# Introduction to Law and Economics: Game Theory and Applications to Law

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# Normal Form Games

- One-Shot.
- Examples:

(1) Prisoner's Dilemma

| | C | D |
|---|---|---|
| C | -10, -10 | -30, 0 |
| D | 0, -30 | -20, -20 |

(2) Battle of the Sexes

| | A | B |
|---|---|---|
| A | 4, 2 | 0, 0 |
| B | 0, 0 | 2, 4 |

(3) Matching Pennies

| | H | T |
|---|---|---|
| H | 1, -1 | -1, 1 |
| T | -1, 1 | 1, -1 |

(4) Chicken

| | C | D |
|---|---|---|
| C | 3, 3 | 1, 4 |
| D | 4, 1 | 0, 0 |

# Dominant Strategy

- Dominant strategy: The best strategy to play regardless of others' strategies. (e.g., PD)
- If a game has a dominant strategy for every player, then outcome is easy to predict.
- Rarely in a game any player has a dominant strategy.

# Equilibrium (Nash)

- Nash equilibrium: An action profile from which no player can unilaterally change strategy and gains.
- Pure strategy example: Battle of the Sexes, Chicken.
- Mixed strategy: randomization over available strategies (e.g., in matching pennies).

# Applications: liability rules

- Benchmark case:

  A motorist ($M$) and a pedestrian ($P$). $M$ can potentially hit $P$ and cause an accident. They can exercise care to reduce occurrence of accident. (Care = C; no care = N.)

  Cost of accident: 100.

  Cost of Care: 10.

  Prob. accident: 1/10 if both exercise due care; otherwise 1.

  $$\text{Social optimum calculation:} \begin{cases} (N, N) : -100 \\ (N, C) : -110 \\ (C, N) : -110 \\ (C, C) : -100 * 1/10 - 10 - 10 = -30 \end{cases}$$

  Social Optimum: ($C$, $C$).

# Applications: liability rules

- What has the liability of accident?
  (i) Strict liability: the injurer is liable regardless of care level of any party
  (ii) No liability: Injurer is not liable what so ever.
  (iii) Simple negligence: Injurer is liable if, and only if, he is negligent.
  (iv) Strict liability with the defense of contributory negligence: Injurer is liable if, and only if, the victim is not negligent.
- No liability and strict liability are two polar cases: The former gives no incentive for the motorist to exercise care, which gives too much incentive for the pedestrian. Strict liability is just the opposite.

# Applications: liability rules

No liability

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -10 |
| C | -110, 0 | -20, -10 |

Strict liability

| | N | C |
|---|---|---|
| N | 0, -100 | 0, -110 |
| C | -10, -100 | -10, -20 |

Simple Negligence

| | N | C |
|---|---|---|
| N | 0, -100 | -100, -10 |
| C | -10, -100 | -20, -10 |

Strict lbty w/ cont. negligence

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -10 |
| C | -10, -100 | -10, -20 |

Simple Negligence and Strict Liability w/ Defense of Contributory Negligence are efficient

# Applications: liability rules

- When care costs differ: $C^P = 10,\ C^M = 85$
- Social optimum: $(N,\ N)$.

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -85 |
| C | -110, 0 | -20, -85 |

| | N | C |
|---|---|---|
| N | 0, -100 | 0, -185 |
| C | -10, -100 | -10, -95 |

| | N | C |
|---|---|---|
| N | 0, -100 | -100, -85 |
| C | -10, -100 | -20, -85 |

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -85 |
| C | -10, -100 | -10, -95 |

No Liability and Strict Liability are efficient.

# Applications: liability rules

- When $M$'s care does not affect prob. of accident, suppose probability of accident is $1/10$ if $P$ has due care, and 1 if not.
- Social optimum: $(C, N)$.

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -10 |
| C | -20, 0 | -20, -10 |

| | N | C |
|---|---|---|
| N | 0, -100 | 0, -110 |
| C | -10, -10 | -10, -20 |

| | N | C |
|---|---|---|
| N | 0, -100 | -100, -10 |
| C | -10, -10 | -20, -10 |

| | N | C |
|---|---|---|
| N | -100, 0 | -100, -10 |
| C | -10, -10 | -20, -10 |

No Liability and Contributory Negligence are efficient

# Applications: liability rules

- When $P$'s care does not affect prob. of accident, suppose probability of accident is $1/10$ if $M$ has due care, and 1 if not.
- Social optimum: $(N, C)$.

| | N | C |
|---|---|---|
| N | -100, 0 | -10, -10 |
| C | -110, 0 | -20, -10 |

| | N | C |
|---|---|---|
| N | 0, -100 | 0, -20 |
| C | -10, -100 | -10, -20 |

| | N | C |
|---|---|---|
| N | 0, -100 | -10, -10 |
| C | -10, -100 | -20, -10 |

| | N | C |
|---|---|---|
| N | -100, 0 | -10, -10 |
| C | -10, -100 | -10, -20 |

Strict Liability and Simple Negligence are efficient

# Applications: liability rules

- General case:
  - Let $p_{ij}$ be the probability of accident when the care taken by $P$ and $M$ are $i$ and $j$, respectively. $(i, j = C, N)$
  - $C_i^P$ and $C_j^M$ are cost of taking care $i$ and $j$, respectively.
  - Total social loss: $\Sigma_{i,j} 100 p_{ij} + C_i^P + C_j^M$.
  - What is the social optimum depends on the values of $p_{ij}$ and $C_i^P$, $C_j^M$.

# Applications: liability rules

- As can be seen from examples, any rule can be optimal under certain values of cost and accident probability.
- Is there a principle behind this ?
- Examples point to the intuition that
  - (i) Party which has more influence on outcome should be more liable; however,
  - (ii) This has to take the cost of care into consideration.

# Applications: liability rules

- Also can draw the game matrix for each liability regime. For examples, strict liability:

| | N | C |
|---|---|---|
| N | $-C_N^P, -C_N^M - 100P_{NN}$ | $-C_N^P, -C_C^M - 100P_{NC}$ |
| C | $-C_C^P, -C_N^M - 100P_{CN}$ | $-C_C^P, -C_C^M - 100P_{CC}$ |

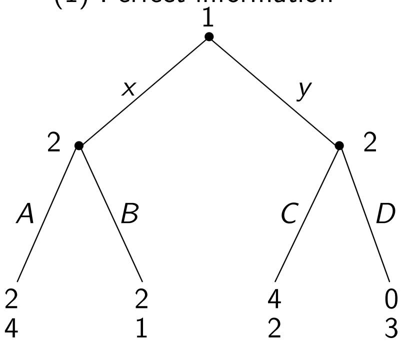
# Applications: liability rules

- General Lesson:
  (i) Depending on environments (viz, values of $p_{ij}$ and $C^M$, $C^P$), different legal rules are needed in order to attain social optimum.
  (ii) The greater one's care can reduce probability of accident, or the lower one's cost of exercising care, the more he should be liable.

# Extensive Form Games

- Dynamic in nature.
- Information matters.
- Examples:

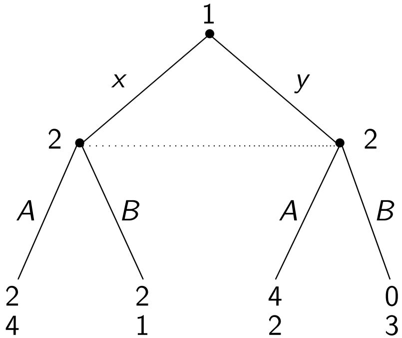
(1) Perfect information




(3)

# Extensive Form Games

(2) Imperfect information




(3)

# Equilibrium: Subgame perfect equilibrium (SPE)

- Key: Backward induction.
- Example I: SPE$\big(x,\ (A,\ D)\big)$.
- Example II: SPE$\big((\frac{1}{4}x,\ \frac{3}{4}y),\ (\frac{1}{2}A,\ \frac{1}{2}B)\big)$.

# Application: Litigation

- Two types of litigation model: divergent expectation model and private information model.
- Divergent expectation (DE) model: The reason why parties do not settle out-of-court is because they have different perceptions of winning chance.
- Private information (PI) model: Because they have different information.
- Under the DE model, at least one party's expectation is wrong. In the PI model, information of both party is correct, only that some has information that the other does not have.

# Application: Litigation

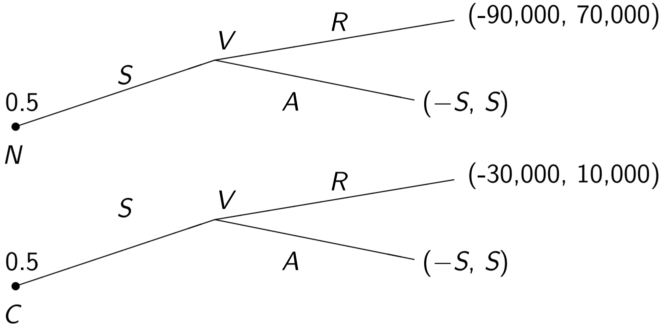
- Example: An accident occurs which costs the victim ($V$) 100,000. Litigation cost for both victim and injurer ($I$) are 10,000.
- Suppose probability that injurer will be found liable is $p$.
- If litigated, $V$ expects to receive $100,000p - 10,000$, while $I$ expects to lose $100,000p + 10,000$. For any $p$, there is a range for settlement. But why sometimes no settlement in reality?
- DE model explanation: $p_I \neq p$ or/and $p_v \neq p$, and $p_v > p_I$.
- If $100,000p_v - 10,000 > 100,000p_I + 10,000$ (i.e., $p_v - p_I > 1/5$), then there exists no settlement range.

# Application: Litigation

- Private information model: One party might know more about the value of $p$ than the other.
- Suppose $I$ is of two types: negligent or careful. The former is expected to prevail with prob 0.2, and the latter 0.8.
- Only $I$ knows his own type.
- $V$ believes that $I$ is equally likely to be either.

# Application: Litigation

- Game form I: Suppose $I$ makes a take-it-or-leave-it offer $S$. If $S$ is rejected, then go to court.




$V$ thus expects to receive 70,000*0.5+10,000*0.5=40,000 in litigation.

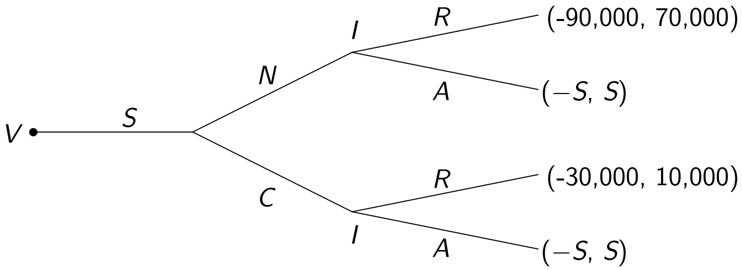
# Application: Litigation

- Separating equilibrium
  - $N$-type offers 70,000.
  - $C$-type offers 0.
  - $V$ accepts iff $S \geq 70,000$
- Pooling equilibrium:

  $V$'s expects payoff is 40,000, and will accept $S$ if and only if $S \geq 40,000$. But $C$-type is only willing to offer 30,000. There is thus no offer that is accepted for sure.

# Application: Litigation

- Game form II: $V$ makes take-it-or-leave-it offer $S$. If $S$ is rejected, then go to court.



# Application: Litigation

- SPE:
  - $N$-type: accept $S$ iff $S \leq 90,000$.
  - $C$-type: accept $S$ iff $S \leq 30,000$.
  - $S^* = 90,000$.
- Expected payoff:
  - $N$-type: -90,000.
  - $C$-type: -30,000.
  - $V = 50,000$.
- In both models, $N$-type settles and $C$-type litigates.
- There is a $1/2$ chance of going to court.

# Application: Litigation

- What if British rule is used?
- $I$'s payoff is -120,000 if wins, and 0 if lose.
- $V$'s payoff is 100,000 if wins, and -20,000 if lose.
- What if $V$ or $I$ are risk-averse? More favorable to proposer.