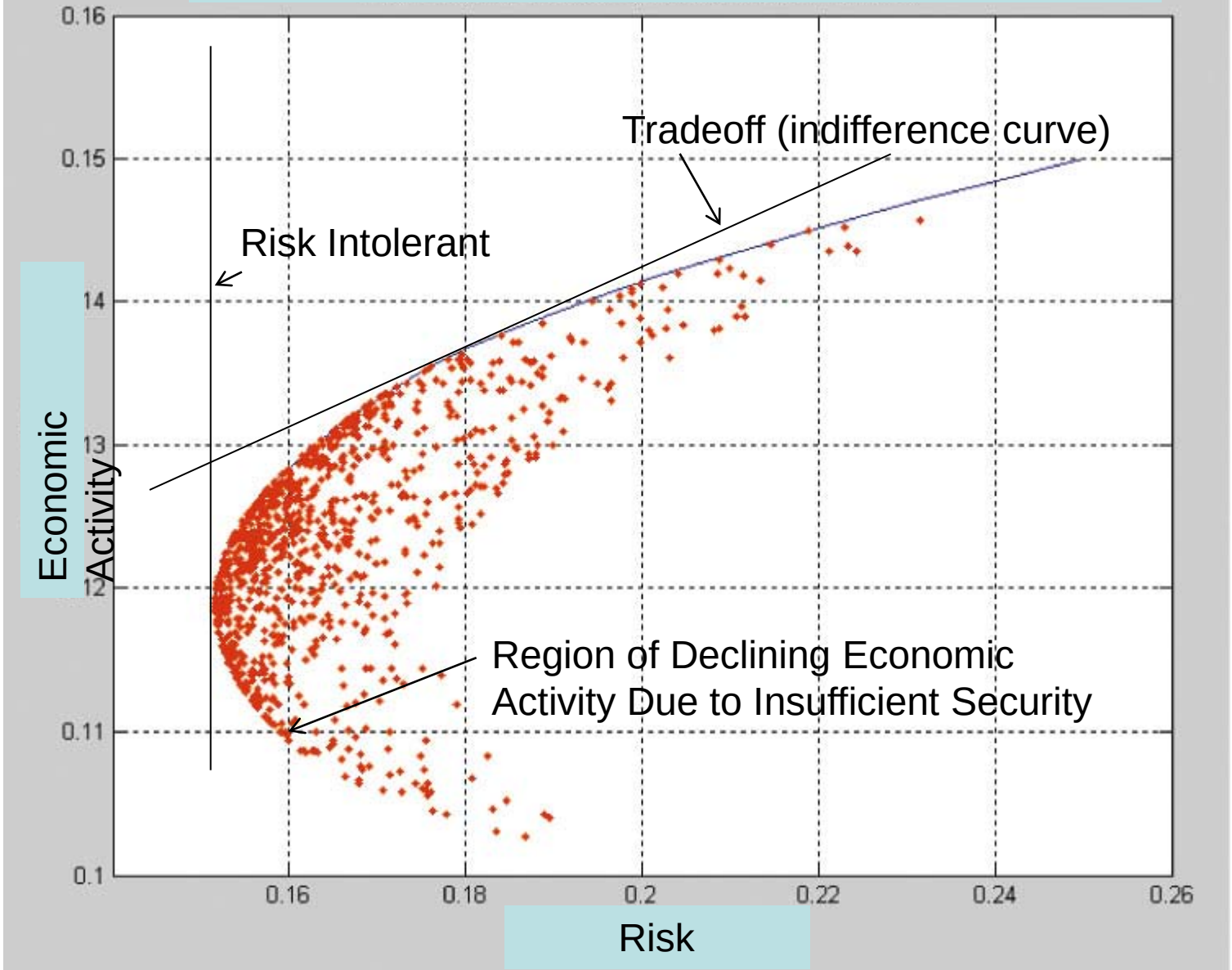
- Evaluation is relatively quick
- All possible portfolios from *m* security measures will be examined
- 2^m possible portfolios including the null portfolio
- Retain only those portfolios that are not dominated

Dominated portfolios

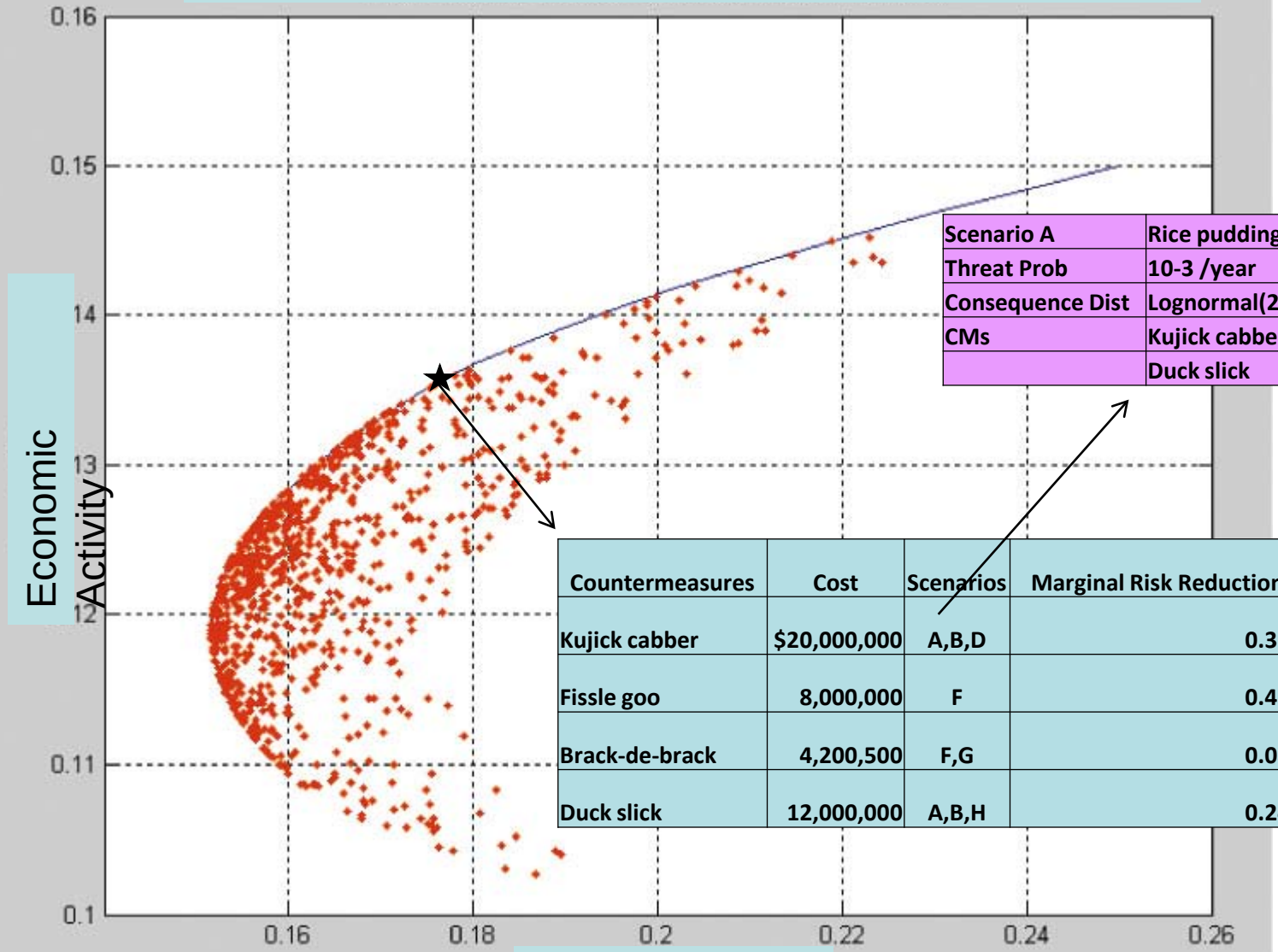
- One portfolio dominates another if it has greater risk reduction for the same level of economic productivity or more economic productivity for the same level of risk reduction


Potential Portfolios of Security Measures
Economic Activity
Risk
A
B
0.16
0.15
0.11
0.1
0.16
0.18
0.22
0.24
0.26

Potential Portfolios of Security Measures



Potential Portfolios of Security Measures



Scenario A	Rice pudding Attack
Threat Prob	10-3 /year
Consequence Dist	Lognormal(20mil,10mil)
CMs	Kujick cabber
	Duck slick

Countermeasures	Cost	Scenarios	Marginal Risk Reduction
Kujick cabber	$20,000,000	A,B,D	0.396
Fissle goo	8,000,000	F	0.428
Brack-de-brack	4,200,500	F,G	0.088
Duck slick	12,000,000	A,B,H	0.245

An Example with 2 Scenarios and 9 Security Measures

		Median conditional probability of defeating an attack	
Code	Security Measures	Scenario 1	Scenario 2
RND	Rad/Nuc detectors	0.55	
P	Police presence/patrol on streets	0.25	0.16
PS	Police presence with enhanced search capabilities	0.35	0.28
C	Cameras	0.03	0.03
I	Intelligence	0.40	0.10
CH	Checkpoints	0.30	0.45
B	Barriers		0.26
EP	Evacuation planning for the hot zone		
KI	Potassium Iodide stockpile		

Sample Portfolios of Security Measures

Code	Portfolios of Security Measures
P1	None
P2	P,PS
P3	RND, P, I
P4	RND, P, C, I
P5	RND, P, PS, C, I
P6	RND, P, C, I, CH
P7	RND, PS, C, I, CH, B, EP
P8	All

Vulnerability Effectiveness Parameters

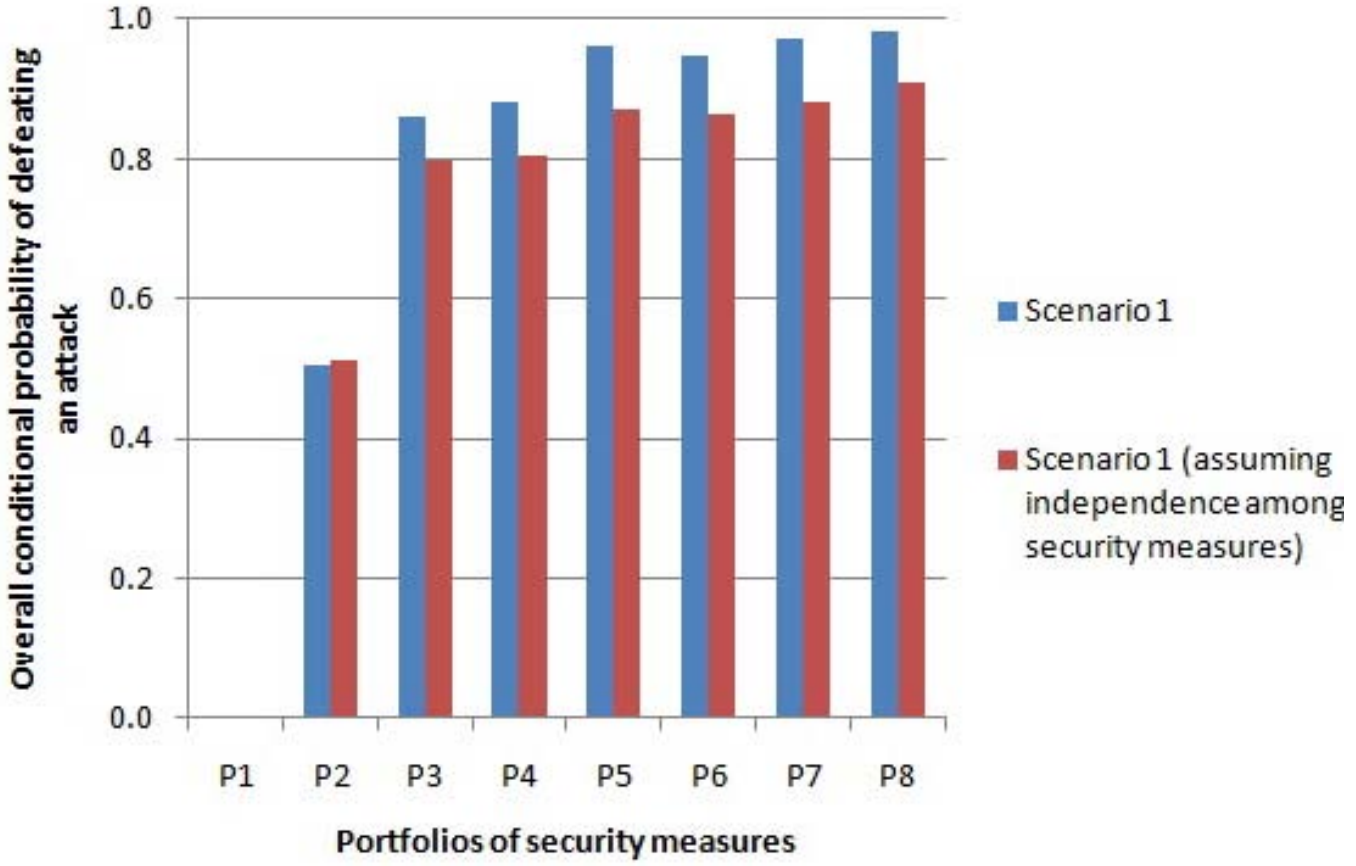
Scenario 1						
Security Measures	RND	P	PS	C	I	CH
RND	***0.55***	1.00	1.00	1.00	1.15	1.31
P	1.24	***0.25***	1.39	1.24	1.50	1.00
PS	1.26	0.70	***0.35***	1.39	1.61	1.00
C	1.00	1.00	1.00	***0.03***	1.34	1.00
I	1.00	1.00	1.00	1.00	***0.40***	1.00
CH	1.25	1.00	1.00	1.00	1.25	***0.30***

Scenario 2						
Security Measures	P	PS	C	I	CH	B
P	***0.16***	1.28	1.14	1.14	1.00	1.00
PS	0.89	***0.28***	1.15	1.15	1.02	1.02
C	1.00	1.00	***0.03***	1.00	1.00	1.00
I	1.00	1.00	1.11	***0.10***	1.21	0.84
CH	1.00	1.00	0.85	1.26	***0.45***	1.00
B	1.23	1.33	1.00	1.00	1.00	***0.26***

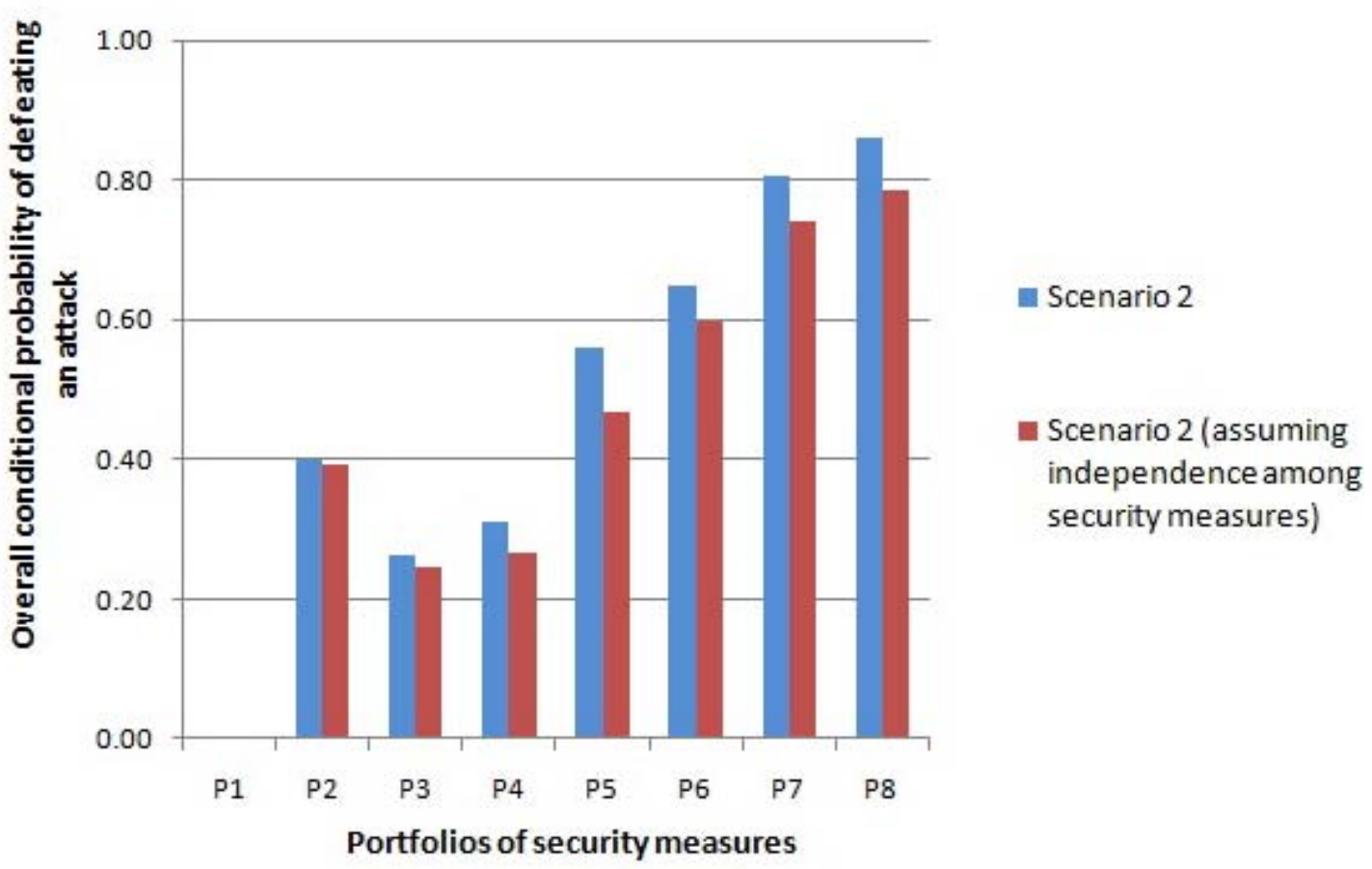
Legend

- Synergistic security measures
- Independent security measures
- Redundant security measures

Vulnerability Effects for Scenario 1



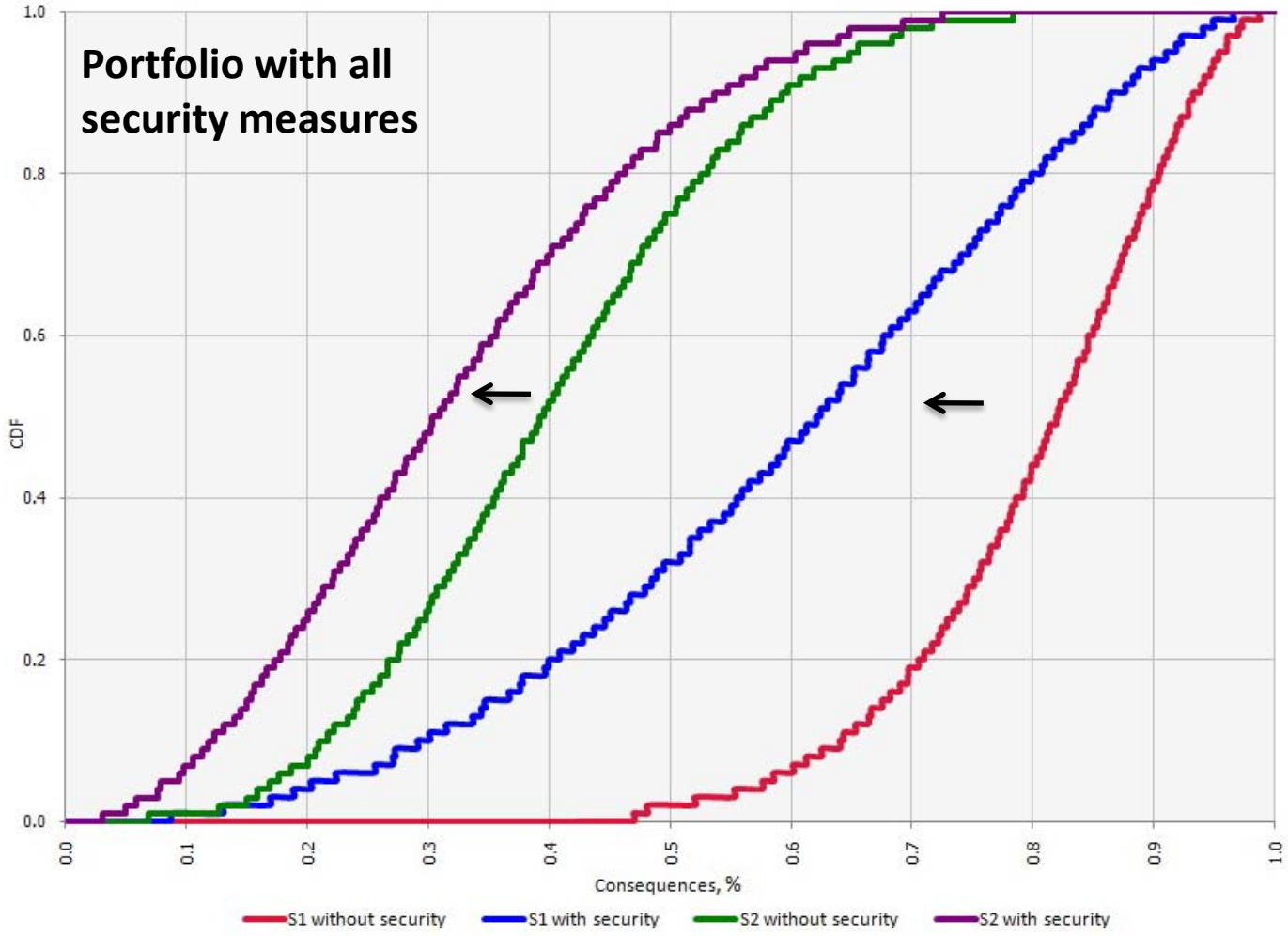
Vulnerability Effects for Scenario 2



Mitigation Effectiveness Parameters

		Percent reduction in median consequences	
Code	**Security Measures**	**Scenario 1**	**Scenario 2**
RND	Rad/Nuc detectors		
P	Police presence/patrol on streets	0.10	0.20
PS	Police presence with enhanced search capabilities	0.10	0.20
C	Cameras	0.05	0.15
I	Intelligence		
CH	Checkpoints		
B	Barriers		
EP	Evacuation planning for the hot zone	0.35	
KI	Potassium Iodide stockpile	0.45	

Mitigation Effects for Scenarios 1 and 2



An Example with 2 Scenarios and 9 Security Measures

		Median conditional probability of defeating an attack	
Code	**Security Measures**	**Scenario 1**	**Scenario 2**
RND	Rad/Nuc detectors	p_1^1	
P	Police presence/patrol on streets	p_2^1	p_2^2
PS	Police presence with enhanced search capabilities	p_3^1	p_3^2
C	Cameras	p_4^1	p_4^2
I	Intelligence	p_5^1	p_5^2
CH	Checkpoints	p_6^1	p_6^2
B	Barriers		p_7^2
EP	Evacuation planning for the hot zone		
KI	Potassium Iodide stockpile		

Sample Portfolios of Security Measures

Code	Portfolios of Security Measures
P1	None
P2	P,PS
P3	RND, P, I
P4	RND, P, C, I
P5	RND, P, PS, C, I
P6	RND, P, C, I, CH
P7	RND, PS, C, I, CH, B, EP
P8	All

Vulnerability Effectiveness Parameters

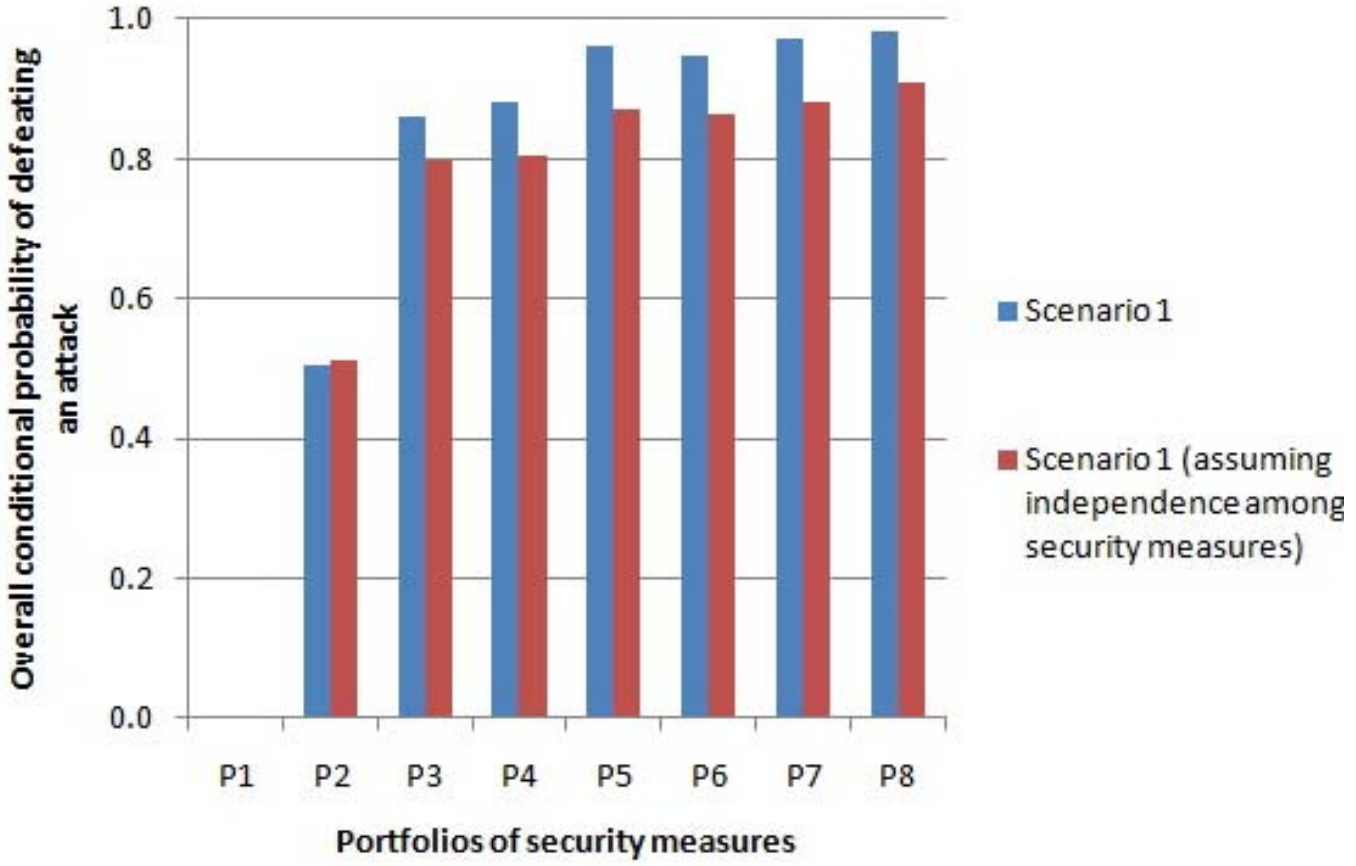
Scenario 1						
Security Measures	RND	P	PS	C	I	CH
RND	p_1^1	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
P	a_{21}	p_2^1	a_{23}	a_{24}	a_{25}	a_{26}
PS	a_{31}	a_{32}	p_3^1	a_{34}	a_{35}	a_{36}
C	a_{41}	a_{42}	a_{43}	p_4^1	a_{45}	a_{46}
I	a_{51}	a_{52}	a_{53}	a_{54}	p_5^1	a_{56}
CH	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}	p_6^1

Scenario 2						
Security Measures	P	PS	C	I	CH	B
P	p_2^2	a_{23}	a_{24}	a_{25}	a_{26}	a_{27}
PS	a_{32}	p_3^2	a_{34}	a_{35}	a_{36}	a_{37}
C	a_{42}	a_{43}	p_4^2	a_{45}	a_{46}	a_{47}
I	a_{52}	a_{53}	a_{54}	p_5^2	a_{56}	a_{57}
CH	a_{62}	a_{63}	a_{64}	a_{65}	p_6^2	a_{67}
B	a_{72}	a_{73}	a_{74}	a_{75}	a_{76}	p_7^2

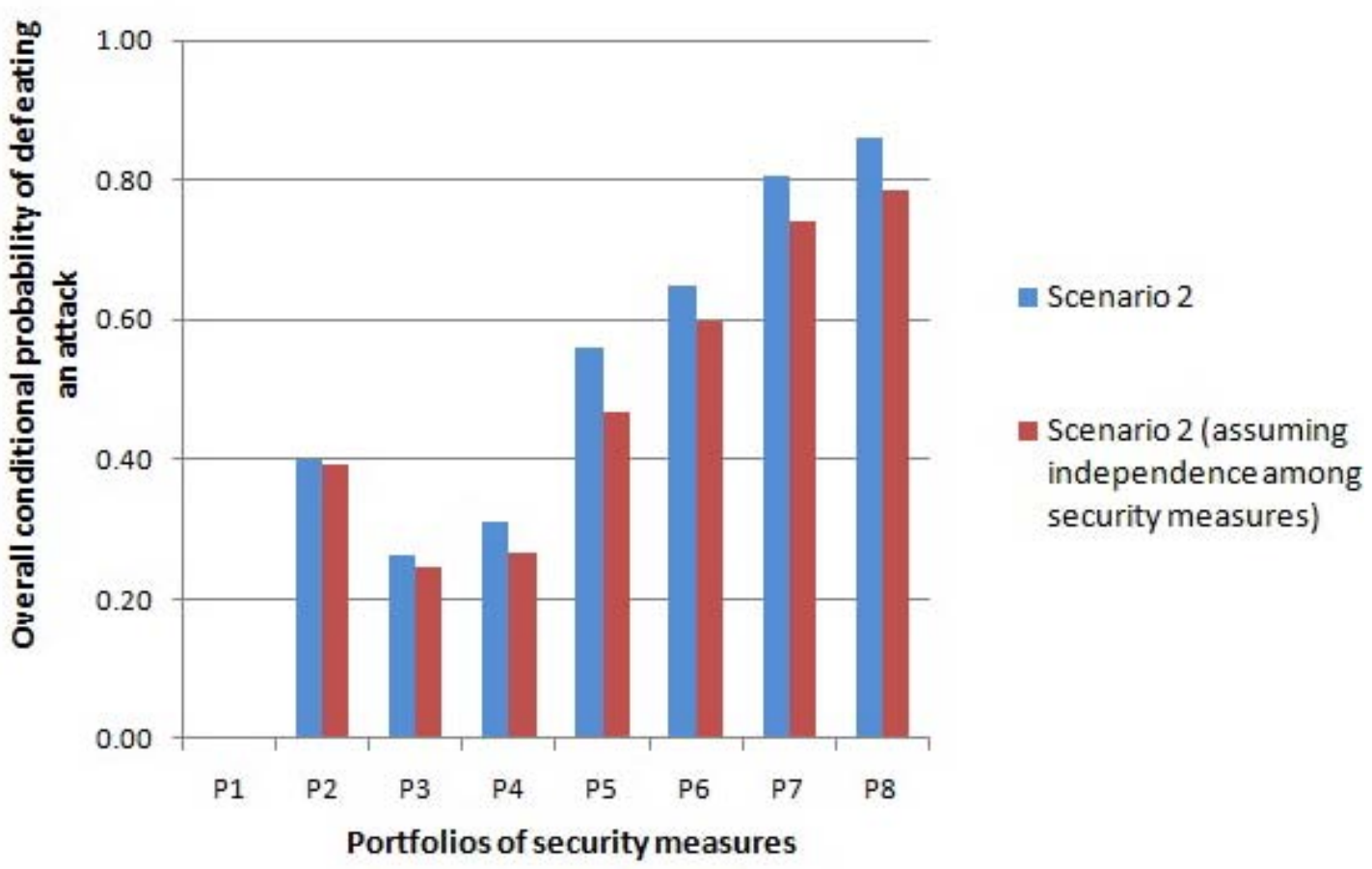
Legend

- Synergistic security measures
- Independent security measures
- Redundant security measures

Vulnerability Effects for Scenario 1



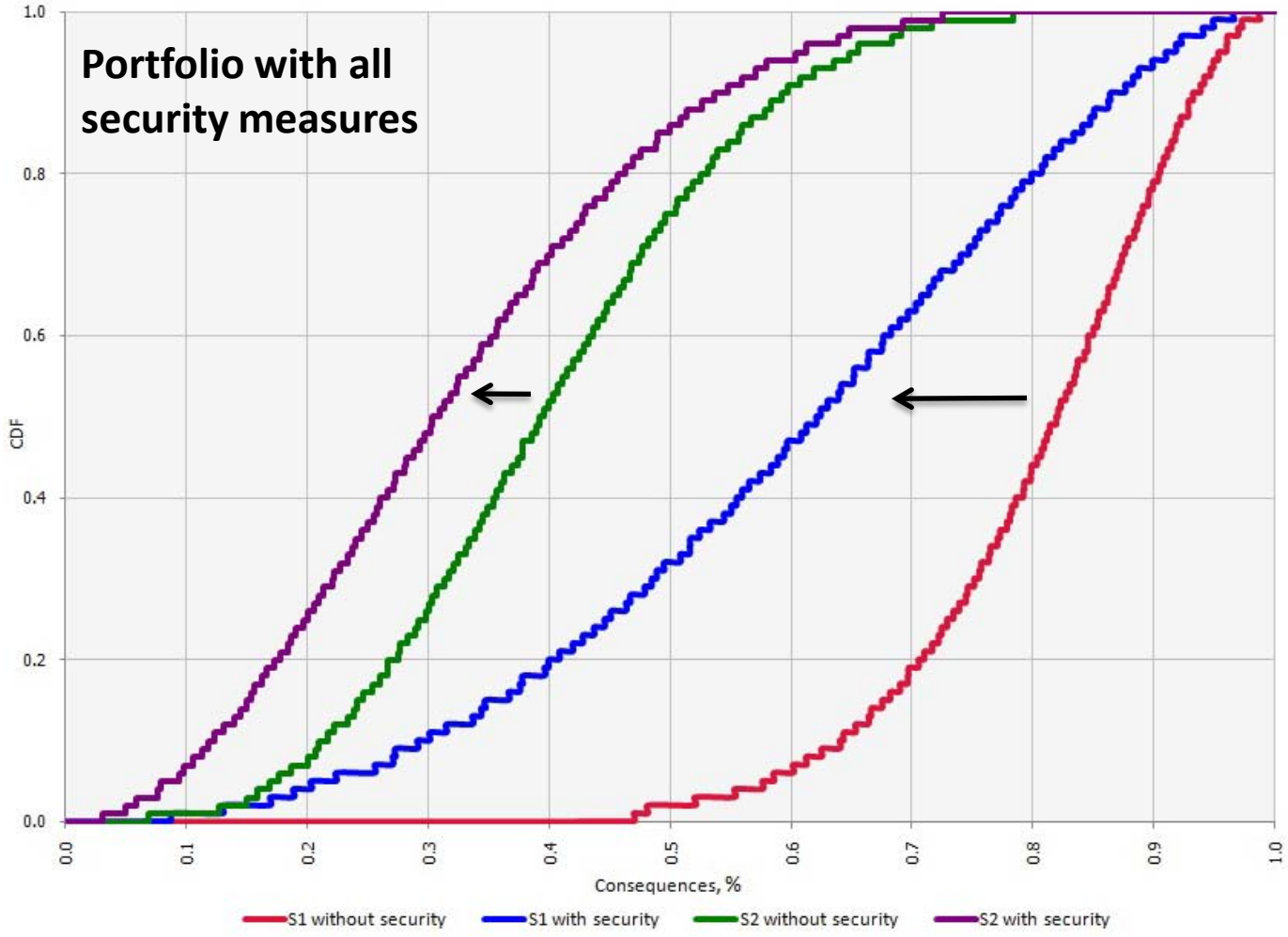
Vulnerability Effects for Scenario 2



Mitigation Effectiveness Parameters

		Percent reduction in median consequences	
Code	**Security Measures**	**Scenario 1**	**Scenario 2**
RND	Rad/Nuc detectors		
P	Police presence/patrol on streets	α_2^1	α_2^2
PS	Police presence with enhanced search capabilities	α_3^1	α_3^2
C	Cameras	α_4^1	α_4^2
I	Intelligence		
CH	Checkpoints		
B	Barriers		
EP	Evacuation planning for the hot zone	α_8^1	
KI	Potassium Iodide stockpile	α_9^1	

Mitigation Effects for Scenarios 1 and 2



About Security Policy

- Security at any cost is a bad policy
- Achieves the terrorist objectives
- Death of a thousand cuts
- Strangles our economy without a successful attack