

- First in-class exam on Monday, Oct 17
- Exam covers Chapters 7 and 9
- No notes, paper, or calculators allowed
- Cannot leave room during exam
- Please do not turn in before 2:30
- Discussion sections do not meet Monday and Wednesday next week

## Chapter 10: Games and Strategic Behavior

### A. Prisoner's dilemma

**Prisoner's dilemma:** A game in which each player has a dominant strategy, and when each plays it, the resulting payoffs are smaller than if each had played a dominated strategy

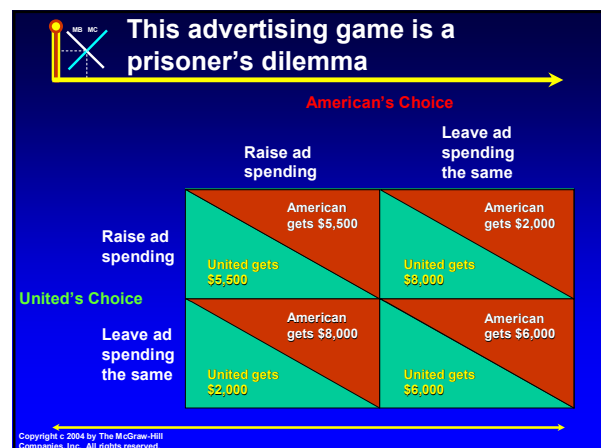
**Nash equilibrium:** a set of strategies such that if any one player  $i$  assumes that all the other players follow those specified, then player  $i$  would want to follow the specified strategy as well.

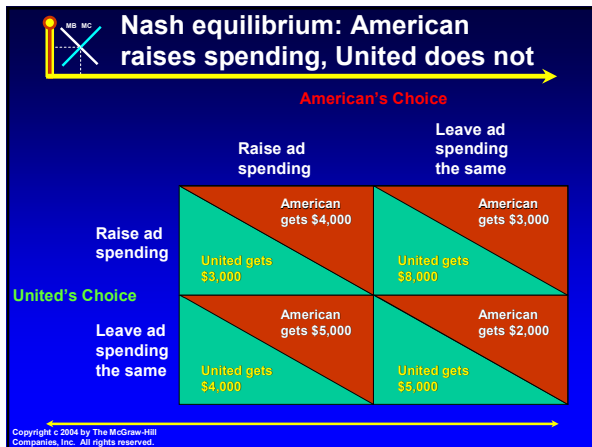
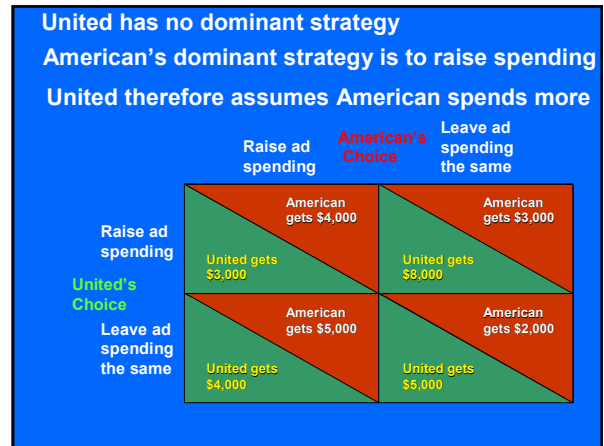
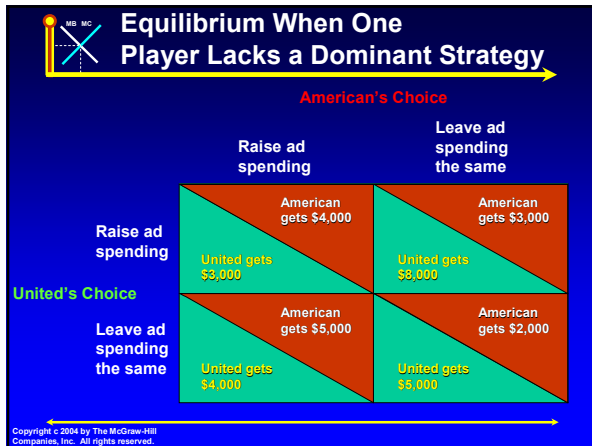
- Why is Jasper confesses, Horace does not not a Nash equilibrium?
- Because if Horace assumes that Jasper confesses, Horace would want to confess too

## Chapter 10: Games and Strategic Behavior

### A. Prisoner's dilemma

### B. Application: strategic interaction in advertising





Chapter 10

- A. Prisoner's dilemma
- B. Application: strategic interaction in advertising
- C. Application: stability of a two-player cartel

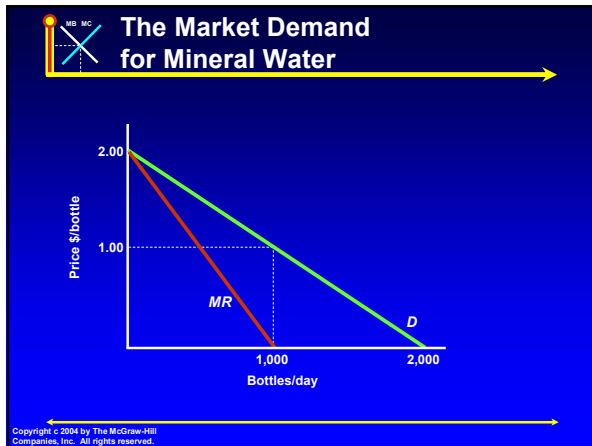
We earlier looked at instability of a cartel when one member can "cheat" by increasing production without the other participants knowing.

If instead the cheater knows that the others will find out and respond, how might that change the incentives?

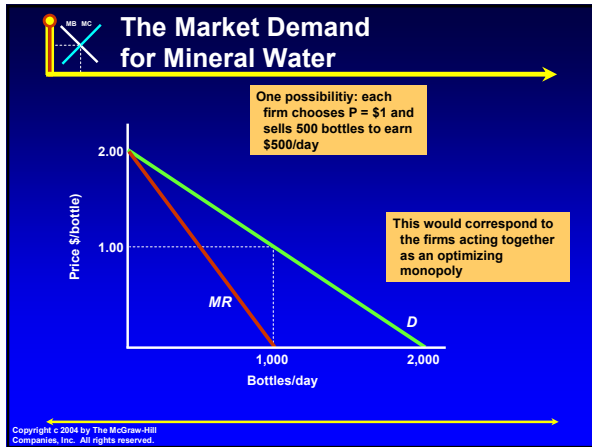
Example:

A duopoly of two firms (Aquapure and Mountain Spring) have exclusive rights to bottle water from a spring.

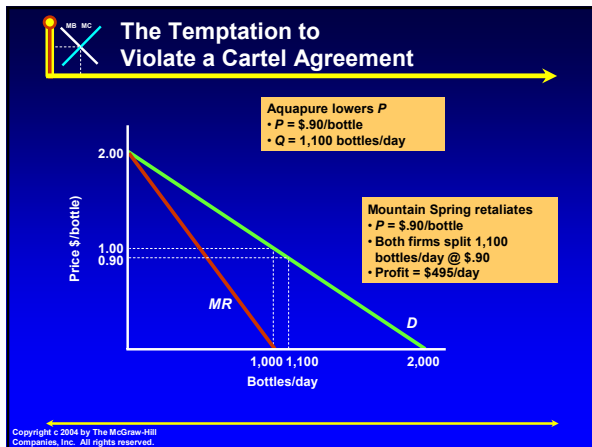
Marginal cost = zero



Players: two firms  
 Strategies: a price each charges (any number between 0 and \$2)  
 Payoffs: price firm charges times number of bottles it would sell at that price



Is this a Nash equilibrium?  
 Suppose that Mountain Spring charges \$1 but Aquapure charges \$0.90.  
 Then Aquapure would sell 1,100 bottles at profit of \$990 > \$500.



Nash equilibrium: price falls to marginal cost (in this case, zero)  
 Have perfect competition even with only two firms

## Chapter 10

- A. Prisoner's dilemma
- B. Application: strategic interaction in advertising
- C. Application: stability of a two-member cartel
- D. Game theory in more complicated settings

Possible extensions:

- What if I don't know for sure the other player's payoffs?
- What if I'm not sure that the other player is rational?
- What if we're going to play the game many times over into the future (called a repeated game)?

Definition:

an *algorithm* is a formal algebraic or computational procedure for choosing strategies

Open competitions between algorithms in 50 repeats of prisoner's dilemma with same opponent/partner



And the winner is ...

tit for tat

Round 1: cooperate  
Round t: do what other  
player did in t - 1



## Chapter 10

- A. Prisoner's dilemma
- B. Application: strategic interaction in advertising
- C. Application: stability of a two-member cartel
- D. Game theory in more complicated settings
- E. Games in which timing matters  
Example: Ultimatum bargaining game

## Ultimatum bargaining game

- Experimenter gives \$10 to Tom
- Tom proposes how to divide \$10 with Michael
- Tom must give Michael at least \$1 ( $X = \text{Tom}$  and  $10 - X = \text{Michael}$ )
- If Michael accepts the proposal, Tom and Michael get the money
- If Michael does not accept the proposal, the money goes to the experimenter

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## Decision Tree for Tom

Possible Moves and Payoffs

```

graph LR
    A[ ] --- B[ ]
    B --- C[Michael accepts]
    B --- D[Michael refuses]
    C --- E["$X for Tom  
$(10 - X) for Michael"]
    D --- F["$0 for Tom  
$0 for Michael"]
  
```

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## Tom's Best Strategy in an Ultimatum Bargaining Game

```

graph LR
    A[ ] --- B[ ]
    B --- C[Michael accepts]
    B --- D[Michael refuses]
    C --- E["$9 for Tom  
$1 for Michael"]
    D --- F["$0 for Tom  
$0 for Michael"]
  
```

• Tom can give Michael a take-it-or-leave-it offer  
 • Tom will propose \$1  
 • Michael will accept  
 • The outcome is a Nash Equilibrium

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## Credible Threat

- ◆ A threat to take an action that is in the threatener's interest to carry out
- ◆ Can Michael threaten Tom that he would refuse  $x = 1$ ?

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## The Ultimatum Bargaining Game with an Acceptance Threshold

New Rule: Michael can *commit in advance* to the minimum offer he will accept

```

graph LR
    A[ ] --- B[ ]
    B --- C["Tom proposes  
$X ≤ $(10 - Y) for himself  
$(10 - X) > Y for Michael"]
    B --- D["Tom proposes  
$X > $(10 - Y) for himself  
$(10 - X) < Y for Michael"]
    C --- E["$X for Tom  
$(10 - X) for Michael"]
    D --- F["$0 for Tom  
$0 for Michael"]
  
```

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Nash equilibrium for this modification of the game:  $Y = \$9$

That is, Tom gets \$1, Michael gets \$9

Tom reasons, if I specify  $X > (10 - Y)$ , then I get nothing

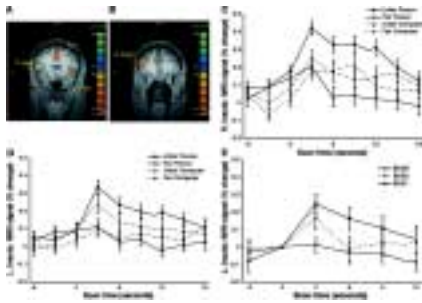
Results from experiments with real people playing original ultimatum bargaining game:

Few people actually choose the Nash equilibrium  $X = \$9$   
If someone does play  $X = \$9$ , usually the other person refuses  
Most common selection:  $X = \$5$

Sanfey, et. al., "The Neural Basis of Economic Decision-Making in the Ultimatum Game", *Science* 2003, 3000, pp. 1755-1758.

Asked subjects to play ultimatum game for \$10 while inside MRI scan.  
Recorded differences in neural activity in response to offer of less than \$2 versus greater than \$2.

Bilateral anterior insula activated in negative emotional states (pain, distress, hunger, thirst)



Study also found:

- People with stronger anterior insula activation were more likely to reject the "unfair" offers ( $\leq \$2$ ).
- People were less likely to reject "unfair" offers if they came from a computer.

Conclusion:

People don't always behave rationally just to get the most money.

Perhaps notions of fairness and moral principles help provide a commitment mechanism that would otherwise be lacking

On the other hand ...

would you refuse Tom's offer if he gets \$9 million and you get \$1 million?

If not, perhaps rational game theory is the right way to understand multimillion dollar business decisions after all