Information Economics

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Course: Information Economics (Adverse selection)

Moral Hazard: Lessons

Lesson 1 Moral hazard (hidden action): A's actions (e) not observable (verifiable): contract cannot include effort level $\rightarrow$ incentive problem

Lesson 2 Franchise contract solves incentive problem, but at a cost: if A is RA franchise contract implies degree of risk sharing that is not Pareto efficient

Lesson 3 Tradeoff between incentive problem and Pareto inefficiency problem

Lesson 4 Incentive constraint: for any given wage schedule, P takes into account that A chooses u-max effort level (backward induction)

Lesson 5 If $e = e^{MIN}$ is optimal for P, the optimal contract equals symmetric information contract.

Lesson 6 If $e > e^{MIN}$ is optimal for P, IC implies a rising $w(x_i)_{i=1}^{n}$, in spite of A being RA

Adverse Selection

- Problem of hidden information (player's type or payoff)
- Akerlof (1970), The market for lemons (QJE)

  Adverse selection: only bad cars (lemons) survive

  bad quality drives good quality out of the market

Adverse Selection

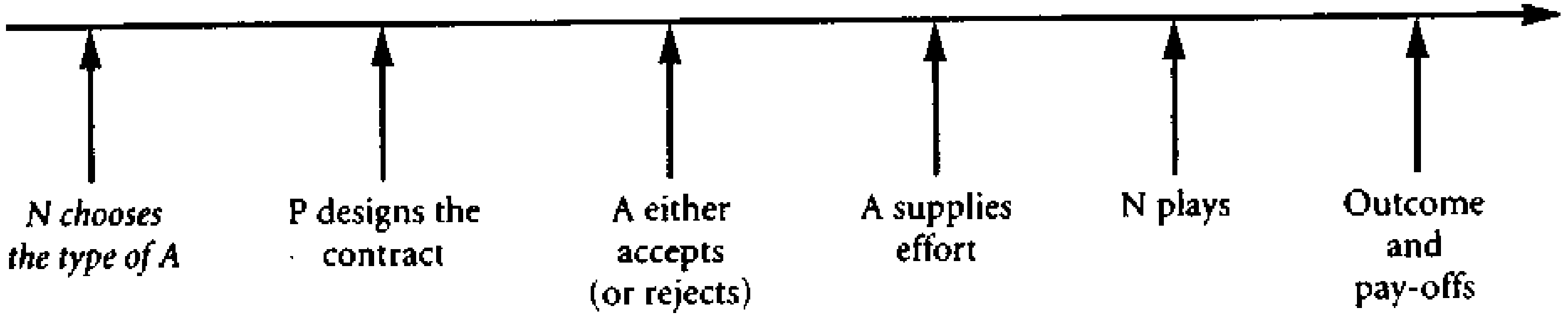
- Adverse Selection: base model w/ symmetric information
- One principal, two agents
- When principals compete for agents
  - benchmark: symmetric information
  - asymmetric information (separating, pooling equilibrium)
- Applications
  - Competition b/w insurance companies
  - Optimal licensing contracts
  - Regulation

- Agents (RA)

  e verifiable

  type: productivity; disutility $v(e)$

- Timing



Symmetric information

- A (RA)
  - 2 types: G, B

    $U^G(w, e) = u(w) - v(e)$; $U^B(w, e) = u(w) - k\,v(e)$; $k > 1$

    $u'(w) > 0$, $u''(w) < 0$, $v'(e) > 0$, $v''(e) > 0$
- P (RN) 2 contracts: (w^G, e^G), (w^B, e^B),
  - $\max_{e,w} \Pi(e) - w$, s.t. $u(w) - v(e) \geq \underline{U}$ and $u(w) - k\,v(e) \geq \underline{U}$

    $\Pi(e) \equiv \sum_{i=1}^{n} p_i(e)\, x_i$, $\Pi'(e) > 0$, $\Pi''(e) < 0$
  - P can identify type

Optimal contracts under symmetric information

- Participation constraints bind (why?)
- G-type

$$u(w^{G*}) - v(e^{G*}) = \underline{U}$$

efficiency condition:

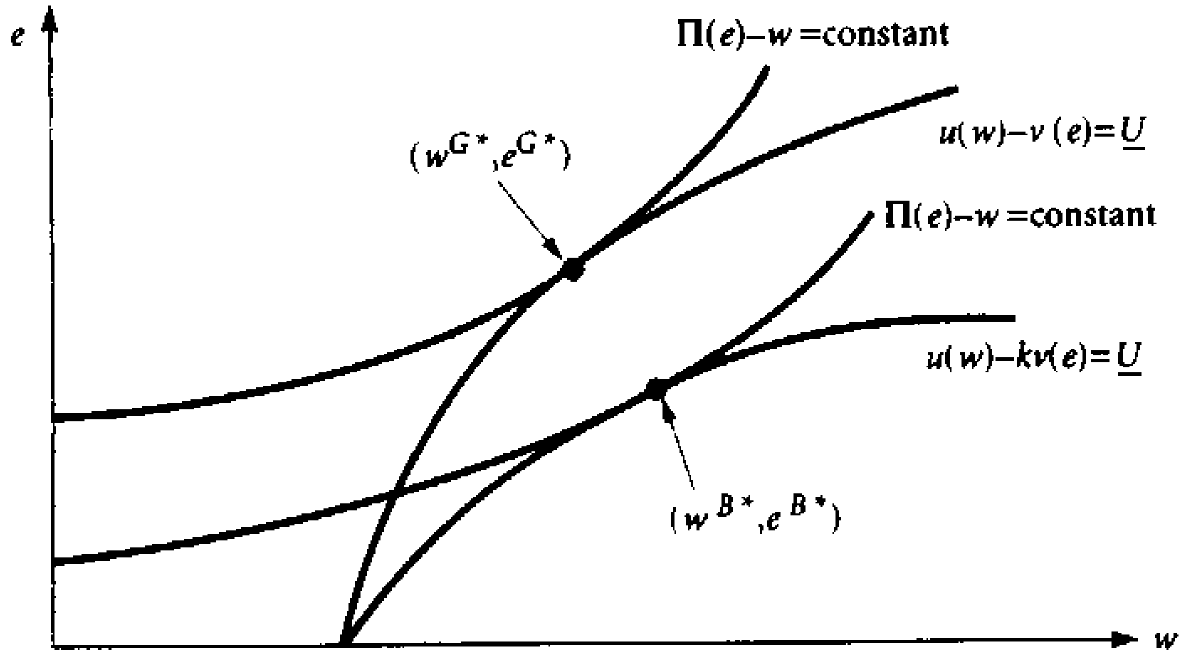
$$\Pi'(e^{G*}) = \frac{v'(e^{G*})}{u'(w^{G*})}$$

- B-type

$$u(w^{B*}) - k\,v(e^{B*}) = \underline{U}$$

efficiency condition:

$$\Pi'(e^{B*}) = \frac{k\,v'(e^{B*})}{u'(w^{B*})}$$



- G less costly: $e^{G*} > e^{B*}$
- $w^{G*} \gtreqless w^{B*}$, 2 opposing effects
- G would prefer contract (w^{B*}, e^{B*}) over (w^{G*}, e^{G*})

- P designs self-selective (incentive compatible) menu of contracts

  $\{(e^G, w^G), (e^B, w^B)\}$

  q share of G-type (public knowledge)

$$\max_{\{(e^G,w^G),(e^B,w^B)\}} q\left[\Pi(e^G) - w^G\right] + (1-q)\left[\Pi(e^B) - w^B\right]$$

$$\text{s.t.} \quad u(w^G) - v(e^G) \geq \underline{U} \qquad (1)$$

$$u(w^B) - k\,v(e^B) \geq \underline{U} \quad [\lambda] \qquad (2)$$

$$\text{for } G \;\; u(w^G) - v(e^G) \geq u(w^B) - v(e^B) \quad [\mu] \qquad (3)$$

$$\text{for } B \;\; u(w^B) - k\,v(e^B) \geq u(w^G) - k\,v(e^G) \quad [\delta] \qquad (4)$$

- (3) + (2) $\Rightarrow$ (1):

  $u(w^G) - v(e^G) \geq u(w^B) - v(e^B) \geq u(w^B) - k\,v(e^B) \geq \underline{U}$

  only participation constraint of least-efficient type is binding

- (3) + (4) $\Rightarrow e^G \geq e^B$
  $v(e^G) - v(e^B) \leq u(w^G) - u(w^B) \leq k\,[v(e^G) - v(e^B)]$
  $[v(e^G) - v(e^B)]\,[1-k] \leq 0$
  as $k > 1$, $v(e^G) \geq v(e^B) \Leftrightarrow e^G \geq e^B$

- first order conditions

$$\mu - \delta = \frac{q}{u'(w^G)} \tag{5}$$

$$\lambda - \mu + \delta = \frac{1-q}{u'(w^B)} \tag{6}$$

$$\mu - \delta\, k = \frac{q\,\Pi'(e^G)}{v'(e^G)} \tag{7}$$

$$\lambda\, k - \mu + \delta\, k = \frac{(1-q)\Pi'(e^B)}{v'(e^B)} \tag{8}$$

Characterization of optimal contract

- (5) + (6): participation constraint of B binds: $\lambda > 0$
  $\lambda = q/u'(w^G) + (1-q)/u'(w^B) > 0\,!$
  B gets exactly $\underline{U}$, G gets at least $\underline{U}$
- self-selection constraint of G binds: $\mu > 0$
  from (5), $\mu - \delta > 0$, and $\delta \geq 0$ by Kuhn-Tucker
- $e^G > e^B$ (contracts differ)
  suppose $e^G = e^B$
  then $w^G = w^B$ (from (3) & μ>0), $\lambda = 1/u'(w) = \Pi'(e)/[k\, v'(e)]$
  then (5), (7):

$$\mu = q/u'(w) + \delta = q\lambda + \delta$$

$$\mu = q\,\Pi'(e)/v'(e) + k\delta = k\,(q\lambda + \delta)$$

but: $q\lambda + \delta \neq k(q\lambda + \delta) \Rightarrow e^G \neq e^B$

- $e^G > e^B$ implies not: $(\mu > 0)$ *and* $(\delta > 0)$
  otherwise, by (3)+(4): $v(e^G) - v(e^B) = k\,[v(e^G) - v(e^B)]$
  - $\mu > 0 \;\Rightarrow \delta = 0$ self-selection constr. of B not binding

- Information rent (market power) of G
  - from (3)+(2):

$$
\begin{aligned}
u(w^G) - v(e^G) &= u(w^B) - v(e^B) \quad \text{by (3)}\\
&= u(w^B) - k\,v(e^B) + (k-1)v(e^B)\\
&= \underline{U} + \underbrace{(k-1)v(e^B)}_{\text{information rent}} \qquad \text{by (2)}
\end{aligned}
$$

Adverse Selection: First Lessons

- Participation constraint binds only for agent with *highest* cost, other agent receives information rent $(k-1)\,v(e^B)$
- Incentive constraint binds only for agent with *lowest* cost
- Non-distortion at the top (agent G)

$$\Pi'(e^G) = \frac{v'(e^G)}{u'(w^G)}$$

- Distortion for agent B

$$\Pi'(e^B) = \frac{k\,v'(e^B)}{u'(w^B)} + \underbrace{\frac{q(k-1)}{1-q}\,\frac{v'(e^B)}{u'(w^G)}}_{\text{incomplete information}}$$

  - $e^B \downarrow$ to make contract less attractive to G

    $e^B \downarrow \Rightarrow v(e^B) \downarrow \Rightarrow$ information rent $\downarrow$

    P minimizes information rent

Asymmetric information (principals, 2 types of agents)

- Setup: several principals
  - 2 types of agents: B, G; differing productivity; unique effort level
  - results: success (x_S), failure (x_F)
  - probability of success p: $p^G > p^B$
  - payoffs: w_S, w_F
  - expected profit (of RN P): $p(x_S - w_S) + (1-p)(x_F - w_F)$
  - expected utility (A):

    $$U^G = p^G\, u(w_S) + (1 - p^G)\, u(w_F);\; U^B = p^B\, u(w_S) + (1 - p^B)\, u(w_F)$$

    - disutility from *unique* effort level considered in $\underline{U}$
  - menu of contracts $\{(w_S^G, w_F^G),\, (w_S^B, w_F^B)\}$

Benchmark: symmetric information

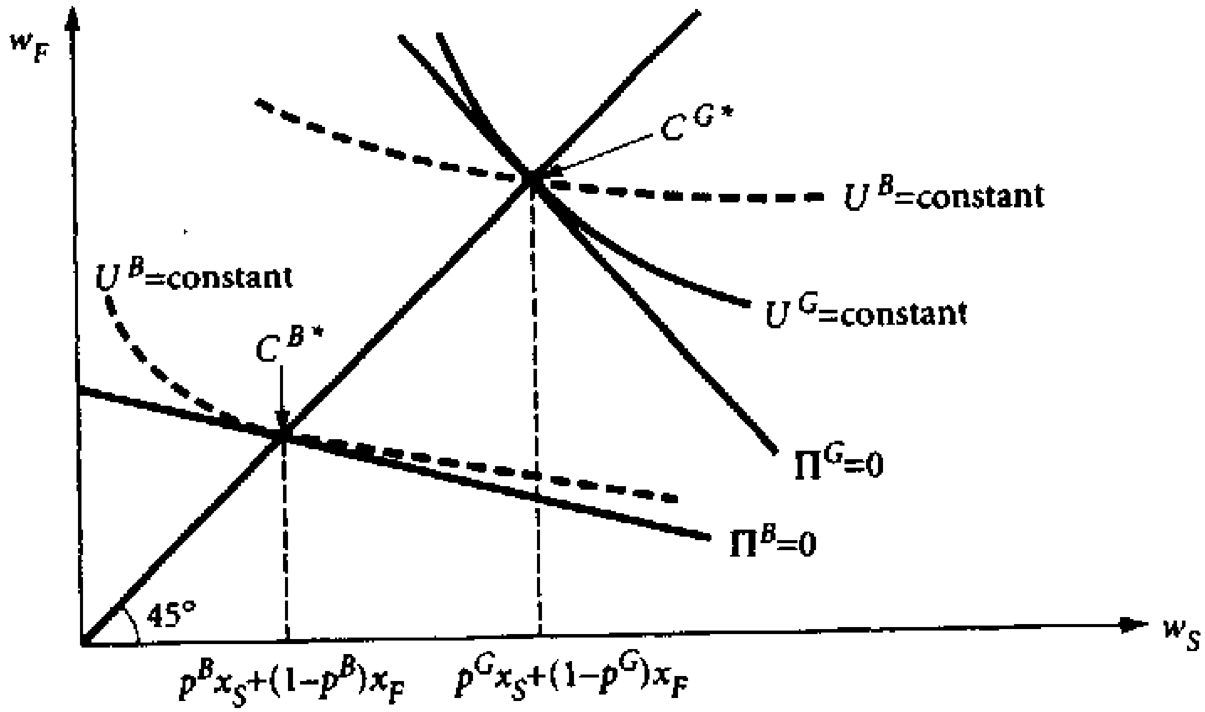
- Menu of contracts: $C^T \equiv (w_S^T, w_F^T)$, $T \in \{G, B\}$

$$\mathcal{L}^T = p^T(x_S - w_S^T) + (1-p^T)(x_F - w_F^T) + \lambda\left[p^T\, u(w_S^T) + (1-p^T)\, u(w_F^T) - \underline{U}\right]$$

  - zero expected profits (competition among P)
  - C^T are Pareto efficient

- Full insurance: $w_S^T = w_F^T$
  - $\partial\mathcal{L}/\partial w_S^T = 0 = \partial\mathcal{L}/\partial w_F^T \Leftrightarrow \lambda\, u'(w_S^T) = 1 = u'(w_F^T)\,\lambda$

- $(w_S^G, w_F^G) \gg (w_S^B, w_F^B)$



- Indifference curve is steeper for G than for B
- Isoprofit line is steeper for G than for B
- Self selection constraint not satisfied for B
  - B prefers C^{G*} over C^{B*}

Asymmetric information

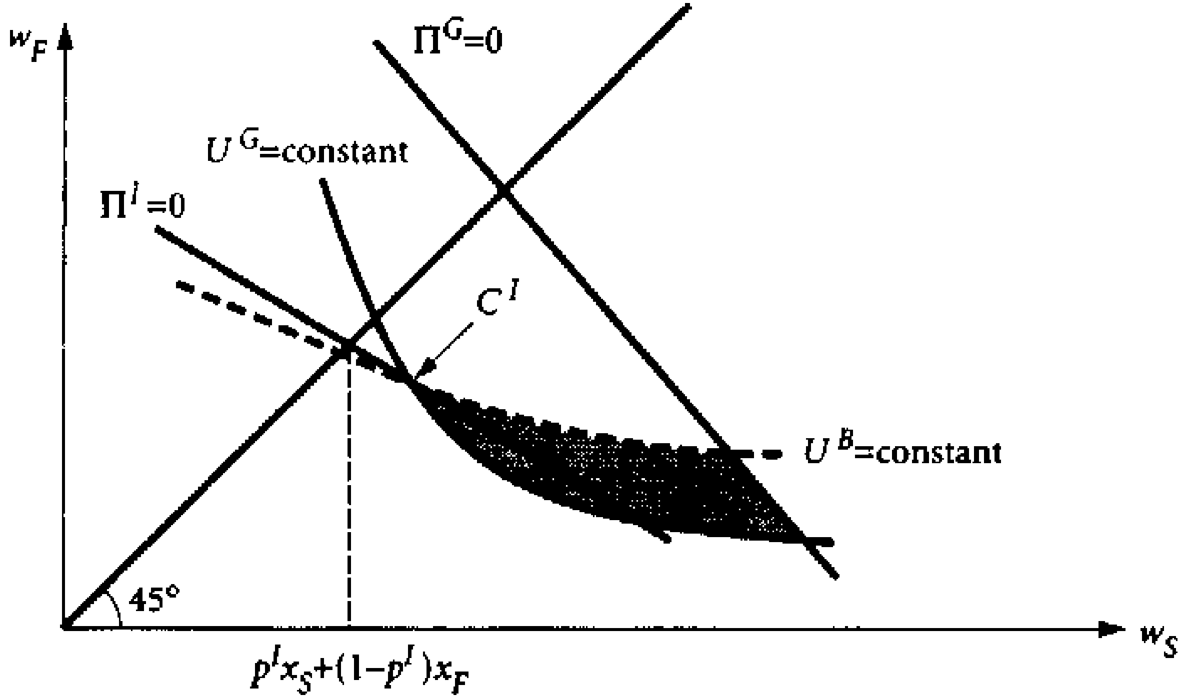
- Equilibrium contract $\{C^G, C^B\} \equiv \{(w_S^G, w_F^G), (w_S^B, w_F^B)\}$
  - pooling (Bayesian Nash) equilibrium: $C^G = C^B$
  - separating (Bayesian Nash) equilibrium: $C^G \neq C^B$
- Requirements: given $\{C^G, C^B\}$
  - $\exists$ no other contract preferred to C^G only by G, with $\Pi > 0$
  - $\exists$ no other contract preferred to C^B only by B with $\Pi > 0$
  - $\exists$ no other contract preferred to C^T only by T with $\Pi > 0$, $T \in \{G, B\}$

$\rightarrow$ rules out B mimicking G

$\rightarrow$ zero expected profits (due to many P)

No pooling equilibria

- Pooling zero profit line:
  - $p^I \equiv q\,p^G + (1-q)p^B$
  - $\Pi^I \equiv p^I(x_S - w_S) + (1-p^I)(x_F - w_F) = 0$

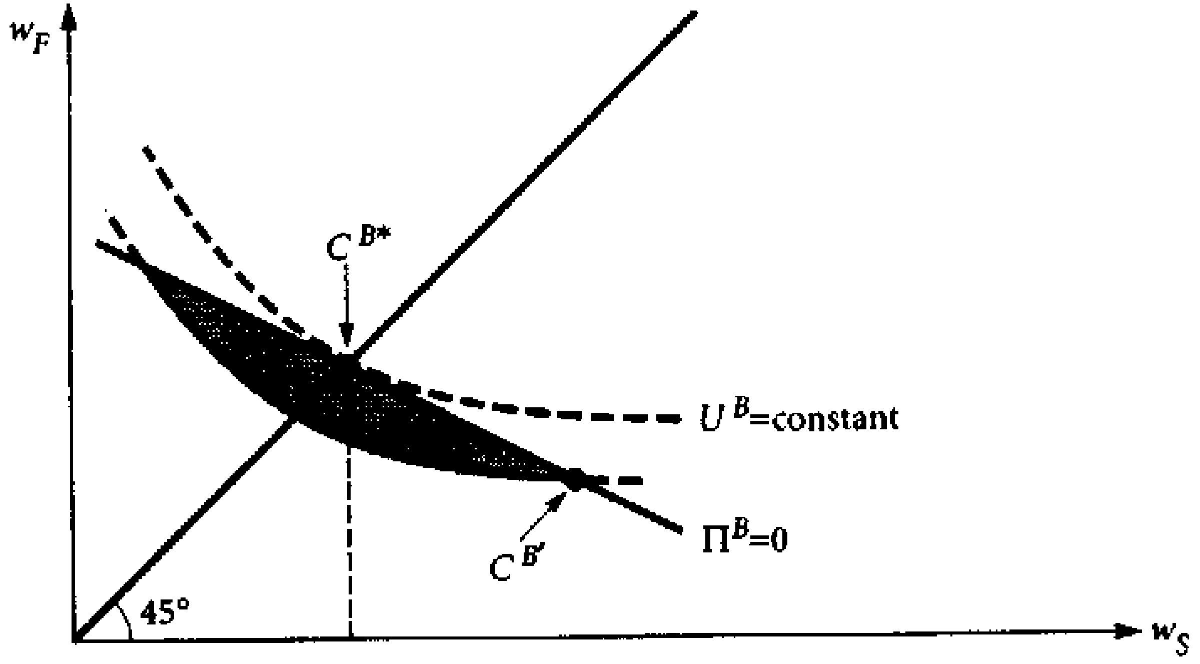


- C^I: for every contract on pooling zero profit line, $MRS^G_{S,F} > MRS^B_{S,F}$

  no pooling equ. b/c cream skimming

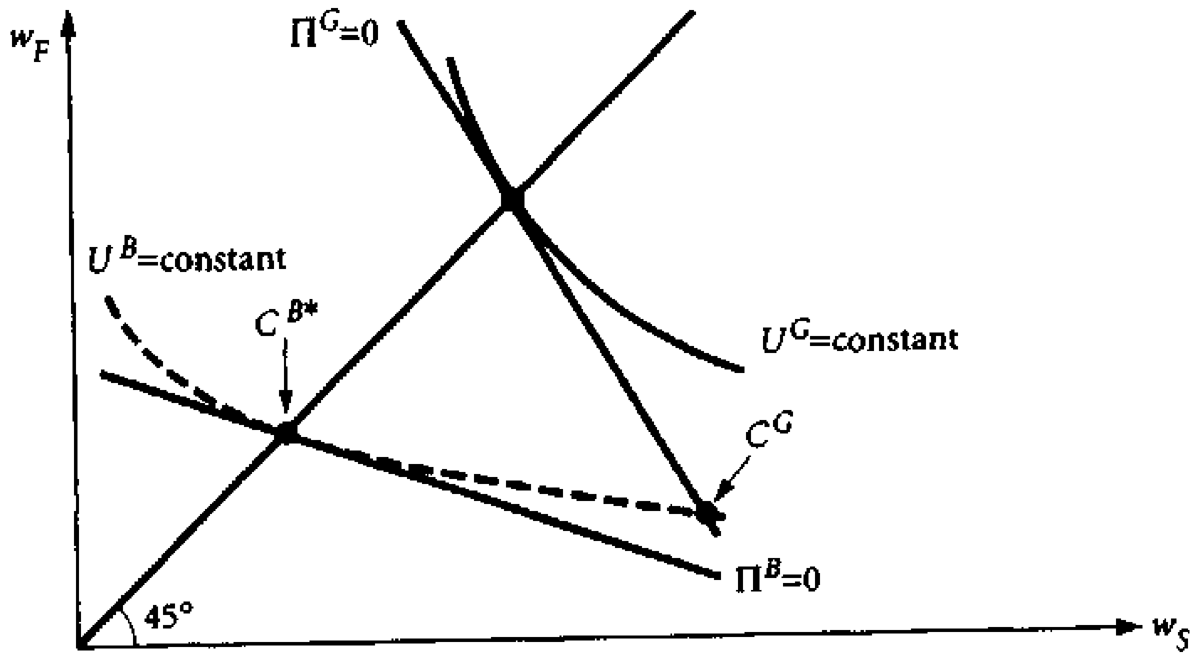
Separating equilibria

- B-type: $C^B = C^{B*}$ (Nash equilibrium contract)



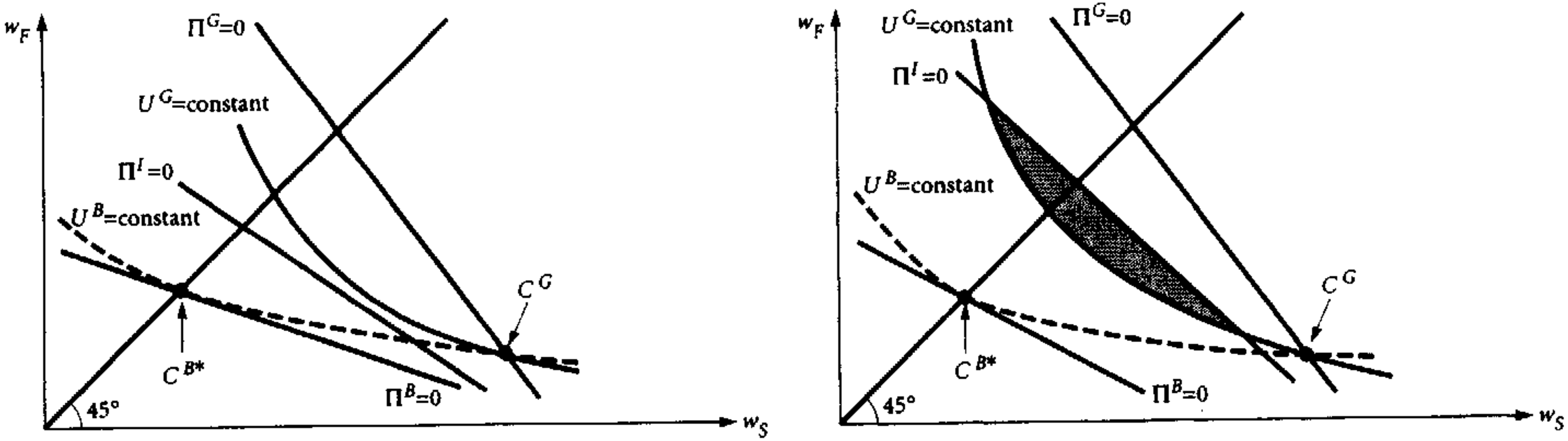
$C^{B'}$ violates equilibrium requirements

- Separating equilibrium (C^G, C^{B*})



$\Pi = 0$
no other contract $(\Pi > 0)$ strictly preferred by either B or G
no other contract $(\Pi > 0)$ strictly preferred by both B and G

Separating equilibrium exists for "low" q



- left: separating equilibrium exists
- right: equilibrium requirements violated; shaded area: both T prefer contract over their equilibrium contract (but positive expected profits)

Adverse Selection: Lessons

Lesson 1 Adverse selection (AS): hidden information about type (payoff) of A

Lesson 2 Optimal contracts differ among type. AS may provoke

- good quality to drive out bad quality (lemons) = adverse selection or
- absence of equilibrium (market) in the extreme

$\rightarrow$ inefficiency: gains from trade go unexploited

Lesson 3 AS: P designs menu of self-selevtive contracts

$\therefore$ Moral hazard: pooling equilibrium (same contract for all A)

Lesson 4 Self-selection constraint rules out mimicking:

cost to P = information rent to A

Adverse Selection: Lessons

Lesson 5 1 P, 2 A:

PC is binding only for least productive A

SSC not binding for least productive A (G wants to mimic B)

non-distortion at the top (G)

P distorts C^B (lowers e^B) in order to minimize information rent

Lesson 6 Many P, 2 A: Every equilibrium contract (if existing) is separating (due to cream skimming)

Lesson 7 Bad risks are fully insured (as w/ symmetric info)

Lesson 8 Good risk (while actuarially fair) get excess clause: less than full insurance due to signaling requirement.

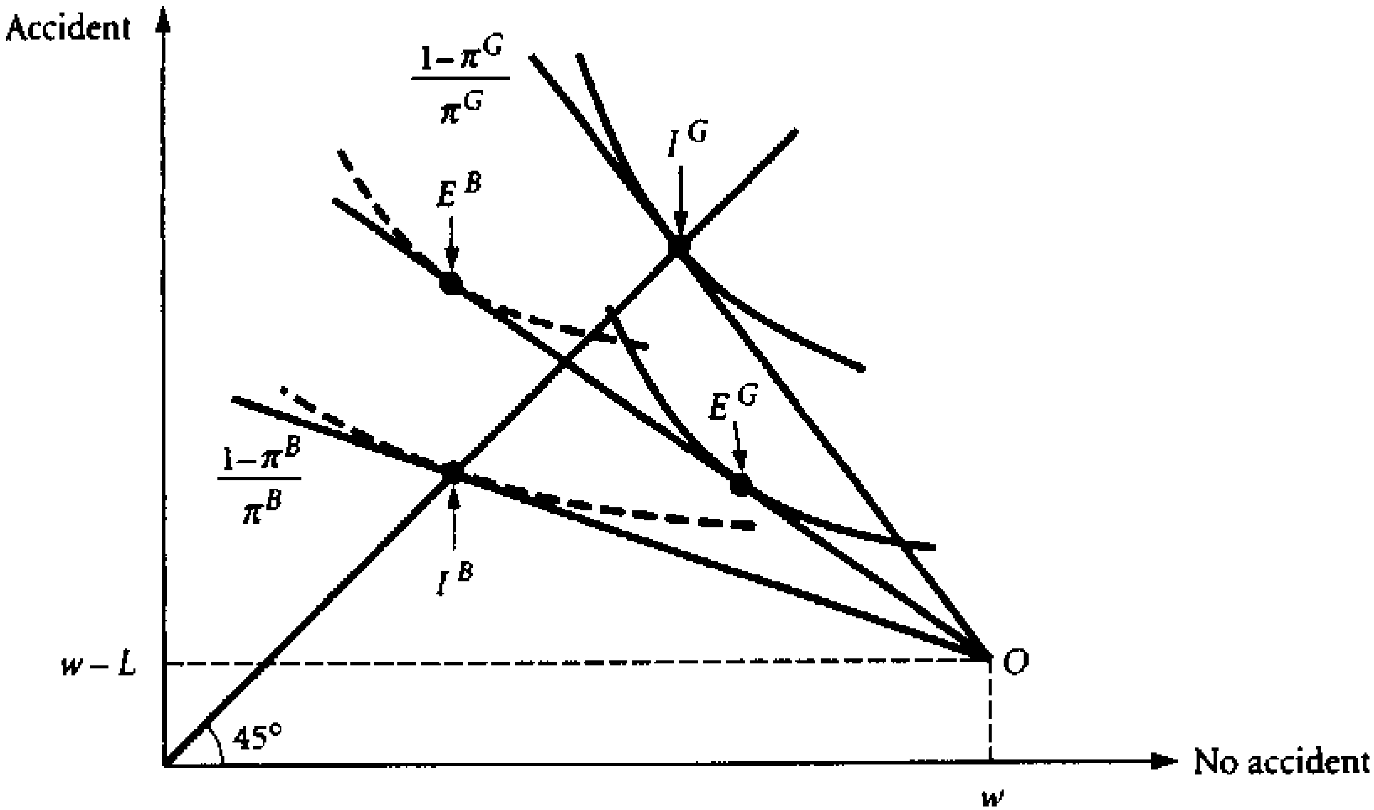
Applications I: competition b/w insurance companies

- A. Single insurance company (P, RN)
  - A: low (accident) risk π^G, high risk $\pi^B > \pi^G$
  - P proposes p per unit of benefit z, A choose coverage z
- Symmetric information (efficient sol)
  - A $\max_{\{z^T\}} \pi^T u(w - L - pz^T + z^T) + (1 - \pi^T) u(w - pz^T)$, $T \in \{G, B\}$

$$\frac{u'(w - L - pz^T + z^T)}{u'(w - pz^T)} = \frac{(1 - \pi^T)p}{\pi^T(1-p)}$$

  - for given p, as $\pi^B > \pi^G$: $z^B > z^G$
  - actuarial fairness: $p^T = \pi^T$

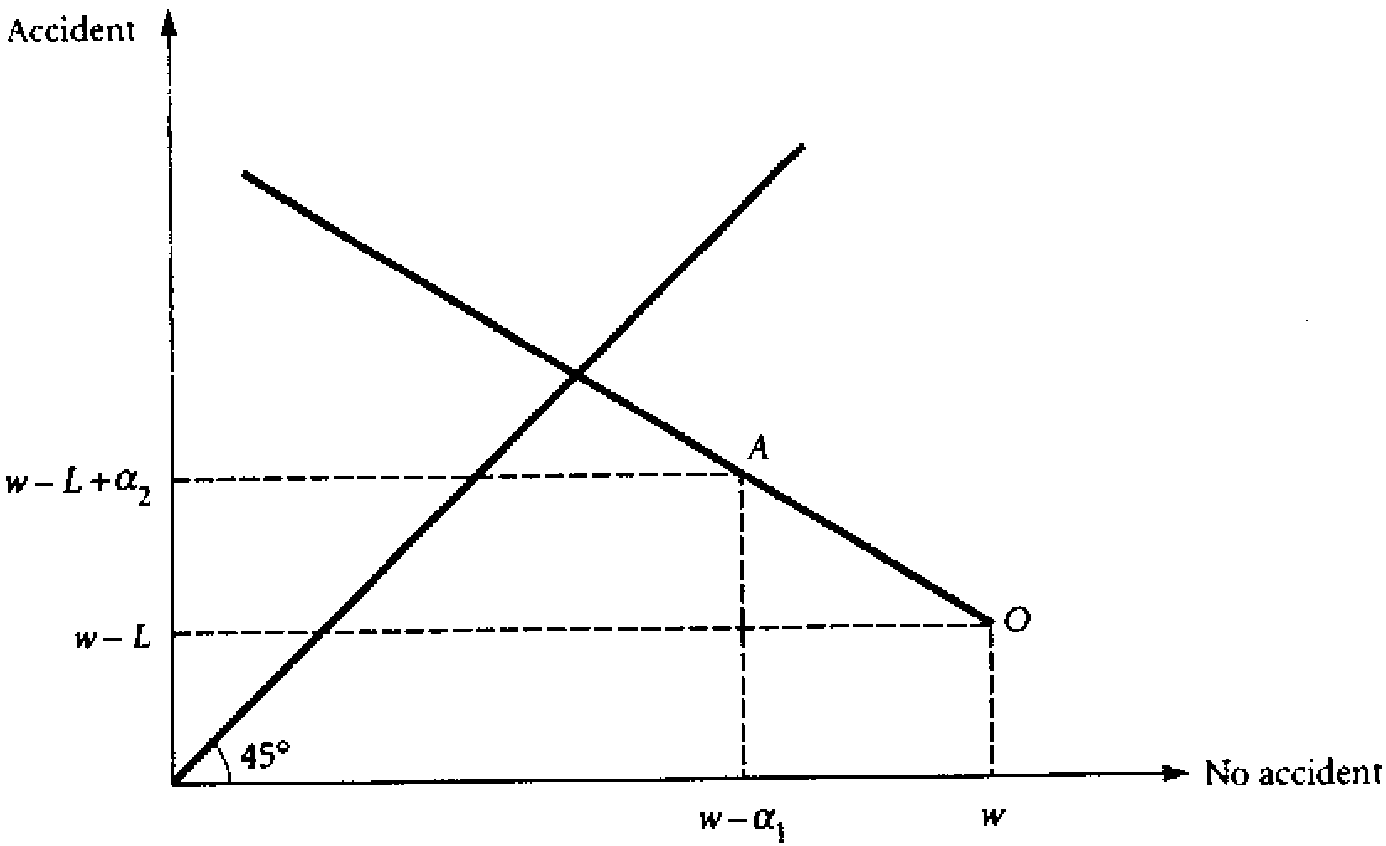
$\rightarrow$ $z^B = L = z^G$, $p^B > p^G$



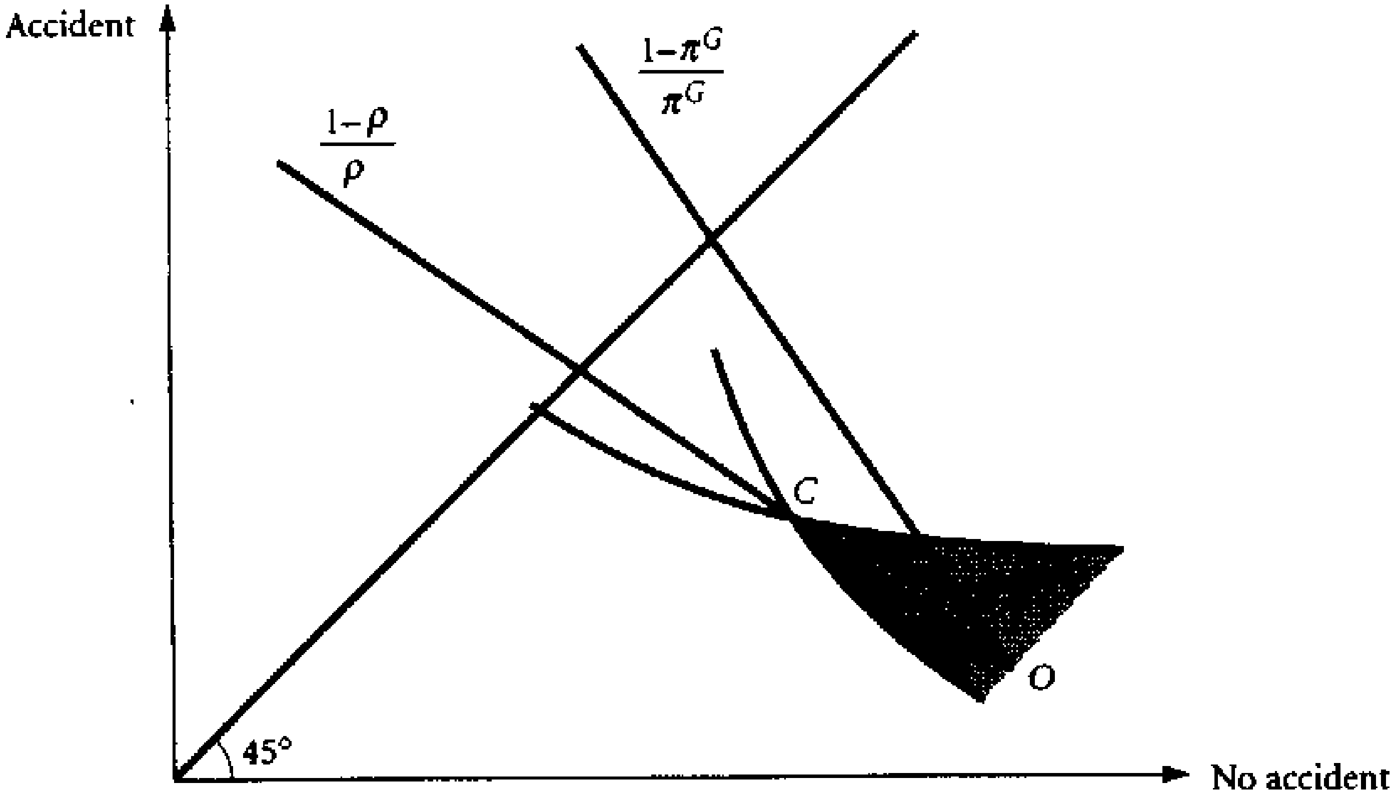
- asymmetric information $\pi^B > p > \pi^G$
- E^B: B overinsures, E^G: G underinsures (expected loss)
- $p\uparrow$ (flatter contract menu line) re-enforcing adverse selection!

- Asymmetric information
  - AS drives out "good" risk from the market
  - inefficiently low insurance coverage for G
  - possibly only equilibrium: I^B for B, 0 for G

- B. Several insurance companies (P) offering (p, z) packages
  - premium $\alpha_1 \equiv pz$; net benefit $\alpha_2 \equiv z - pz$
  - contract (α_1^T, α_2^T): pooling, separating

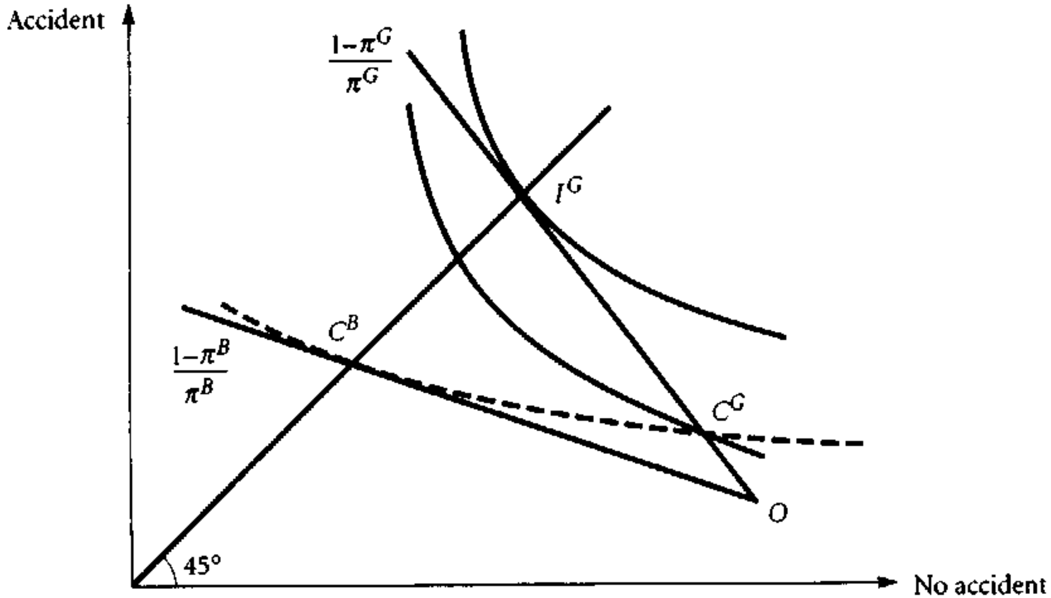


- Non-existence of pooling equilibrium contracts
  - actuarially fair price $\rho = q\pi^G + (1-q)\pi^B$



- MRS differ: cream skimming on zero-profit pooling line "below" C

Separating contracts $\{C^B, C^G\}$



- both contracts must be on respective zero profit lines
- C^G must not be above B's indifference curve (expected loss)
- C^G must not be below B's indifference curve (competition for G)
- C^B must be on 45° line (most preferred one by B on zero profit line)

- Existence of separating contracts
  - no dominating pooling contract (holds if q "low")
  - signalling π^G is costly (in terms of low coverage)
  - only pays if there is significant amount of bad risk in the market
- Compared to symmetric info equilibrium
  - B gets same contract
  - G gets partial coverage at lower price ($p^G = \pi^G$)
    … needs to signal G-characteristic by accepting lower coverage

Application II: Optimal licensing contracts

- P research lab, selling license f/ cost reducing technology
- A monopolist, AC c^0; technology lowers c^0 to $c < c^0$
- Contract (F, ϵ)
- Symmetric information (backward induction)
- A

$$\Pi^m(c+\epsilon) = [p^m(c+\epsilon) - (c+\epsilon)]\, D^m(p^m(c+\epsilon))$$

$$p^m(c+\epsilon) \in \arg\max_p [p - (c+\epsilon)]\, D(p)$$

- P

$$\max_{F,\epsilon} F + \epsilon\, D^m(p^m(c+\epsilon))$$

$$\text{s.t. } \Pi^m(c+\epsilon) - F \geq \Pi^m(c^0) \quad [\lambda]$$

$$\epsilon \geq 0\,, \quad F \geq 0$$

- Optimal contract / symmetric information
  - $\lambda > 0 \Rightarrow$ part. constraint binds
  - $\epsilon^* = 0,\ F^* = \Pi^m(c) - \Pi^m(c^0)$

- Asymmetric information on cost: $c^G < c^B < c^0$
  - $\epsilon^{G^*} = 0,\ F^{G^*} = \Pi^m(c^G) - \Pi^m(c^0)$

    $\epsilon^{B^*} = 0,\ F^{B^*} = \Pi^m(c^B) - \Pi^m(c^0)$

  $\rightarrow$ sym. inf. contract not optimal, as G chooses $(\epsilon^{B^*}, F^{B^*})$
  - P needs to make (ϵ^B, F^B) less attractive to G
    - $\epsilon^B > 0$ (distortion)

$$\max_{F^G,\epsilon^G,F^B,\epsilon^B} q[F^G+\epsilon^G D^m(p^m(c^G+\epsilon^G))]+(1-q)[F^B+\epsilon^B D^m(p^m(c^B+\epsilon^B))]$$

$$\Pi^m(c^G+\epsilon^G)-F^G \geq \Pi^m(c^G+\epsilon^B)-F^B \qquad [\mu]$$

$$\Pi^m(c^B+\epsilon^B)-F^B \geq \Pi^m(c^B+\epsilon^G)-F^G \qquad [\lambda]$$

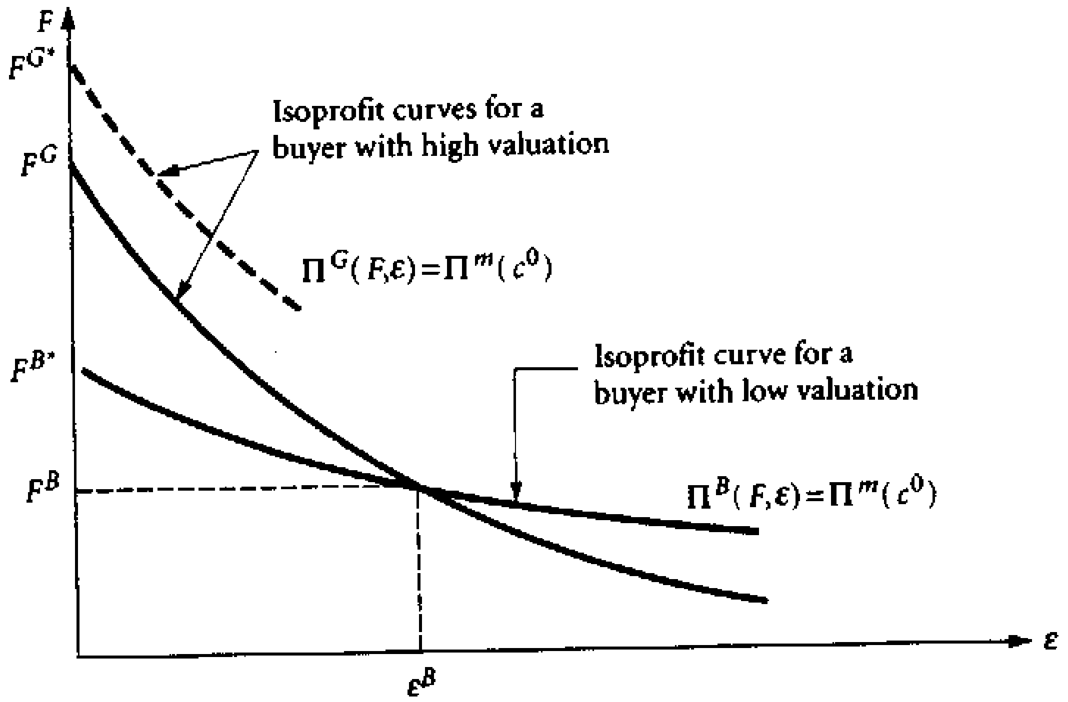
$$\Pi^m(c^G+\epsilon^G)-F^G \geq \Pi^m(c^0) \qquad [\rho]$$

$$\Pi^m(c^B+\epsilon^B)-F^B \geq \Pi^m(c^0) \qquad [\delta]$$

$$F^G \geq 0,\ F^B \geq 0,\ \epsilon^G \geq 0,\ \epsilon^B \geq 0$$

- PC of G not binding $\rho = 0$, info rent for G
- PC for B binding $\delta > 0$
- SSC for G binding $\mu > 0$, and $\lambda = 0$

- FOC imply separating equilibrium contracts
  - $\epsilon^G = \epsilon^{G^*} = 0$ no distortion at the top
  - $\epsilon^B > \epsilon^{B^*} = 0$ distortion to discourage mimicking
  - $F^G < F^{G^*}$ information rent for G
  - $F^B < F^G$



Applications III: Regulation under adverse selection

- Regulation of natural monopolist (A)
  - prices, quantities, subsidies set by public sector (P)
  - cost function of monopoly often private information
  - monopolist $C(Q) = F + c\,Q$ (decreasing AC)
  - households $U(Q)$, paying T
  - government
    - S, with social cost $(1+g)S$, $g > 0$
    - max consumer surplus + firm profits - social cost of subsidy

- Symmetric information

$$\max_{T,S,Q} [U(Q) - T] + [T + S - cQ - F] - [(1+g)S]$$

$$\text{s.t. } T + S - cQ - F \geq 0 \qquad [\lambda]$$

$$U(Q) - T \geq 0 \qquad [\mu]$$

- both PC bind: $\lambda = \mu = g > 0$
- optimal quantity decision: $U'(Q) = c$ (MWP = MC)

- Asymmetric information about c: $c^G < c^B$
  - for finding Bayesian NE: P proposes $\{(T^G, S^G, Q^G), (T^B, S^B, Q^B)\}$ given beliefs about types of monopolist $q, (1-q)$

$$\max_{(T^G,S^G,Q^G),(T^B,S^B,Q^B)} [q(U(Q^G) - T^G) + (1-q)(U(Q^B) - T^B)]$$
$$+ q[T^G + S^G - c^G Q^G - F] + (1-q)[T^B + S^B - c^B Q^B - F]$$
$$- (1+g)[qS^G + (1-q)S^B]$$

s.t. $T^G + S^G - c^G Q^G - F \geq 0\,; \quad T^B + S^B - c^B Q^B - F \geq 0$

$U(Q^G) - T^G \geq 0; \quad U(Q^B) - T^B \geq 0$

$T^G + S^G - c^G Q^G - F \geq T^B + S^B - c^G Q^B - F\,;$

$T^B + S^B - c^B Q^B - F \geq T^G + S^G - c^B Q^G - F$

- too complicated? no!
- eliminate some constraints and investigate foc
  - PC of G firm; SSC of B firm
  - G wants to mimic B, SSC of G binds
  - no distortion at top: $U'(Q^G) = c^G$
  - distortion for B $U'(Q^B) > c^B$ to make contract less attractive for G
  - information rent for G

    distortion for B lowers information rent
- optimal contract under asymmetric info
  - $Q^G = Q^{G^*}$, $Q^B < Q^{B^*}$
  - G obtains an information rent
  - government distorts B contract to lower information rent