Market Impact on IT Security Spending

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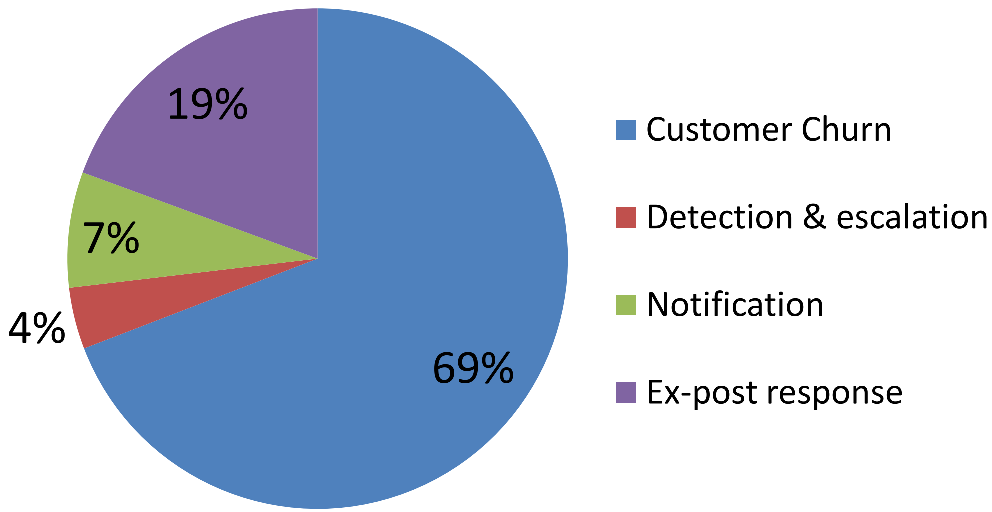
SCHOOL of BUSINESS

Motivation

Cost of Breach



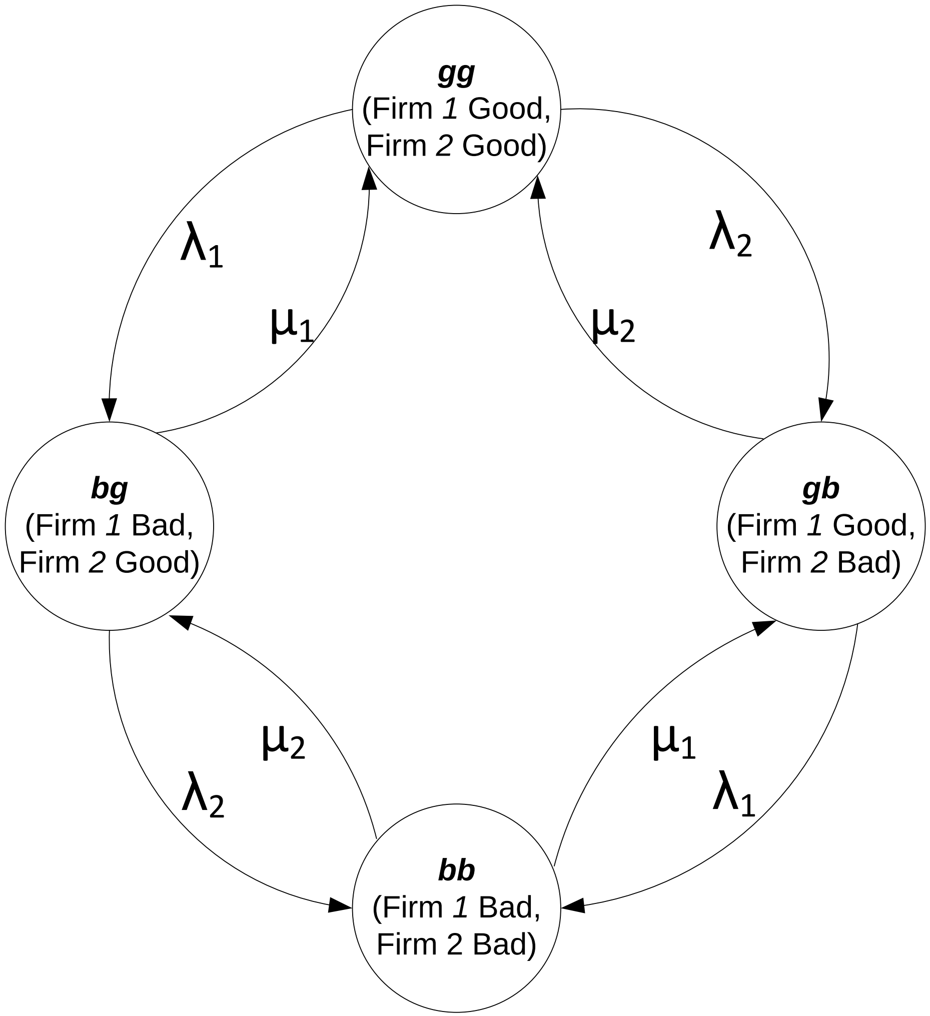
Ponemon (2009)

- 77% of survey respondents said they would stop doing business with a firm after a breach (Javelin, 2007).
- Newspapers reported decreased sales of deli meats following Maple Leaf listeria outbreak (Crawford, 2008; Donville & Bell, 2008).

Literature

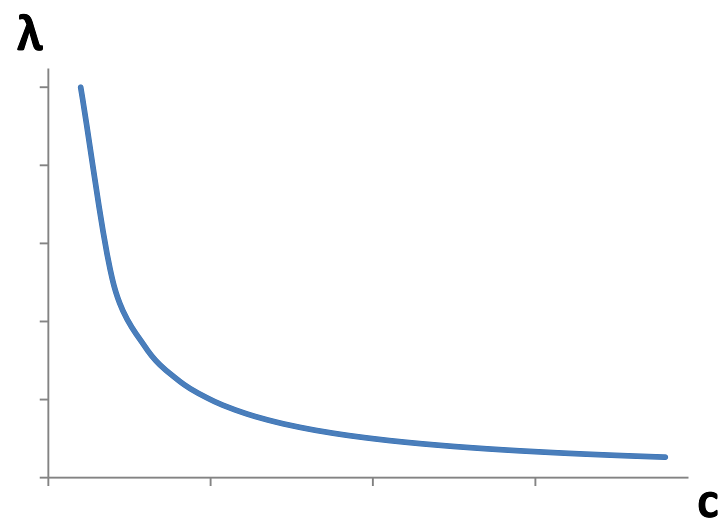
Authors	Summary
Gordon & Loeb, 2002	Investment decisions for single firm for breach probability function.
Gordon et al, 2003	Show that when two firms coordinate by sharing information, it is possible to achieve the same level of security prior to information sharing at a lower cost.
Gal-Or & Ghose, 2005	Effect of interaction between competitors on firms' spending and willingness to share information about security. Positive spill-over effects of breaches in the other firm.
Hausken, 2006	Consider attacker and firm motivations when making investment decisions. Look at the returns on investments for each party.
Cavusoglu et al, 2008	Compare decision theory to game theory where the players are firms and attackers, show that game theory approach yields better IT security investment decisions.
Kunreuther & Heal, 2003	Model security in interdependent networks of firms where weakest link can compromise security of all.

Model



Adverse Events Arrival Rate:

$$\lambda_i = \Lambda_i / c_i$$



Expected Duration of Event:

$$1/\mu_i$$

State Probabilities

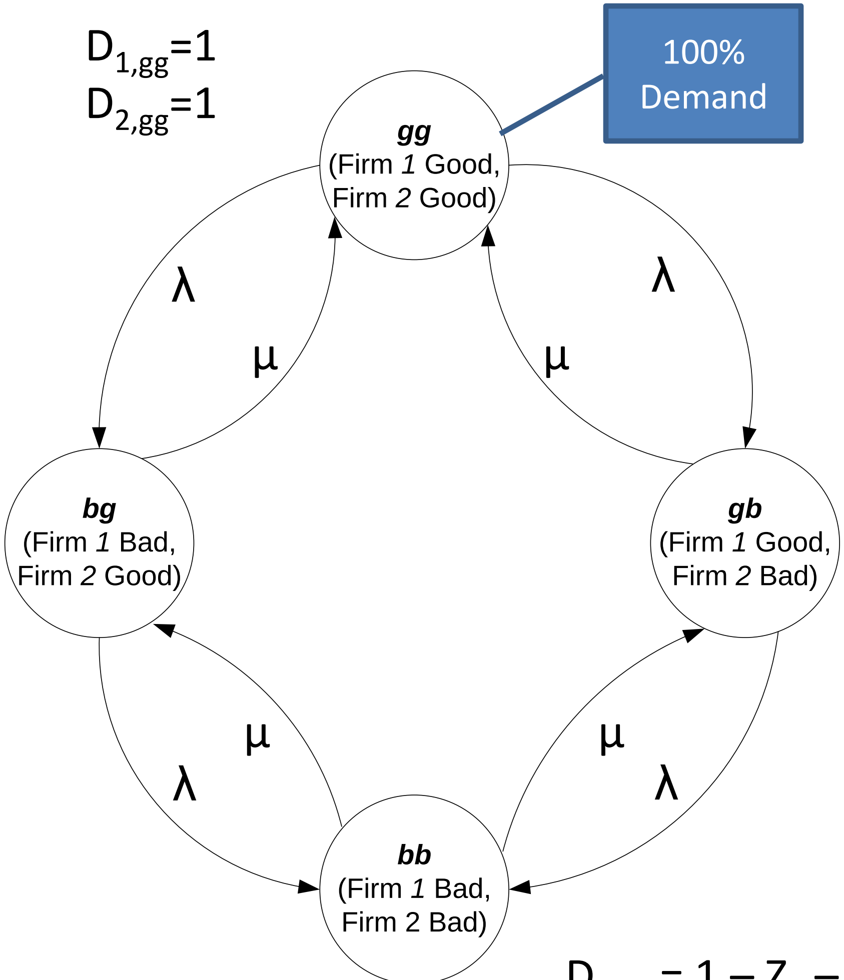
$$P_{gg} = \frac{c_1 c_2}{(c_1+\rho_1)(c_2+\rho_2)}, \qquad P_{bb} = \frac{\rho_1 \rho_2}{(c_1+\rho_1)(c_2+\rho_2)}$$

$$P_{bg} = \frac{\rho_1 c_2}{(c_1+\rho_1)(c_2+\rho_2)}, \qquad P_{gb} = \frac{\rho_2 c_1}{(c_1+\rho_1)(c_2+\rho_2)}$$

Where $\rho_i = \frac{\Lambda_i}{\mu_i}, \qquad \text{for firm } i = 1, 2.$

ρ represents the riskiness of the environment

Demand – Symmetric Model



$D_{1,gg}=1$
$D_{2,gg}=1$

$D_{1,bg} = 1 - Z_1$
$D_{2,bg} = 1 - Z_2$

$D_{1,gb} = 1 - Z_2$
$D_{2,gb} = 1 - Z_1$

$D_{1,bb} = 1 - Z_1 - Z_2$
$D_{2,bb} = 1 - Z_1 - Z_2$

Restrictions on Elasticity Parameters

- When a firm experiences an adverse event:

$$Z_1 \in [0, 1]$$

  - It cannot gain demand.
  - Demand cannot be negative

- When the competitor experiences an adverse event:

$$Z_2 \in [-1, 1]$$

  - The firm cannot gain more than the competitor's total demand.
  - The firm's demand cannot be negative

ASSUMPTION 1. $0 \leq Z_1 + Z_2 \leq 1$

- When both firms have experienced adverse events, a firm's demand
  - cannot be negative.
  - cannot be greater after it has experienced an adverse event, even if it takes demand from a competitor

ASSUMPTION 2. $Z_2 \leq Z_1$

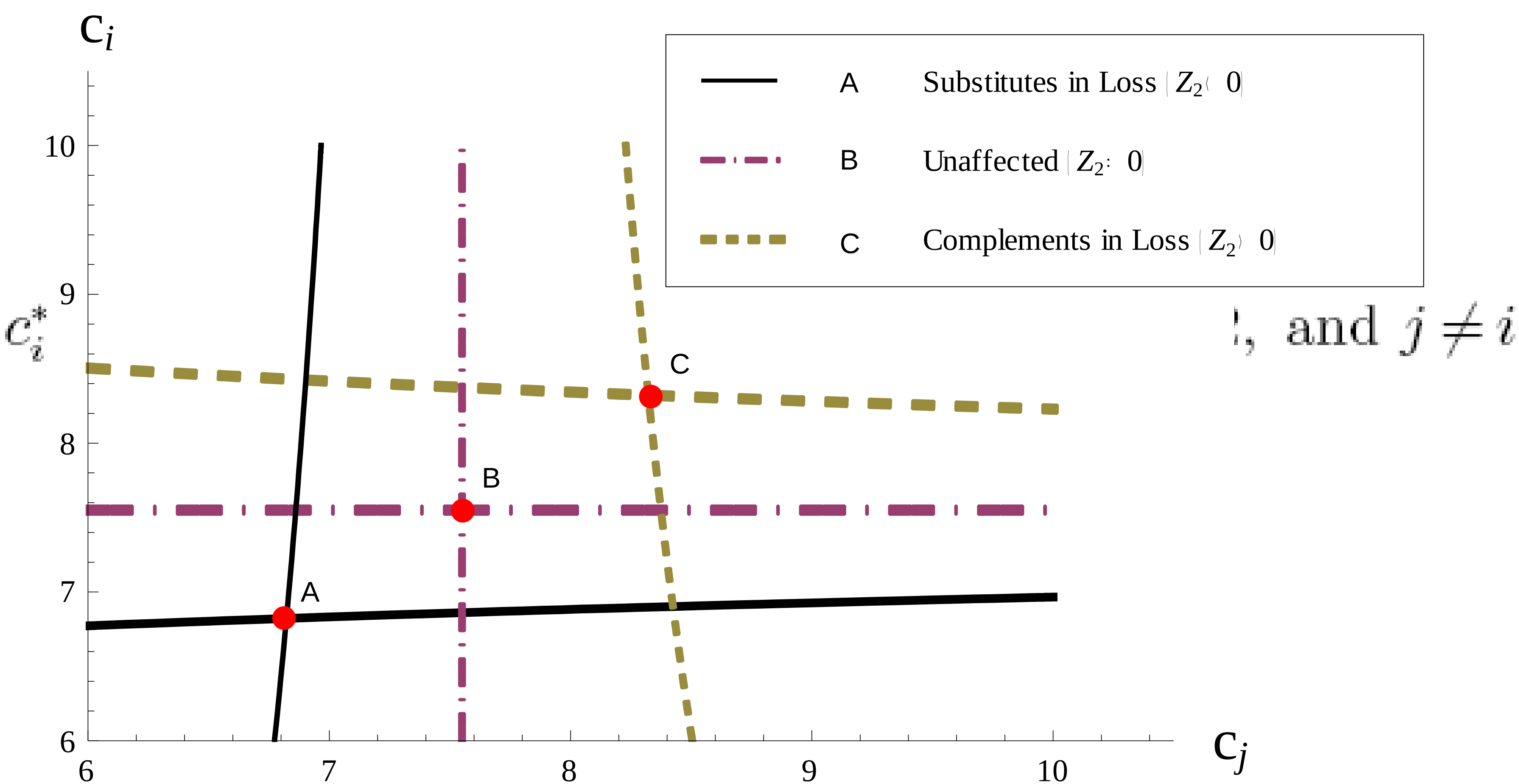
- The impact of events at a firm is greater than the impact from events at the competitor.

Expected Profit

$$E[\Pi_i] = (P_{gg}D_{i,gg} + P_{bg}D_{i,bg} + P_{gb}D_{i,gb} + P_{bb}D_{i,bb})(\pi - c_i)Q$$

$$E[\Pi_i] = \left(1 - \frac{Z_1\rho}{c_i+\rho} - \frac{Z_2\rho}{c_j+\rho}\right)(\pi - c_i)Q \qquad \text{for } i = 1,2, \text{ and } j \neq i.$$

Optimal Spending



Equilibrium spending is higher for complements in loss.

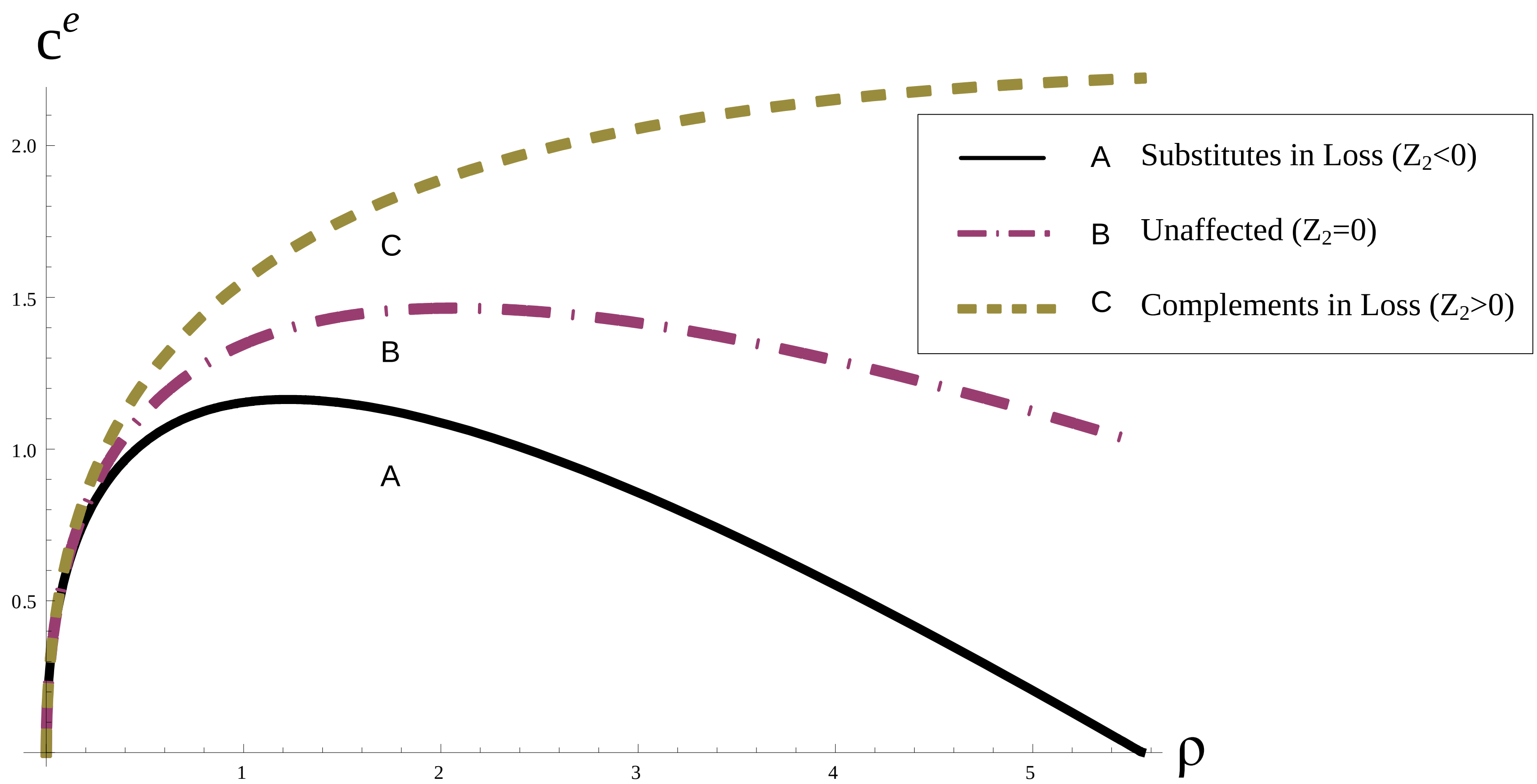
Equilibrium spending is

Increasing in π

Increasing in Z_1

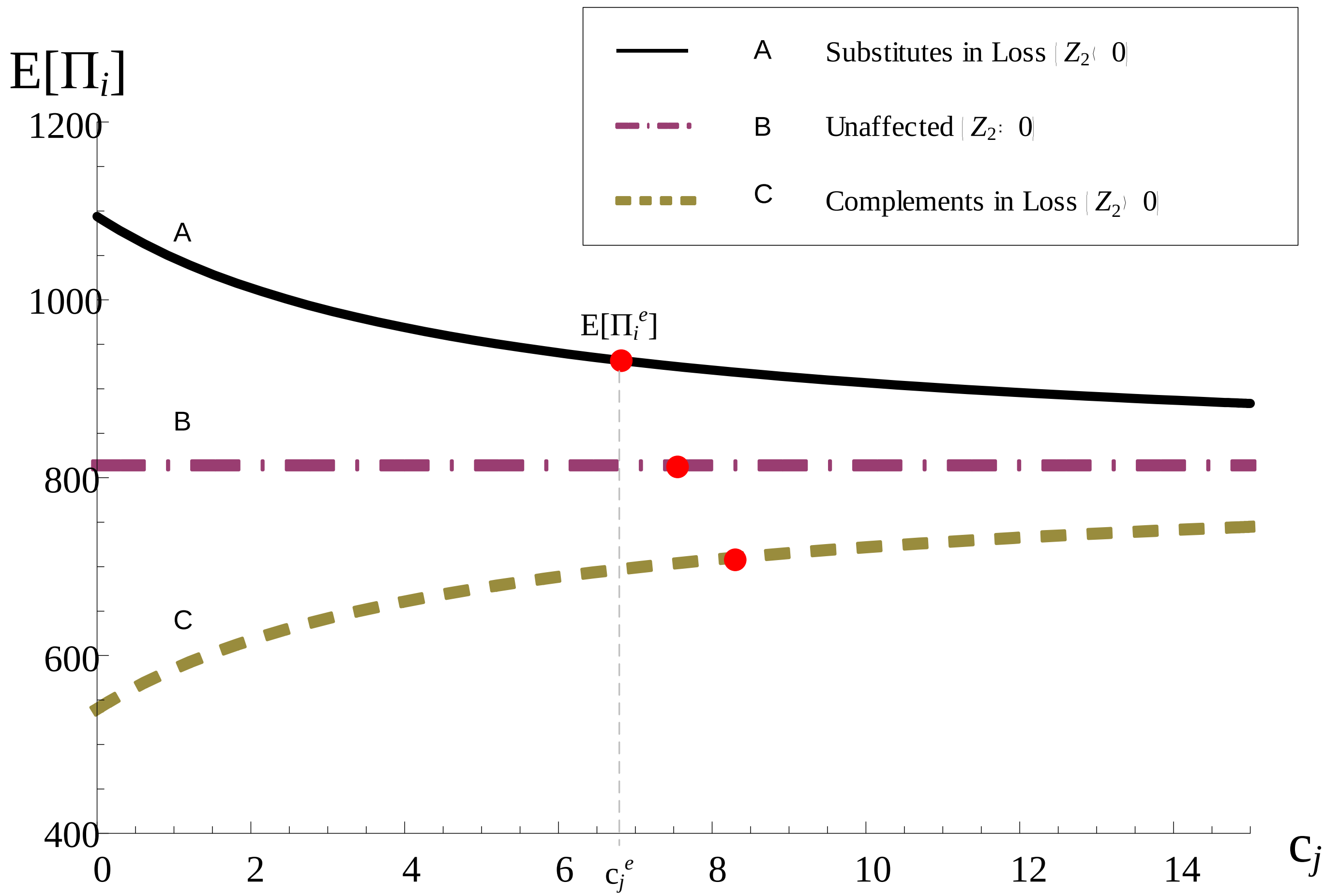
Increasing in Z_2

Equilibrium Spending and Riskiness of the Environment



The riskiness threshold is highest for complements in loss.

Symmetric – Expected Profits



Interaction effects lead to marked differences in equilibrium profit

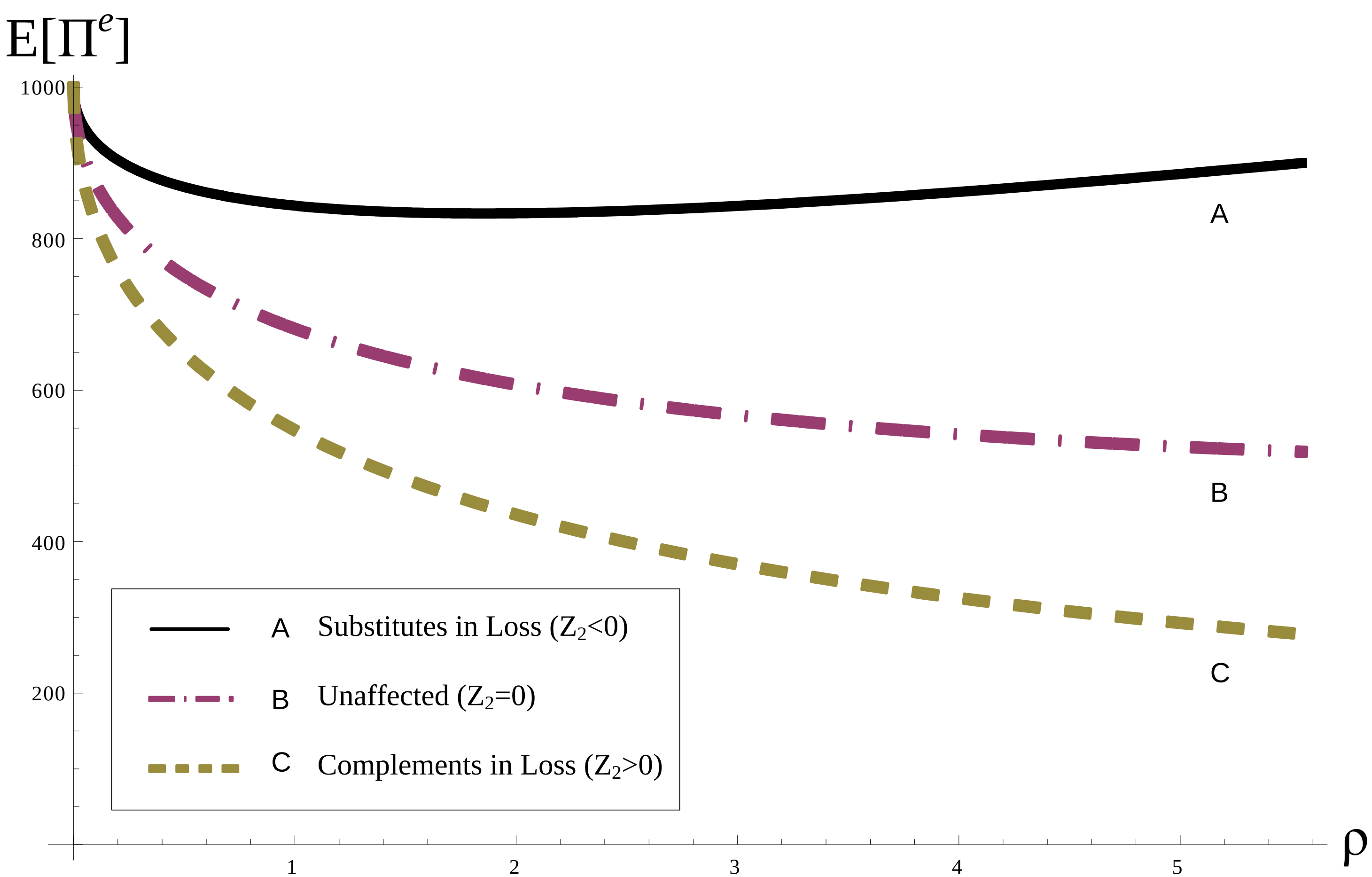
Equilibrium expected profit is

Increasing in π

Decreasing in Z_1

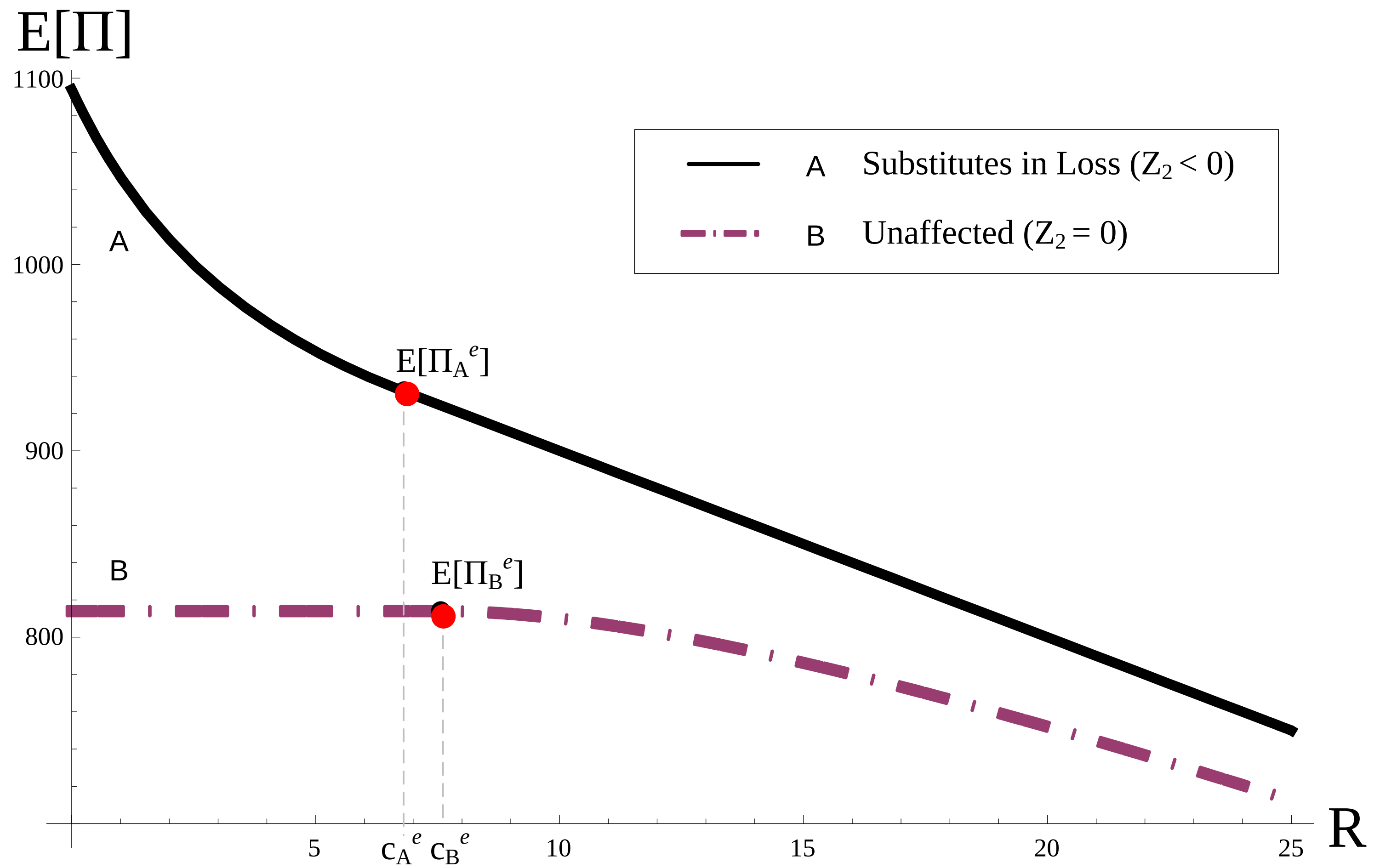
Decreasing in Z_2

Equilibrium Profit and Riskiness of the Environment



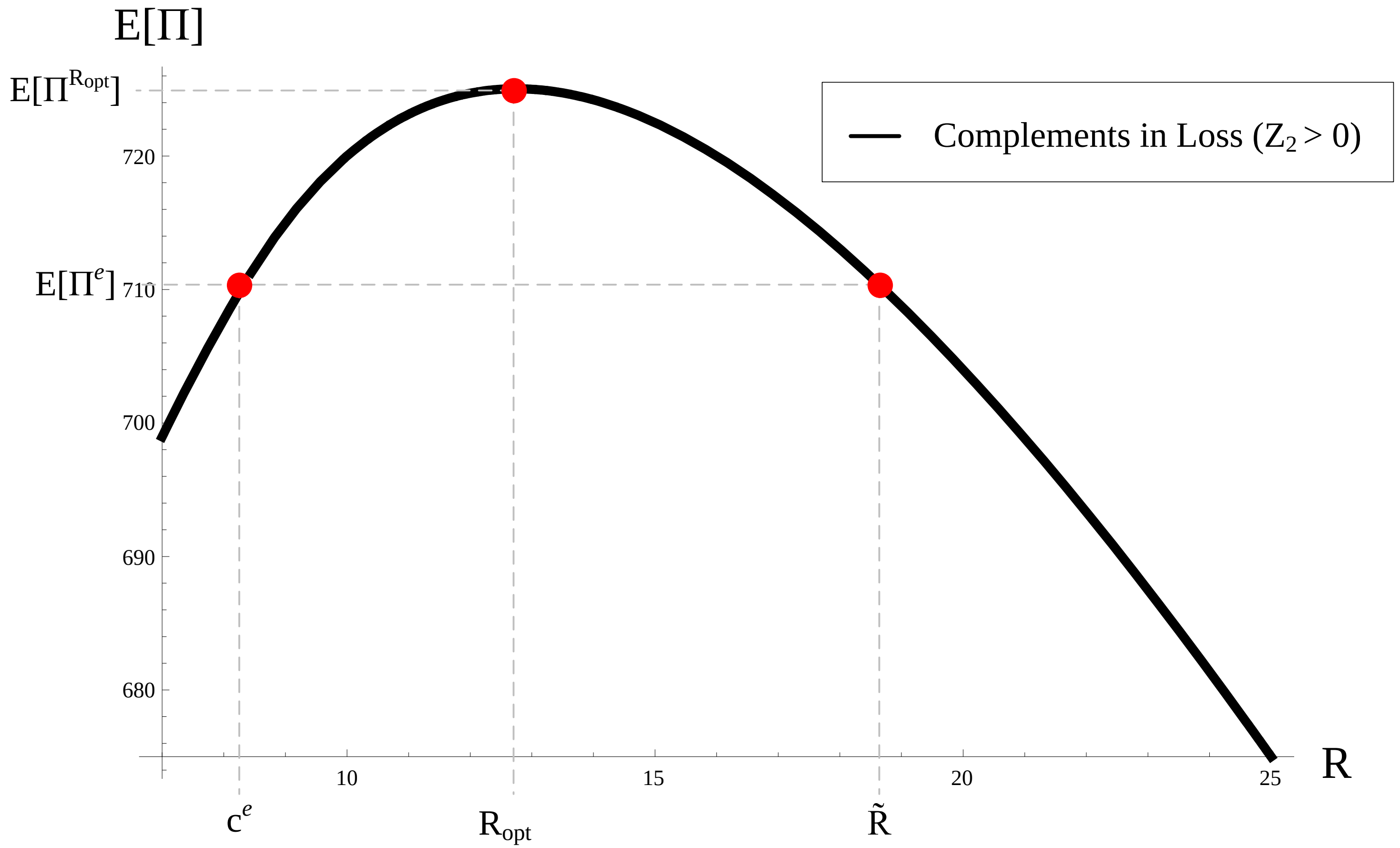
Profits can increase in riskiness when firms are substitutes in loss.

Required Spending – Cases I & II



Increased required spending reduces firms' profits

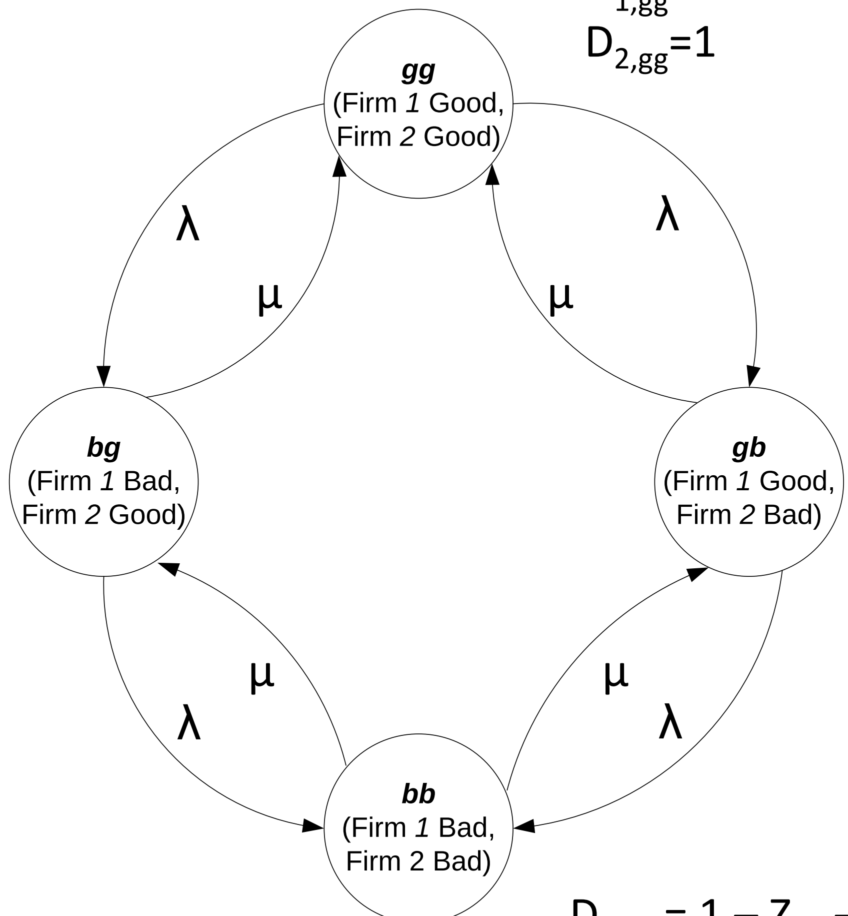
Required Spending – Case III Complements in Loss



Increased required spending improves firm profits, over a range

Asymmetric Model

$D_{1,gg}=1$
$D_{2,gg}=1$



$D_{1,bg} = 1 – Z_{11}$
$D_{2,bg} = 1 – Z_{22}$

$D_{1,gb} = 1 – Z_{12}$
$D_{2,gb} = 1 – Z_{21}$

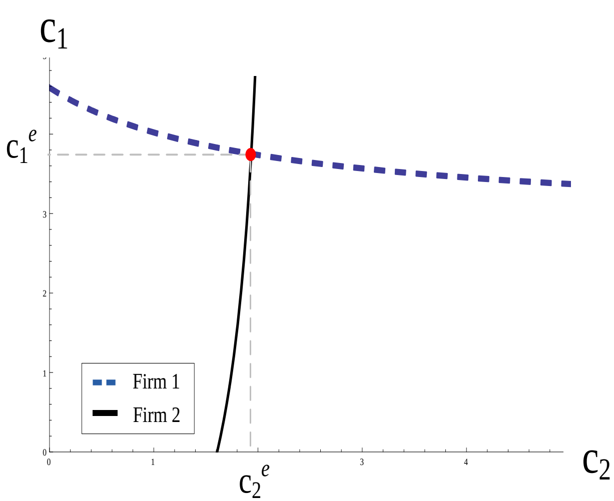
$D_{1,bb} = 1 – Z_{11} – Z_{12}$
$D_{2,bb} = 1 – Z_{21} – Z_{22}$

Expected Profit & Optimal Spending

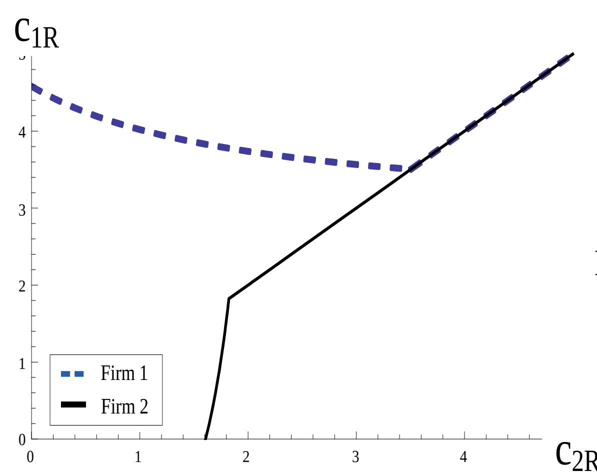
$$E[\Pi_i] = \left(1 - \frac{Z_{i1}\rho}{c_i + \rho} - \frac{Z_{i2}\rho}{c_j + \rho}\right)(\pi - c_i)Q \qquad \text{for } i = 1, 2, \text{ and } j \neq i.$$

$$c_i^* = \rho\left(\sqrt{\frac{Z_{i1}(\pi + \rho)(c_j + \rho)}{\rho(c_j + \rho - Z_{i2}\rho)}} - 1\right) \qquad \text{for } i = 1, 2, \text{ and } j \neq i.$$

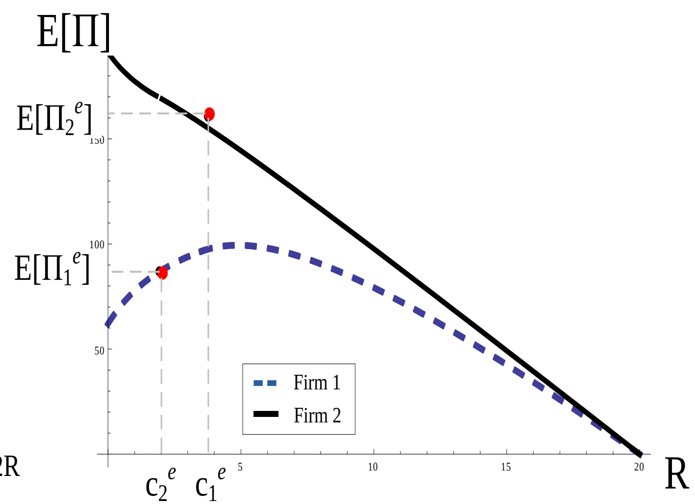
Complement and Substitute



(a) Optimal Spending

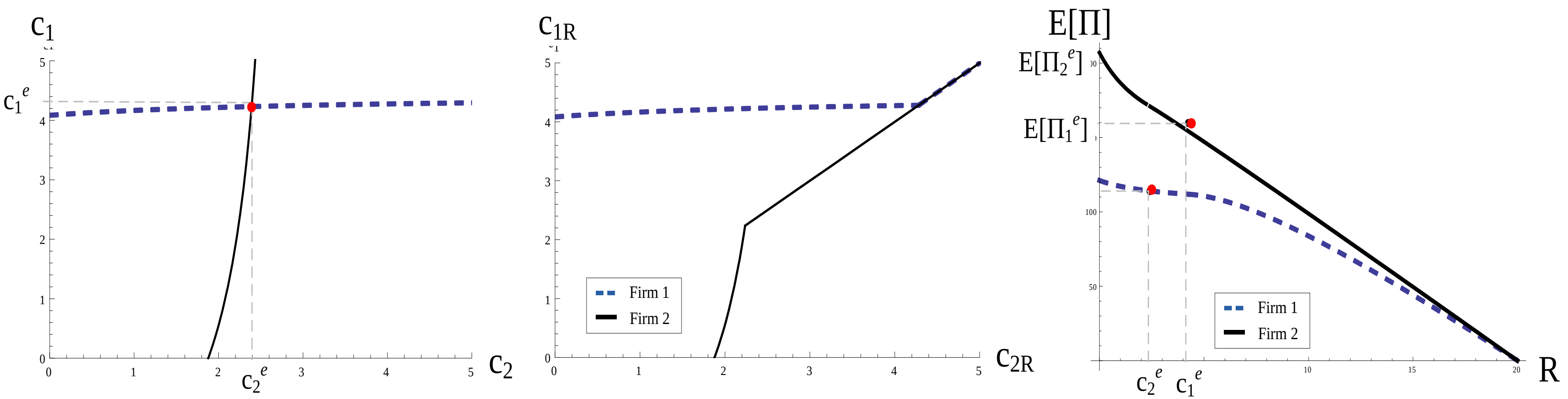


(b) Spending with Regulation



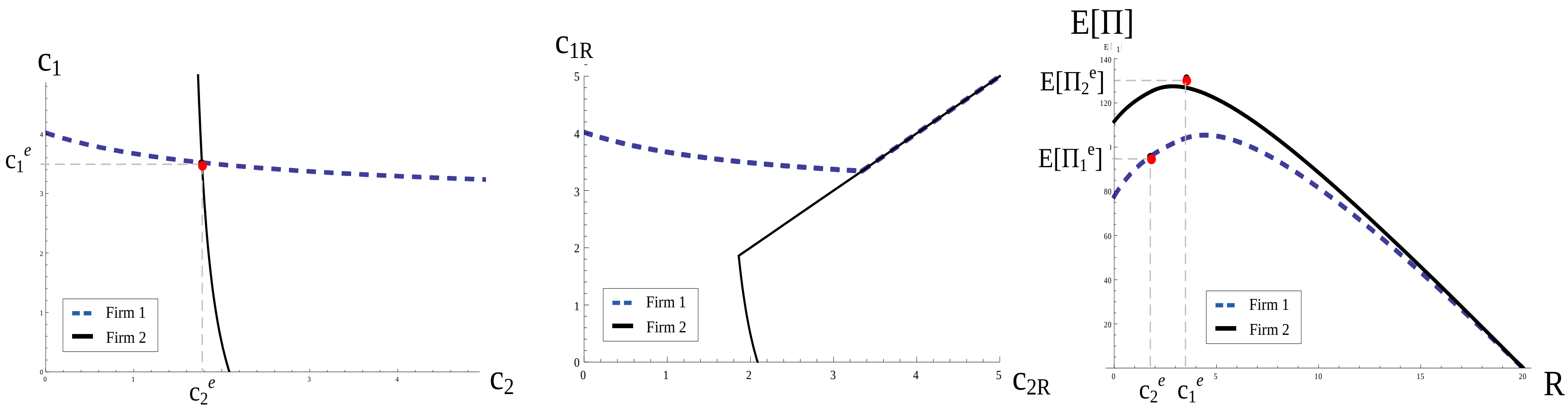
(c) Expected Profit

Both Substitutes



(a) Optimal Spending (b) Spending with Regulation (c) Expected Profit

Both Complements



(a) Optimal Spending

(b) Spending with Regulation

(c) Expected Profit

Both Complements

- OBSERVATION 1: As direct-risk elasticity increases, the opportunity window for firm 2 to increase profit under required spending decreases, everything else being constant.
- OBSERVATION 2: As cross-risk elasticity increases, the opportunity window for firm 2 to increase profit under required spending increases, everything else being constant.
- OBSERVATION 3: The largest increases in profit for firm 2 occur when the firms are "more similar" in terms of both direct- and cross-risk elasticity values.

Conclusions

- Spend differently from unaffected case
  - More when firms are complements in loss
  - Less when firms are substitutes in loss
- Standards or Regulation?
  - Decreased profits for unaffected and substitutes in loss
  - Range for increased profit for complements in loss
- Identify when cooperation possible, or not.
  - Increase industry security → increase demand
  - eCommerce standards

Future Work

- Breach disclosure
  - Data needed to estimate indirect effects on demand
- Customers with different risk profiles
  - Security as product differentiator?