Competitive strategies in commodity oligopolies

L 05: Introduction to game theory

Prof. Dr. Ulrich Pidun

Some definitions (I)

Game: Situation in which players make strategic decisions that take into account each other's actions and responses

Players: All the relevant participants in the game. Games usually have at least two players. If there is any randomness in the game, it is represented by an extra player ("Nature")

Payoff: Numbers that represent the net value to players of obtaining a particular outcome. Players are trying to maximize their payoffs. If the players are trying to maximize something other than profit, for example, the payoffs must be adjusted accordingly

Strategy: Rule or plan of action for playing the game. A single strategy represents a complete set of contingent instructions for what actions to take under what circumstances

Optimal strategy: Strategy that maximizes a player's expected payoff (assumption: rational players)

Some definitions (II)

Cooperative game: Game in which participants can negotiate binding contracts that allow them to plan joint strategies

Noncooperative game: Game in which negotiation and enforcement of binding contracts are not possible

Constant sum game: Game in which the sum of the payoffs of the players is independent of the outcome of the game

Nonconstant sum game: Game in which the sum of the payoffs of the players will depend on the outcome of the game

Strategic decision making in game theory

It is essential to understand your opponent's point of view
and to deduce his or her likely responses to your actions

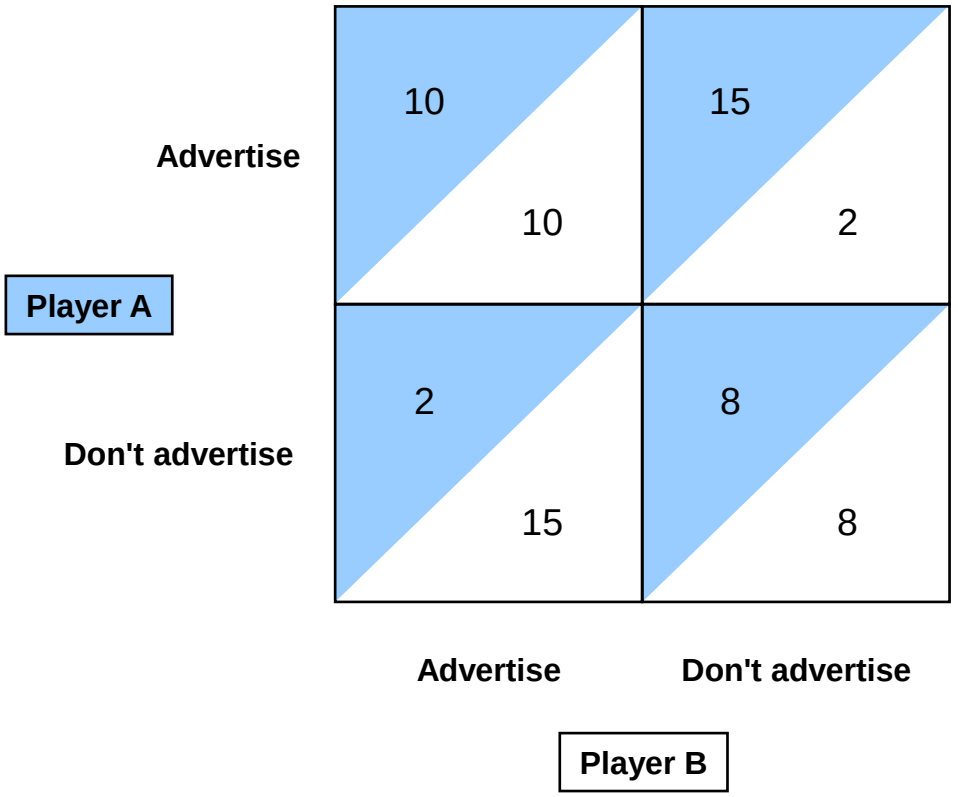
Example: The Euro Game

A Euro coin is auctioned, but in an unusual way. The highest bidder receives the Euro coin in return for the amount bid. However, the second-highest bidder must also hand over the amount that he or she bid – and get nothing in return.

If you were playing the game, how much would you bid for the Euro coin?

Games with dominant strategies (I)

Simple Advertising Game



Payoff matrix is the **strategic form of the game**

What will be the outcome of this game?

Dominant strategy:

Strategy that is optimal no matter what the other players do

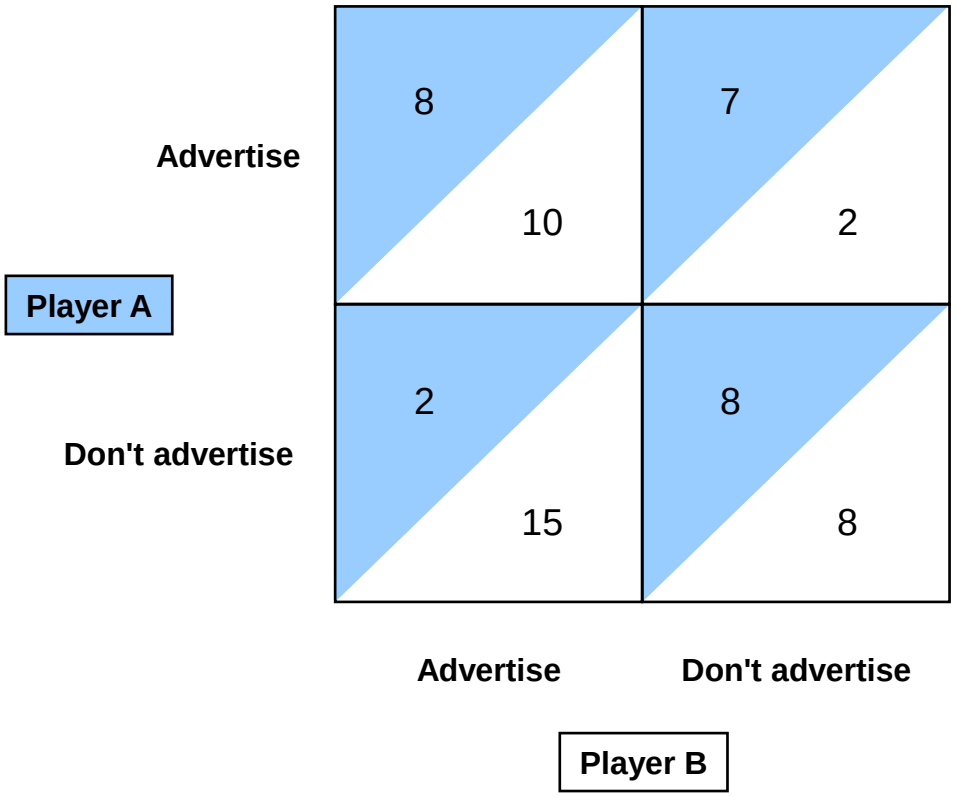
Equilibrium in dominant strategies:

Outcome of a game in which each player follows its dominant strategy

However, not every game has a dominant strategy for each player

Games with dominant strategies (II)

Modified Advertising Game



Advertising is more costly for Player A

Player A no longer has a dominant strategy

But Player B still has a dominant strategy

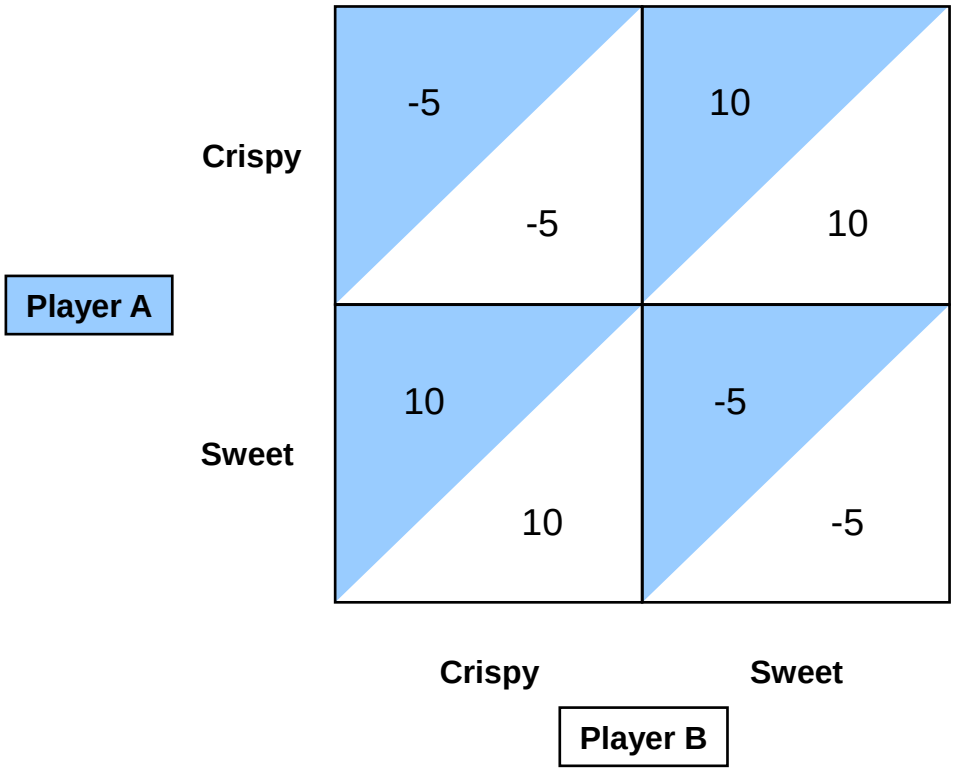
What will be the outcome of the game?

No equilibrium in dominant strategies!

How can we find the outcome of a game if there are no dominant strategies?

Coordination games (I)

Product Choice Problem



Both players want to introduce a new breakfast cereal and can choose between a crispy or sweet product

No player has a dominant strategy

What will be the outcome of the game?

Nash equilibrium:

Each player is doing the best it can given the actions of the other players

The strategies are stable because no player has an incentive to change its strategy

The challenge of coordination: Schelling Point

Imagine the following coordination game: Two players are presented a group of numbers and must independently choose one of these numbers. If it is the same number, they will receive 100 €, if the numbers are different, they will lose.

Which numbers would you choose from the following group:

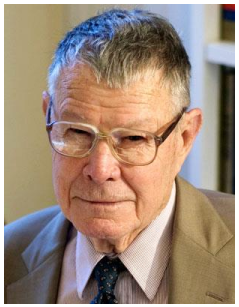
- -10, 1, 2, 3, 4, 5

And which date would you choose from the following group:

- Mo, 9 June; Tu, 10 June; We, 11 June; Th, 12 June; Fr, 13 June

And which number would you choose from the following group:

- 13, 99, 100, 222, 273

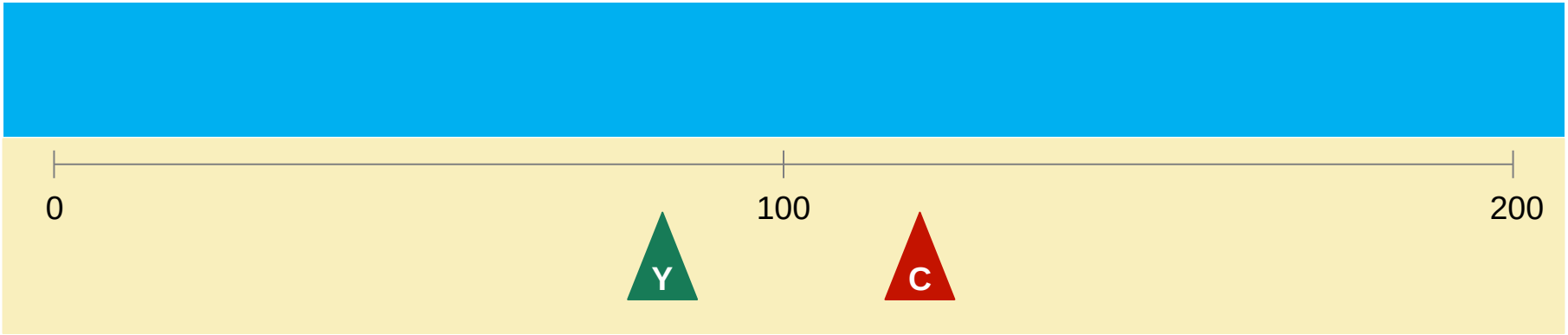


Thomas C. Schelling (1921-2016)

A **Schelling point** (or focal point) is a solution that people will tend to use in the absence of communication, because it seems natural, special or relevant to them

Coordination games (II)

Beach Location Game

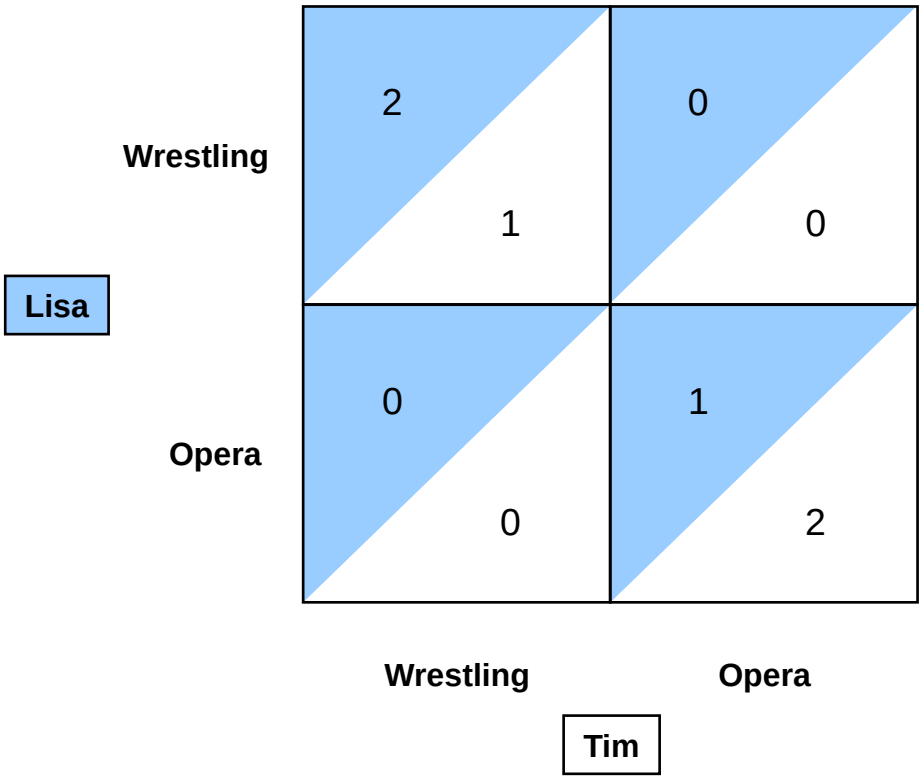


You (Y) and your competitor (C) plan to sell soft drinks on a beach. The beach is 200 m long and guests are spread evenly across its length. You and your competitor sell drinks at the same prices, so customers will walk to the closest vendor.

Where on the beach will you locate, and where do you think your competitor will locate?

Coordination games (III)

Battle of the Sexes



Lisa and Tim reflect on how to spend Saturday night: opera or wrestling?

What will be the outcome of the game?

Which of the two Nash equilibria will be reached?

Solution: First mover advantage (cf. Stackelberg model), commitment

Coordination games (IV)

Hawk Dove Game

Player A \ Player B	Dove	Hawk
Dove	1 / 1	0 / 2
Hawk	2 / 0	-10 / -10

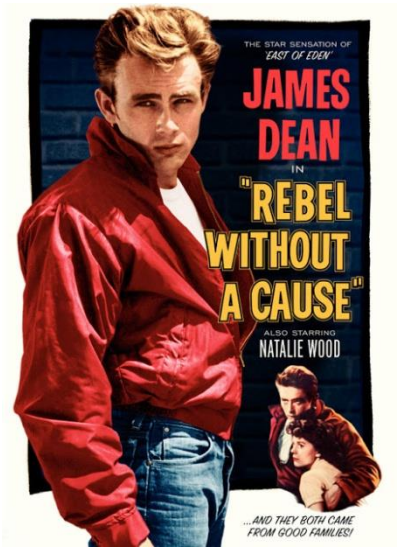
What will be the outcome of the game?

What is the difference to "Battle of the Sexes"?

Maximin strategy:

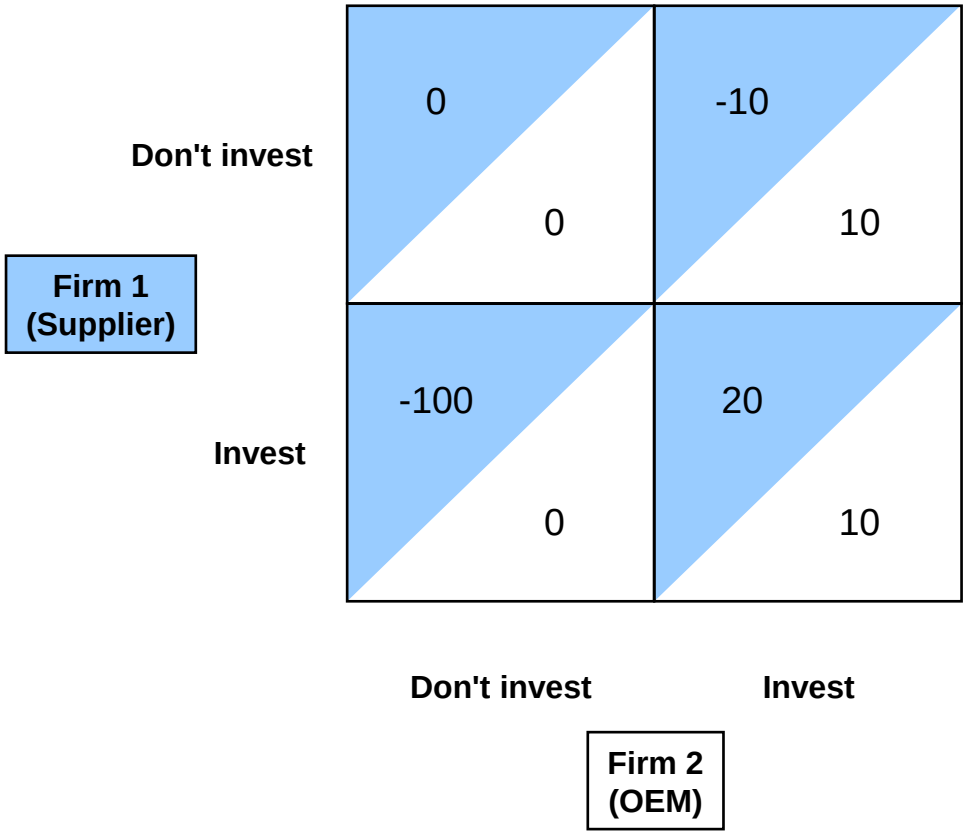
Strategy that maximizes the minimum gain that can be earned

The game is also known as the "Chicken Game"



Maximin strategy

Maximin strategy example



What will be the outcome of the game?

Both firms investing is the only Nash equilibrium of the game

However, if Firm 2 should happen to make a mistake (or not behave in a rational way), it would be extremely costly for Firm 1

A maximin strategy (don't invest) reduces this risk, but also lowers the expected payoff

In general, a maximin strategy is conservative, but not profit-maximizing

Equilibrium concepts

Dominant strategies

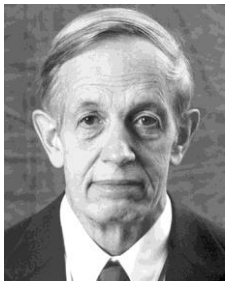
- I'm doing the best I can *no matter what you do*
- You're doing the best you can *no matter what I do*

Nash equilibrium

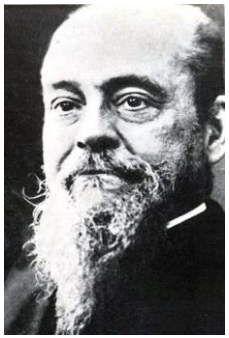
- I'm doing the best I can *given what you are doing*
- You're doing the best you can *given what I am doing*

Pareto efficiency

- I cannot do better *without making you worse off*
- You cannot do better *without making me worse off*



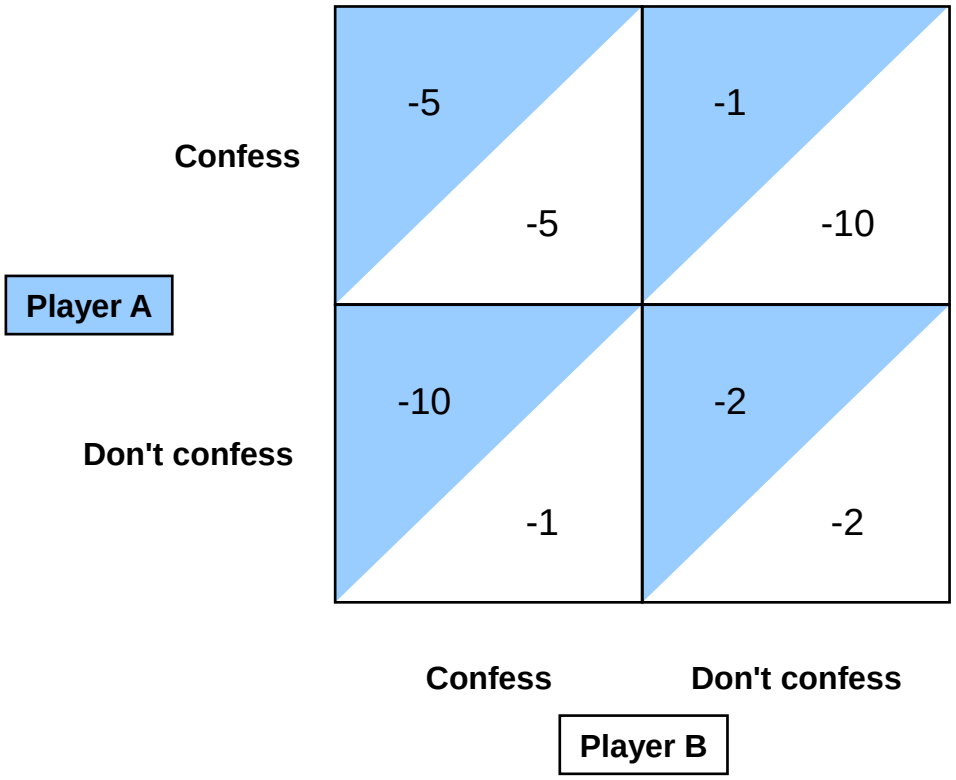
John F. Nash
(1928-2015)



Vilfredo F. Pareto
(1848-1923)

Coordination games (V)

The Prisoner's Dilemma



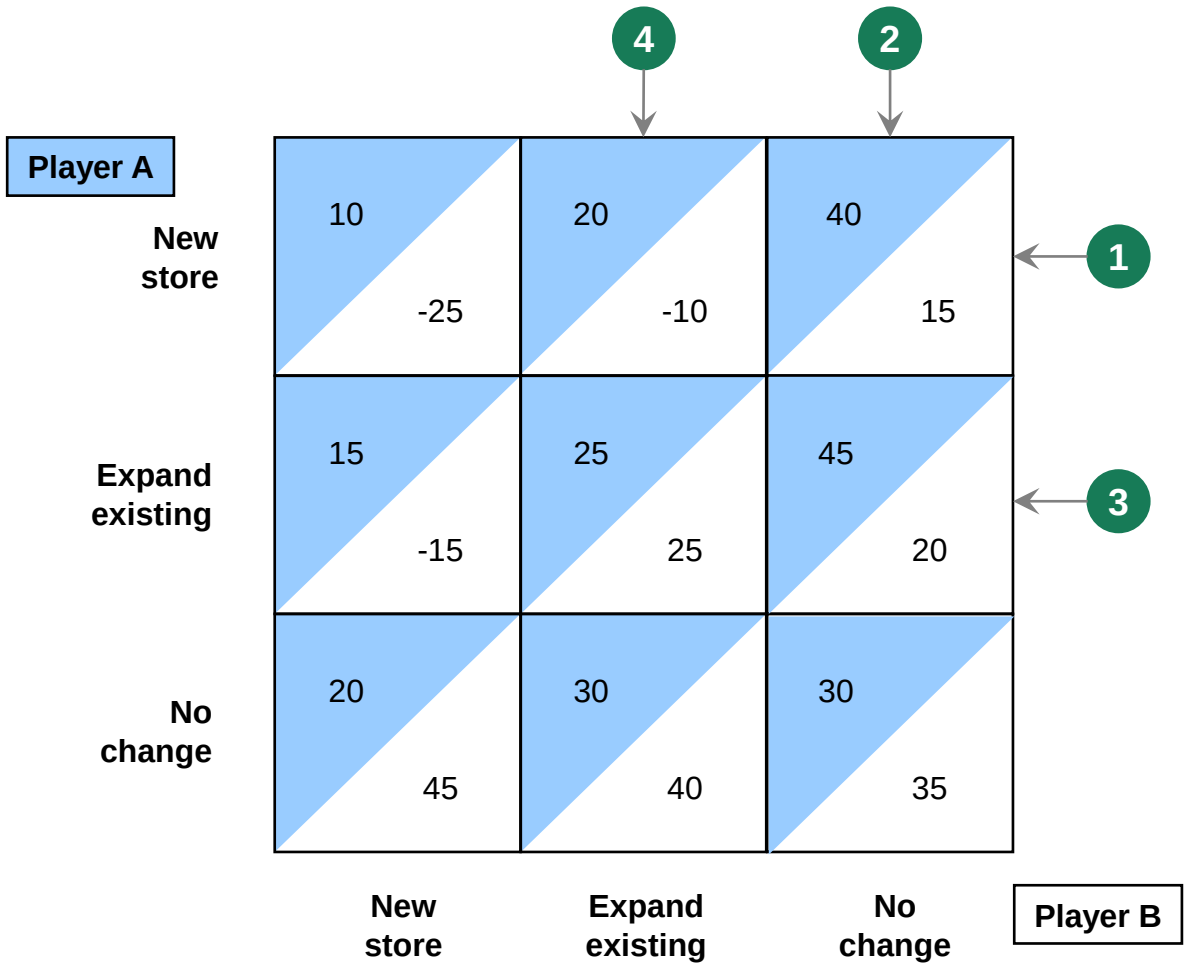
What will be the outcome of the game?

The solution is

- Equilibrium in dominant strategies
- Nash equilibrium
- But not Pareto efficient!

Solving a game by eliminating dominated strategies

Dominated strategy example



What will be the outcome of the game?

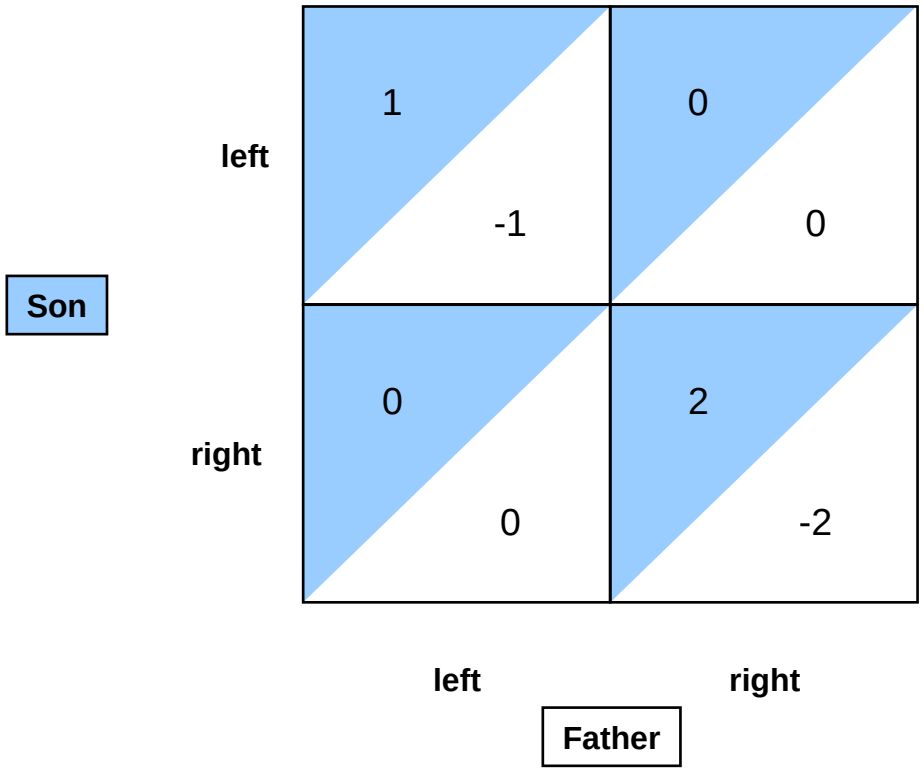
Solution: Iterative elimination of dominated strategies will lead to a Nash equilibrium

Caution: Not every Nash equilibrium can be found by this iterative technique

Caution: If weakly dominated strategies (which have in some situations the same payoff as the alternative) are eliminated, the sequence of elimination can play a role

Discoordination games (I)

Montmort Game



Story: A father makes a tricky present to his son. He hides a gold coin in one of his hands. If the son guesses where the coin is and it's the left hand, he gets the coin. If it's the right hand, he receives two gold coins. If he guesses wrong, he loses.

The game has no solution in pure strategies.

Mixed strategy:

Strategy in which players make random choices among two or more possible actions, based on sets of chosen probabilities

Mixed strategies: Solution to the Montmort Game

Probabilities:

- p = probability that father chooses *right*
- w = probability that son chooses *right*

Expected payoffs:

- Expected payoff for the father: $P_f = -2\ p\ w - (1 - p)\ (1 - w)$
- Expected payoff for the son: $P_s = 2\ p\ w + (1 - p)\ (1 - w)$

Optimal choice for the father:

- $\partial P_f / \partial p = 0$
- $-2\ w - w + 1 = 0 \quad \rightarrow \quad w = 1/3$

$$P_f = -2/3\ p + 2/3\ p - 2/3 = -\ 2/3$$

Optimal choice for the son:

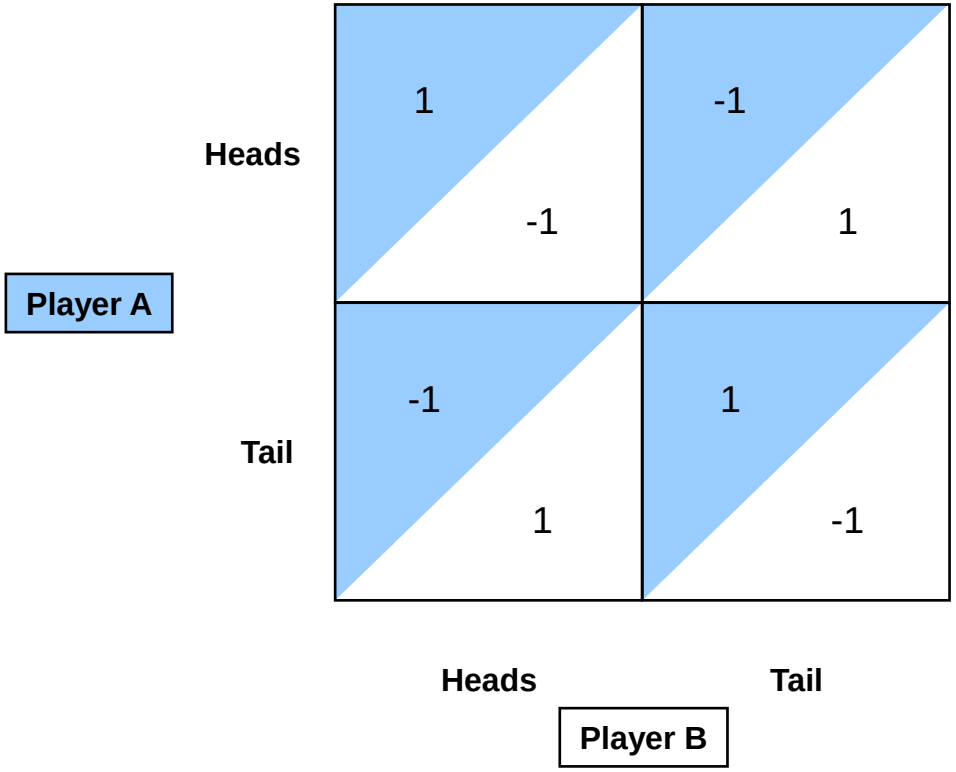
- $\partial P_s / \partial w = 0$
- $2\ p + p - 1 = 0 \quad \rightarrow \quad p = 1/3$

$$P_s = 2/3\ w - 2/3\ w + 2/3 = +\ 2/3$$

Intuitive interpretation: The father chooses the left hand with a higher probability because it is less costly for him. Consistently, the son also predicts the left hand with a higher probability.

Discoordination games (II)

Matching Pennies



This game also has no solution in pure strategies.

Nash equilibrium in mixed strategies: Both players flip the coin, thereby playing heads with probability ½ and playing tails with probability ½ .

The proof is analogous to the proof for the Montmort Game.

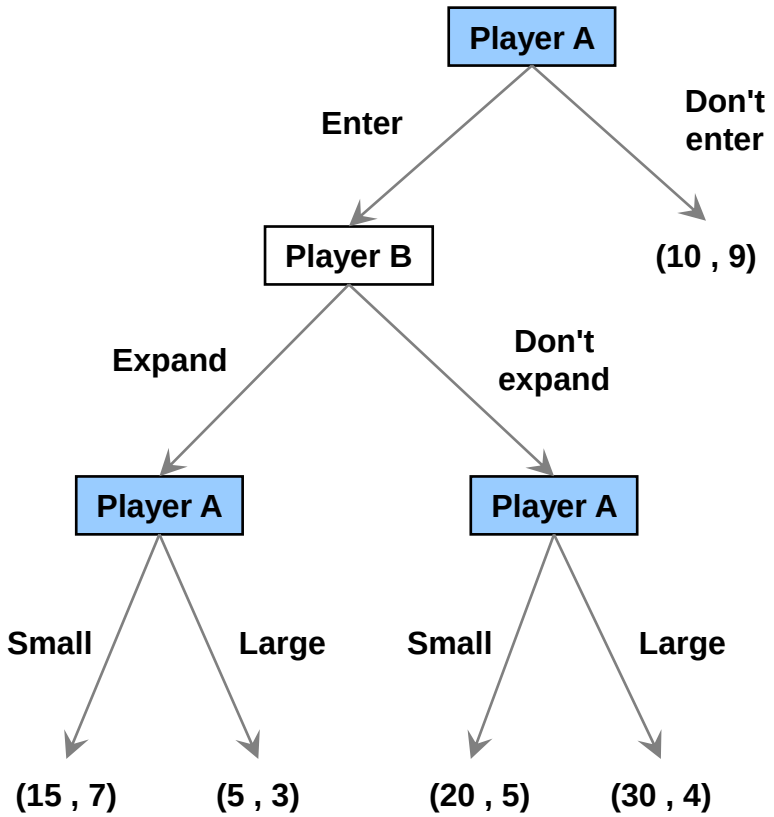
Similar game: Rock-Paper-Scissors

Rule:

Once we allow for mixed strategies, every game with a finite number of players and a finite number of actions has at least one Nash equilibrium.

Sequential games and the extensive form

Sequential game example



Extensive form of a game:

Sequential games can be easier visualized in the form of a decision tree. This is called the extensive form of a game.

What will be the outcome of the game?

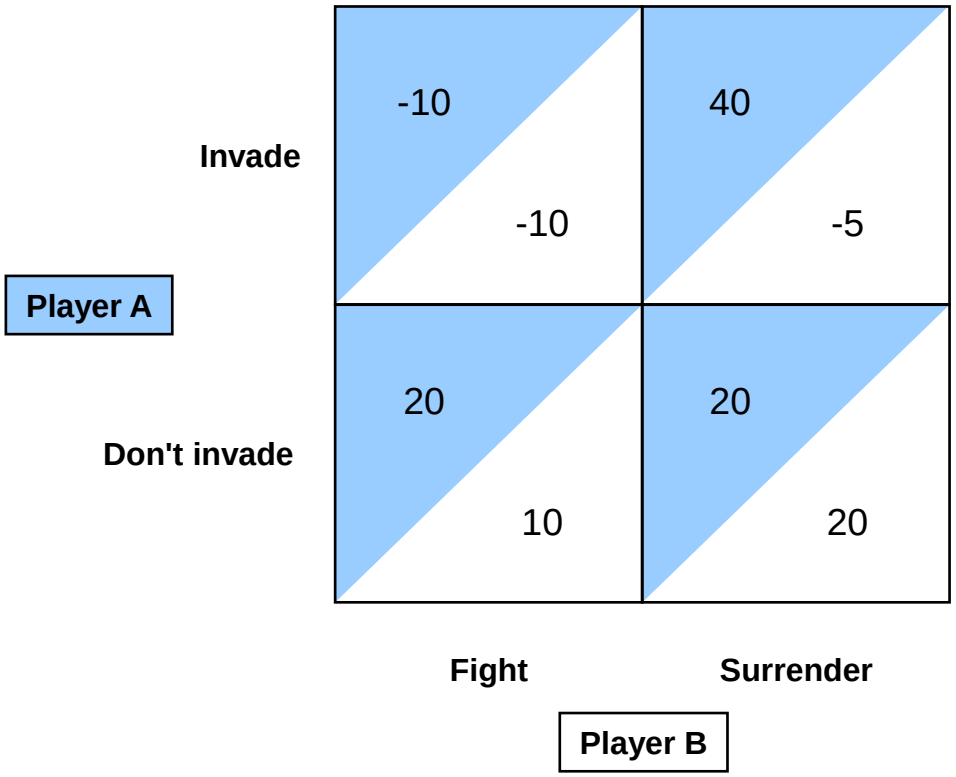
Backwards induction:

Sequential games can be solved by backwards induction. By working backward from the end, the preferred decision for each step is identified and the best sequence of moves can be uncovered.

How can Player A obtain a better outcome?

Threats, commitments and credibility

Deterrence Game



What will be the outcome of the game?

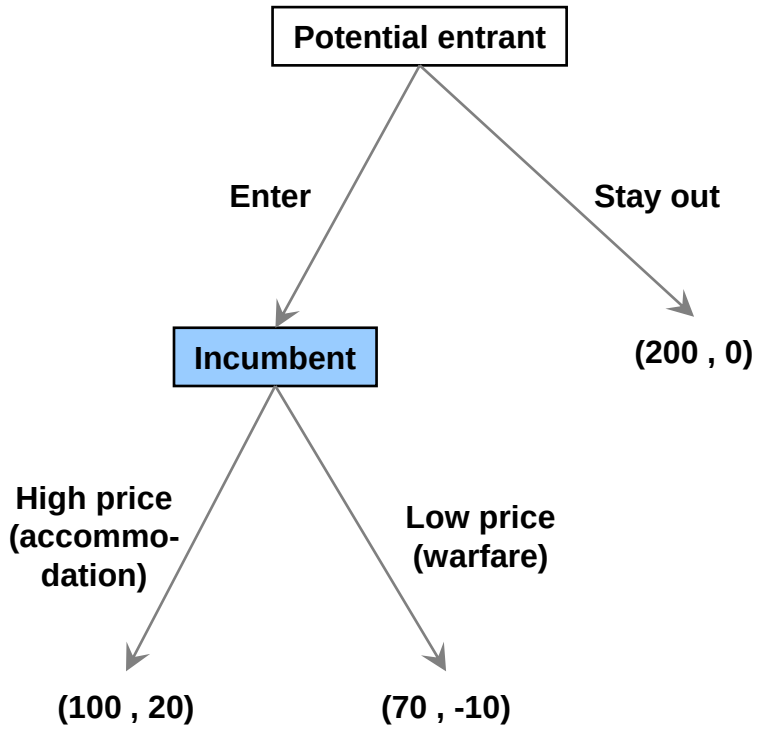
But: If Player B commits to fight, Player A will not invade

Cheap talk is a message that a player can send that does not have commitment value. Cheap talk can be used as a coordinating tool when both players' incentives are compatible.

Threats and commitments are only useful if they are credible. To this extent they must be costly and effectively constrain your own behavior.

Entry deterrence (I)

Market Entry Game (I)



Note: Payoffs (Incumbent, Potential entrant)

What will be the outcome of the game?

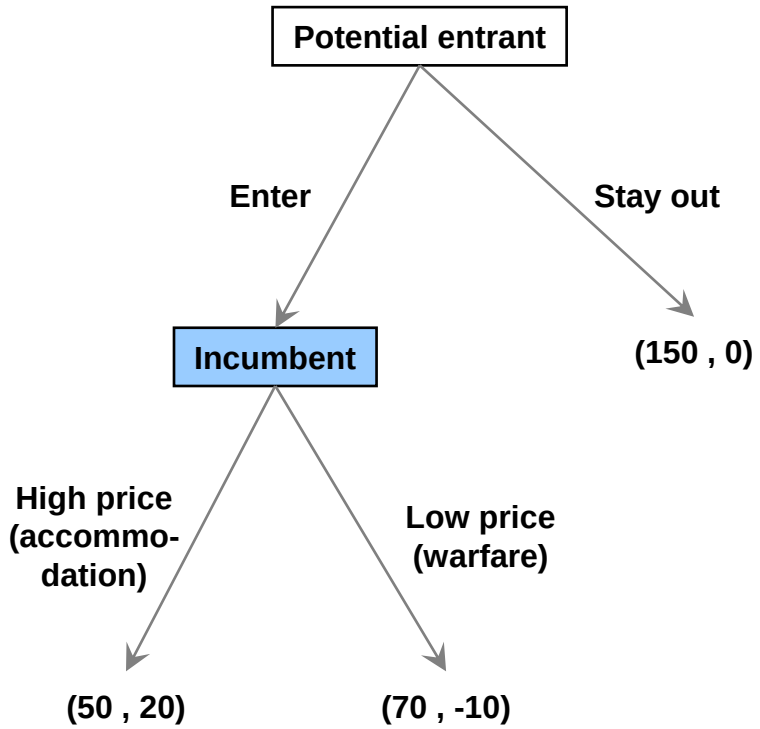
To keep the potential entrant out, the incumbent can threaten to start a price war if the new firm enters.

The threat, however, is not credible: Once entry has occurred, it will be in the incumbent's best interest to accommodate and maintain a high price.

How can the incumbent make its threat credible?

Entry deterrence (II)

Market Entry Game (II)



Note: Payoffs (Incumbent, Potential entrant)

If the incumbent invests upfront into an expansion of its production capacity (-50), the threat to engage in competitive warfare is completely credible (the payoffs in the decision tree have changed).

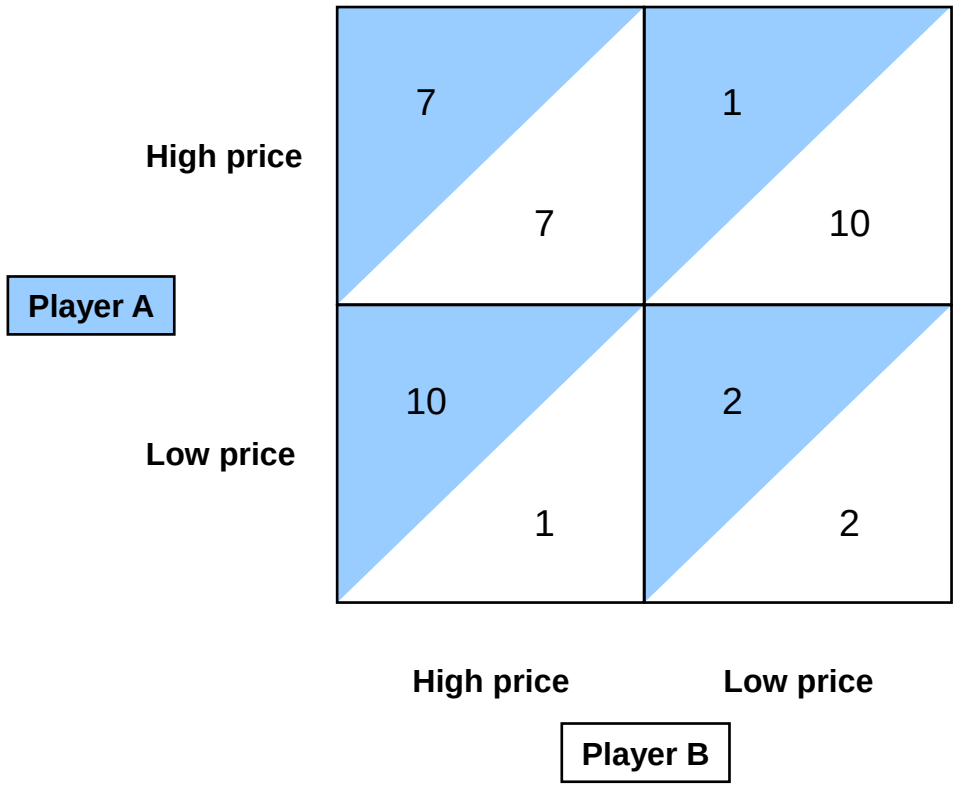
Because the potential competitor now knows that entry will result in a price war, it is rational for it to stay out.

However, the threat comes at a cost and reduces the payoff for the incumbent if the potential competitor stays out.

In a repeated game, building a reputation has an additional effect (next lecture).

Price competition in a duopoly

Pricing Game

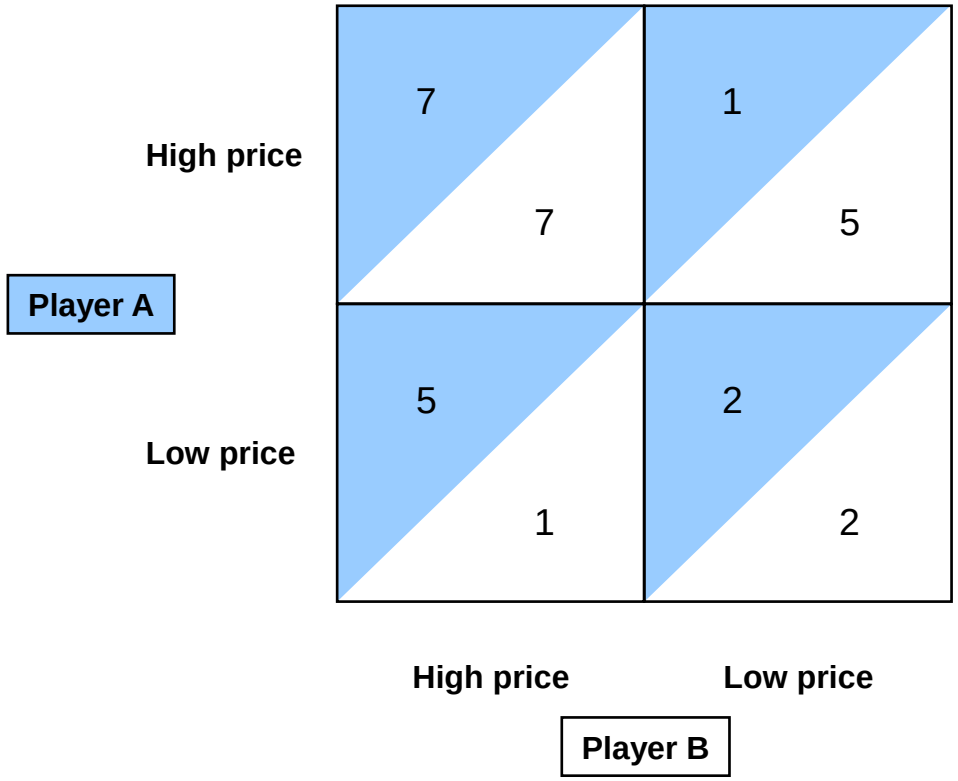


What will be the outcome of the game?

How can the Prisoner's Dilemma be overcome?

Most favored customer clause

Pricing Game with MFC



Most favored customer clause:

Guarantee to offer each customer the best price that is offered to the most favored customer

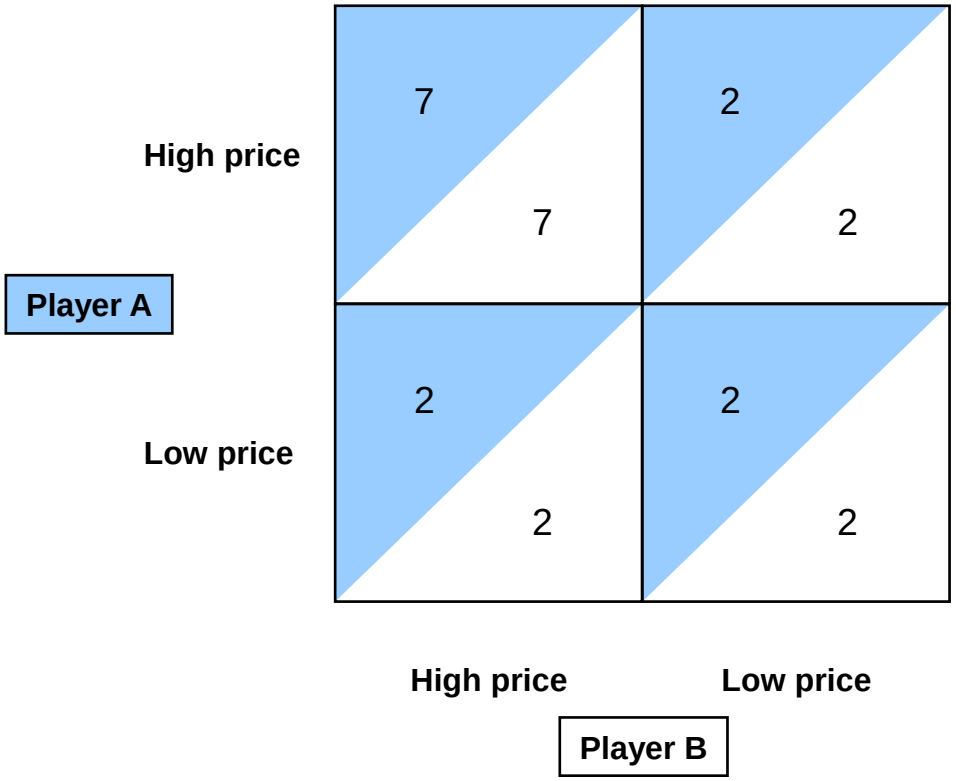
Effect on the Pricing Game: No incentive to deviate from a high-price strategy (Nash equilibrium)

Added benefits:

- Strengthens the bargaining position with strong-negotiating customers
- Makes weak-negotiating customers happy without changing the contracts with strong-negotiating customers

Meet the competition clause

Pricing Game with MTC



Meet the competition clause:

Guarantee to offer the lowest price that a customer can get from a competitor

Effect on the Pricing Game: No incentive to deviate from a high-price strategy (Nash equilibrium)

Added benefits:

- Customers report on rival's prices
- Allows price discrimination: customers who search for lowest prices are charged less than other customers

Conclusion: Uses and limits of game theory

Uses of game theory

- Think rigorously and systematically
- Analyze how the rules affect the game
- See things from your rival's point of view
- Understand strategic interactions
- Identify critical assumptions and strategies

Limitations of game theory

- Not (necessarily) a predictive tool
- Outcomes are very sensitive to assumptions
- Not intended to be "realistic"