Strategic Behaviour

Reading – Ch. 3, 5 & Ch. 15 NW

Outline

- Describe what is meant by strategic interaction
- Game Theory definitions
- Simultaneous Games
    - Draw the normal form of a game
    - Define and solve for a Nash Equilibrium
    - Describe how repetition can help players cooperate
- Sequential Games
    - Draw an extensive game
    - Define subgame perfect equilibrium – *credible equilibrium*
    - Show how commitment can increase a player's payoff
    - Define first and second mover advantage

Oligopoly

- We have discussed specific types of industries:
  - Perfect competition
  - Monopoly
  - Monopolistic competition3
- Each are defined by:
  - Number of competitors
  - Ease of entry or exit – barriers to entry
  - Whether product is homogeneous or heterogeneous

Oligopoly

- An oligopoly is an industry:
  - Where a small number of firms compete
  - Firms may produce identical or differentiated products
  - Firms have some market power
  - There are barriers to entry
    - Scale economies
    - Entry or exit costs
    - Patents
    - Strong brands

Oligopoly

- Examples:
  - Coke versus Pepsi
  - Apple versus Dell
  - Coles versus Woolworths
  - iPhone versus Samsung galaxy ..

Strategic interaction

- Because there are only a small number of firms, firms recognise that:
  - actions of rival firms can have large impact on profits,
  - firm's own actions can influence the profits and actions of rivals,
  - quantity sold by each firm depends on the prices and quantities chosen by rivals,
  - firms have an incentive to act strategically to influence the actions of competitors.
- **Game theory** is a tool used to analyse the strategic interaction of agents (firms or people)

Game theory

- Components of a game:
  - **<u>Players:</u>** How many? Does nature/chance play a role?
  - **<u>Action:</u>** available choices/decisions
  - **<u>Strategies:</u>** a strategy is a contingent plan of action
    - E.g. If my competitor charges $100, I will charge $95
  - **<u>Rules:</u>** describe how the game works – e.g. sequential or simultaneous decisions, can players communicate or not, one-shot or repeated interaction?
  - **<u>Information:</u>** what do players know when making decisions
  - **<u>Payoffs:</u>** consequences to players for each possible outcome, e.g. profits

Prisoners' dilemma

– Imagine that two suspects of anti-competitive behaviour, Alf and Bob, have been captured by the police
– Without a confession, the police have insufficient evidence to convict Alf and Bob
– The police have a plan…

Prisoners' dilemma

– Suspects are put in separate rooms and cannot communicate with each other
– Suspects are then questioned by the police
– If only one of the suspects confesses, he can go free. The partner will then be convicted and face a heavy sentence for uncooperative behaviour
– If both prisoners confess, they will be convicted and face a moderate sentence
– If neither confesses, they only face minor charges

Prisoners’ dilemma

– Each player has two possible *actions*: confess or deny
– *Strategies* (contingent plans of action) are the same because suspects play simultaneously and cannot condition their action on what the other one does: confess or deny
– Possible *outcomes*:
  - both confess,
  - both deny,
  - Alf confesses and Bob denies,
  - Bob confesses and Alf denies

Prisoners’ dilemma

- *Payoffs*
  - If both confess, they will get 5 years
  - If only one confesses, he is free. The other gets 10 years
  - If neither confesses, each gets 1 year for the minor crime
- The payoff matrix describes the payoffs to both players for every possible outcome
  - Called *a normal form representation*

Alf

		Confess	Deny
Bob	Confess		
	Deny		

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny	-10,0	-1,-1

Definitions

- A ***dominant strategy*** is a strategy that is optimal for *every* possible strategy of your rival
  - A *weakly dominant strategy* gives a payoff that is at least as good as (can be equal to) any other own strategy, for every possible strategy of the opponent
  - A *strictly dominant strategy* gives a strictly larger payoff than any other own strategy, for every possible strategy of the opponent
- In a ***Nash equilibrium (NE),*** players choose the best possible strategy given the strategies of their opponents. No player can benefit from changing own strategy

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny	-10,0	-1,-1

The prisoners' dilemma

		Alf	
			Deny
Bob	Confess		0,-10
	Deny		-1,-1

"A player has a dominant strategy when the action that gives him/ her the highest payoff does not depend on what the other player chooses"

- Suppose Alf denies. If Bob confesses, he is free. If Bob denies, he gets 1 year. Confessing is better!

The prisoners' dilemma

		Alf	
		Confess	
Bob	Confess	-5,-5	
	Deny	-10,0	

"A player has a dominant strategy when the action that gives him/her the highest payoff does not depend on what the other player chooses"

- Suppose Alf confesses. If Bob confesses, he gets 5 years. If Bob denies, he gets 10 years. Confessing is better!

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny	-10,0	-1,-1

– Regardless of what action Alf chooses

Confessing is a *dominant* strategy for Bob

"A player has a dominant strategy when the action that gives him/ her the highest payoff does not depend on what the other player chooses"

- Suppose Alf denies. If Bob confesses, he is free. If bob denies, he gets 1 year. Confessing is better!
- Suppose Alf confesses. If Bob confesses, he gets 5 years. If Bob denies, he gets 10 years. Confessing is better!

The prisoners’ dilemma

		Alf: Confess	Alf: Deny
Bob	Confess		
	Deny	-10,0	-1,-1

“Suppose Bob denies. If Alf confesses, he is free. If Alf denies, he gets 1 year. Confessing is better!

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny		

- Suppose Bob confesses. If Alf confesses, he gets 5 years. If Alf denies, he gets 10 years. Confessing is better!

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
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Confessing is a *dominant* strategy for Alf

"A player has a dominant strategy when the action that gives him/ her the highest payoff does not depend on what the other player chooses"

- Suppose Bob denies. If Alf confesses, he is free. If Alf denies, he gets 1 year. Confessing is better!
- Suppose Bob confesses. If Alf confesses, he gets 5 years. If Alf denies, he gets 10 years. Confessing is better!

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny	-10,0	-1,-1

- Bob is better off confessing no matter what Alf does
- The same reasoning shows that confessing is a *dominant strategy* for Alf
- Nash equilibrium: Alf confesses and Bob confesses

Nash equilibrium and optimality

- It may happen that Nash equilibrium is not Pareto optimal
- The prisoners' dilemma illustrates why it is difficult to cooperate even when it is in the best interest of both parties
- Games like the prisoner's dilemma can be used to study strategic interaction in oligopolies

The prisoners' dilemma

		Alf	
		Confess	Deny
Bob	Confess	-5,-5	0,-10
	Deny	-10,0	-1,-1

- Nash equilibrium — Alf confesses and Bob confesses — is not a Pareto optimal outcome!
- Can firms avoid a Prisoner's Dilemma?
  - Pre-game communication - So players communicate before they make their move or choice in which case they will promise to ….
    - Problem – not fulfilled promises…
  - Perhaps commitment is possible
    - An industry group or government removing the option to cheat by banning advertising or regulating prices using law (minimum price)
    - Repetition: future punishments make cheating less attractive.

Repeated prisoners’ dilemma

- If a game is repeated one firm has the opportunity to punish the other
- Hence a cooperative outcome might be sustainable
- That is, an outcome in which both duopolists split the monopoly profits. But, there must be a penalty for cheating:
  - Tit-for-tat strategy – see below
  - Trigger strategy – see below

Repeated prisoners' dilemma

- Begin by asking what happens if the game is played twice?
  - In the last period we play the original game
  - So each player does what?
- In the first period:
  - Each players know they will confess
  - in the last period
  - Effectively playing the original game in the first period
  - So each player does what?

Repeated prisoners' dilemma

- Begin by asking what happens if the game is played twice?
  - In the last period we play the original game
  - So each player does what?

  In the second round, the incentives of the players are the same as when they are playing the game only once; regardless of what happened in the first round, the dominant strategy is confess
- In the first period:
  - Each players know they will confess
  - in the last period
  - Effectively playing the original game in the first period
  - So each player does what?

  Thus, in the first round, both players know that the outcome in the second round is confess; no matter what they choose in the first round, they cannot induce cooperation in the second round. Therefore, the incentives are as though they were playing a single round of the game, so in the first round both parties have a dominant strategy, confess.

Repeated prisoners' dilemma

- But now, what happens if we play this game forever?
  - If the other player cheats today and sets a low price
  - Next period you ….
- If such threats are credible then high prices might be sustainable. How?
- With appropriate punishment strategies

Repeated prisoners' dilemma

- Types of punishment
  - Tit-for-tat punishment strategies
    - Cooperate as long as your rival cooperated yesterday
    - If your rival cheated yesterday you 'punish' them by cheating today
    - Punishment is temporary – one period only
    - Possible we may never see punishment occurring because parties always cooperate
    - Threat of punishment dissuades cheating

Repeated prisoners' dilemma

- Types of punishment
  - Trigger strategies
    - Cooperate as long as your rival has cooperated
    - If your rival cheats punish them forever
    - More extreme than 'tit-for-tat'
    - May never actually observe punishment

Application of Game Theory on Different Settings

See Canvas for Video recording of following games

<u>Simultaneous</u>

- Price-fixing Game
- Coordination Game
- Research and Development Game
- Advertising Game
- Location Game

<u>Sequential</u>

– Dating Game (First mover advantage)

Location game

		Kebab: City	Kebab: Beach
Pub	City	30,20	10, 10
Pub	Beach	10,10	20,30

– Is there a dominant strategy? No!
– Two Nash equilibria:
  - Both locate in the City
  - Both locate near the beach
  - Notice that these equilibria are not fair. One player consistently does better than the other

Remember:

- In *Nash equilibrium* everyone chooses the best possible strategy, given the choices of all other players.
- *Dominant strategy* is the best possible plan of action for any possible strategy of all other players

Assumptions underlying NE

- Rationality
- Common knowledge: each player needs to know the other player is rational, and that the other player knows he is rational, and that the other player knows he knows the other player is rational…
- The payments in the payoff matrix need to represent "utility" (especially relevant for individuals).
- Perfect information: players need to know the structure of the game and the payoffs (profits of the other firm).

Sequential games

Sequential games

- We considered simultaneous move games – that is when players made their choices simultaneously
  - This might have simply meant that neither player knew what the other had chosen when they made their choice
  - In many economic and business decision settings, players or economic agents make their choices after overserving the choice of other players
  - That is, players make their choice **sequentially**

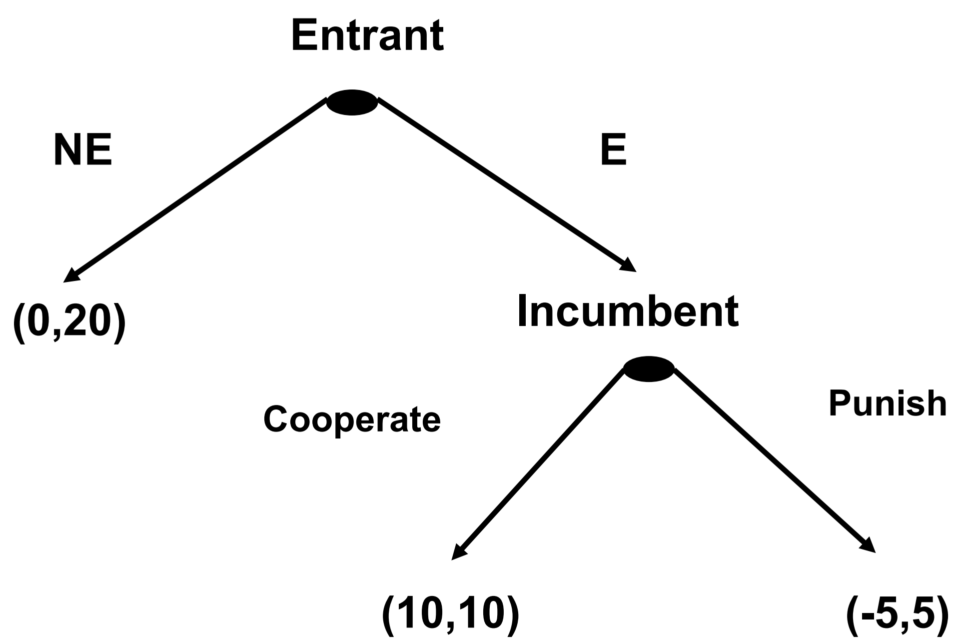
Sequential games

- In some games players move sequentially
  - For example, one firm (Honda) chooses to build a small or large factory ***after*** observing the choice of a rival (Toyota)
  - Woolworths makes a choice about the price of milk ***after*** observing the choice of Coles
- Also think about bargaining settings
  - *One party makes an offer*
  - *The other party accepts, or not, and makes a counter offer ….*
- To solve such problems we will need additional tools

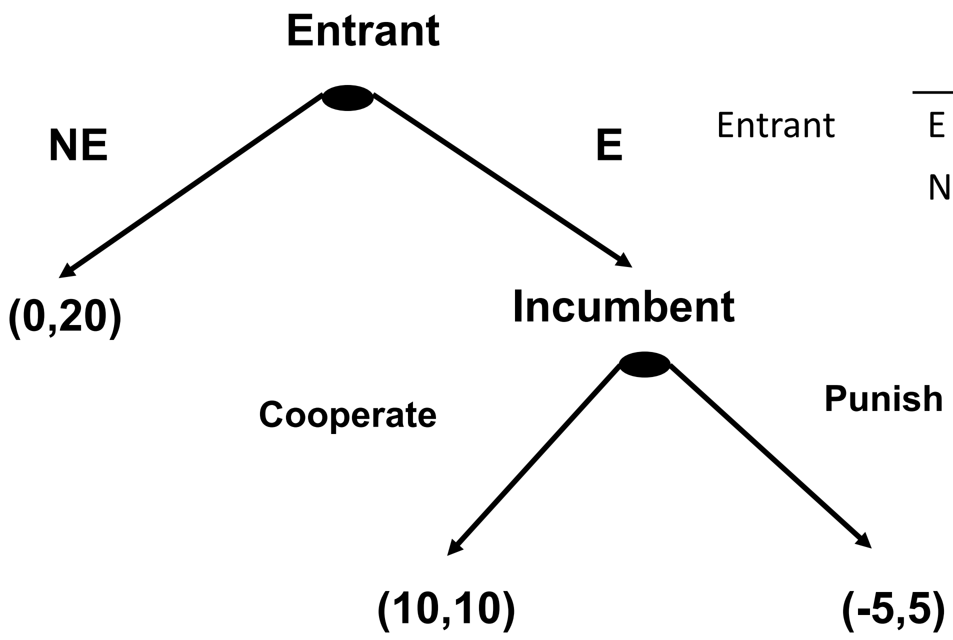
Extensive & normal form

- In the game below we think about two firms, an incumbent and a potential entrant
  - *The potential entrant makes a choice to enter or not*
  - *The incumbent then makes a choice about how to react…*

Extensive and normal form



Extensive and normal form

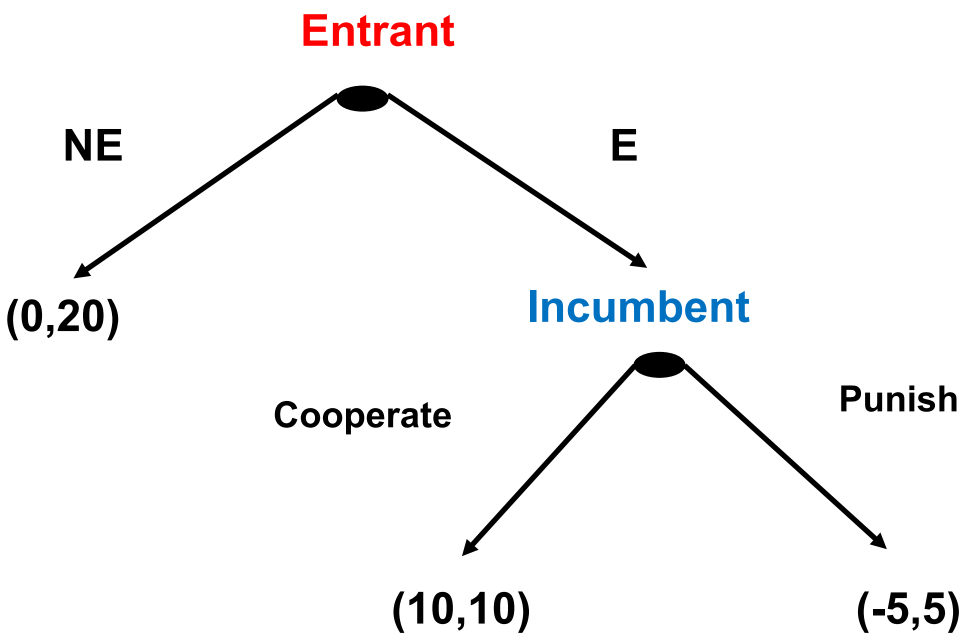


		Incumbent	
		C	P
Entrant	E	(10,10)	(-5,5)
	NE	(0,20)	(0,20)

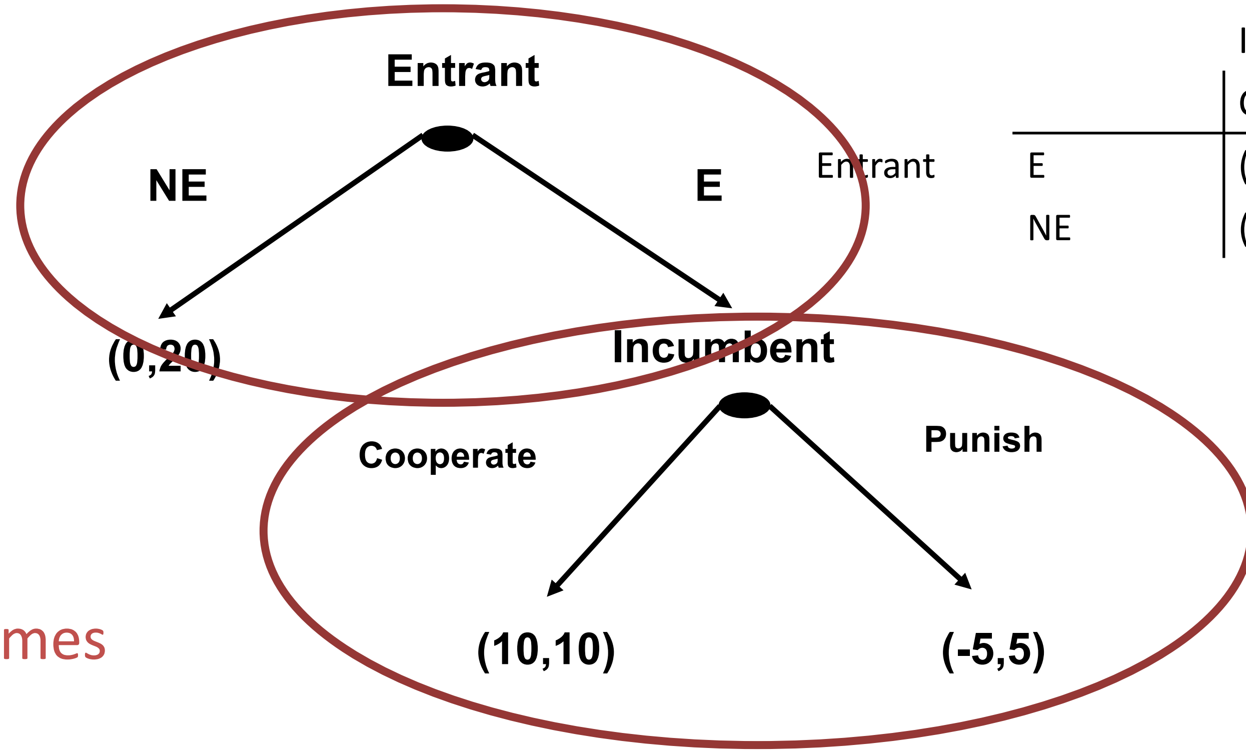
Equilibrium analysis

- Nash Equilibrium in the (normal form) game above are *(NE, P if E) & (E, Cooperate in E)*
- Ask yourself, do these seem sensible?
- Examine the subgames - each subgame consists of one choice by one player
- Hence, Entrant’s choice to enter or not is a sub-game. Also, Incumbent’s choice to punish or not is a subgame.

		Incumbent	
		C	P
Entrant	E	(10,10)	(-5,5)
	NE	(0,20)	(0,20)



Equilibrium analysis



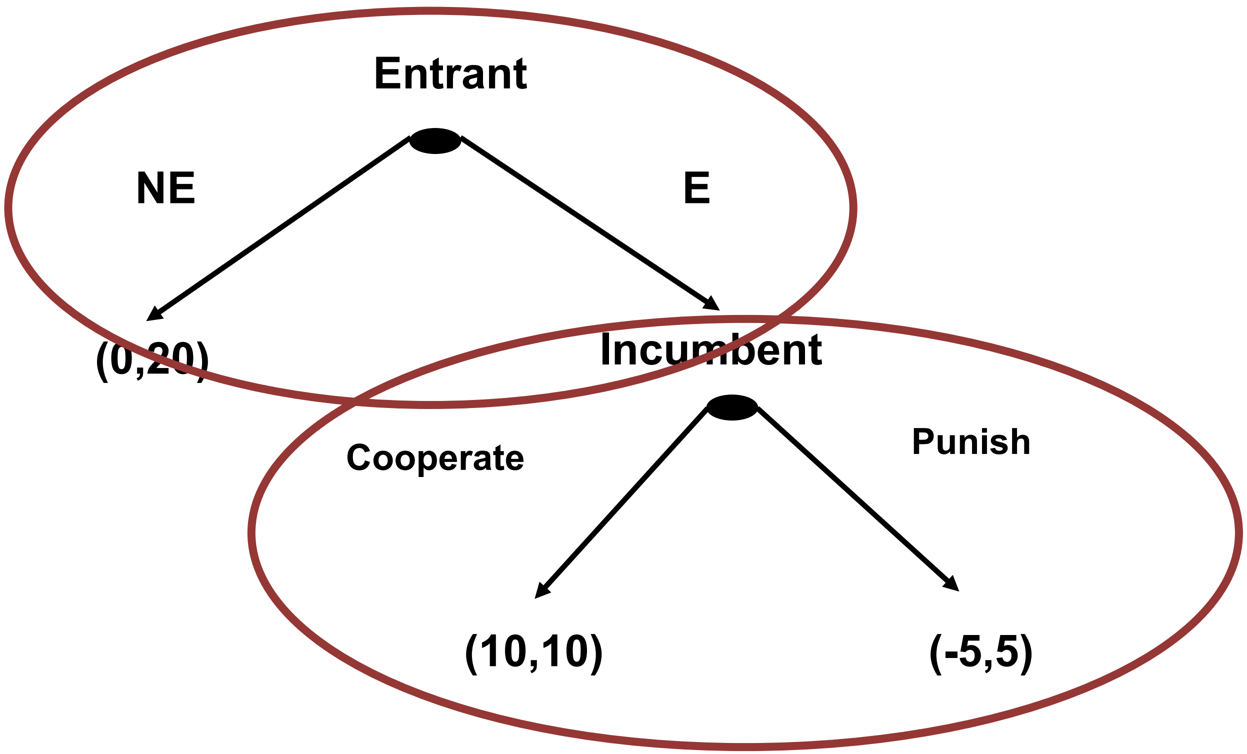
subgames

		Incumbent	
		C	P
Entrant	E	$(\underline{10},\underline{10})$	(-5,5)
	NE	$(0,\underline{20})$	$(\underline{0},\underline{20})$

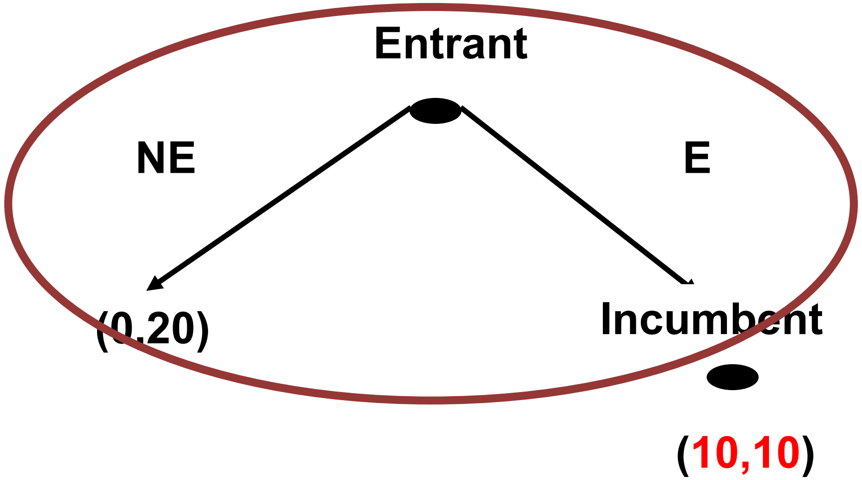
Equilibrium analysis – Subgame Perfect Equilibrium

- Subgame perfect equilibrium – each players strategy must be a NE in every subgame
  - Threats credible – strategy would be adopted if needed
- To solve such games we use backward induction
- This identifies the subgame perfect equilibrium so that every players actions are a Nash equilibrium
- Solving the game in this way identifies credible equilibria by eliminating non-credible strategies

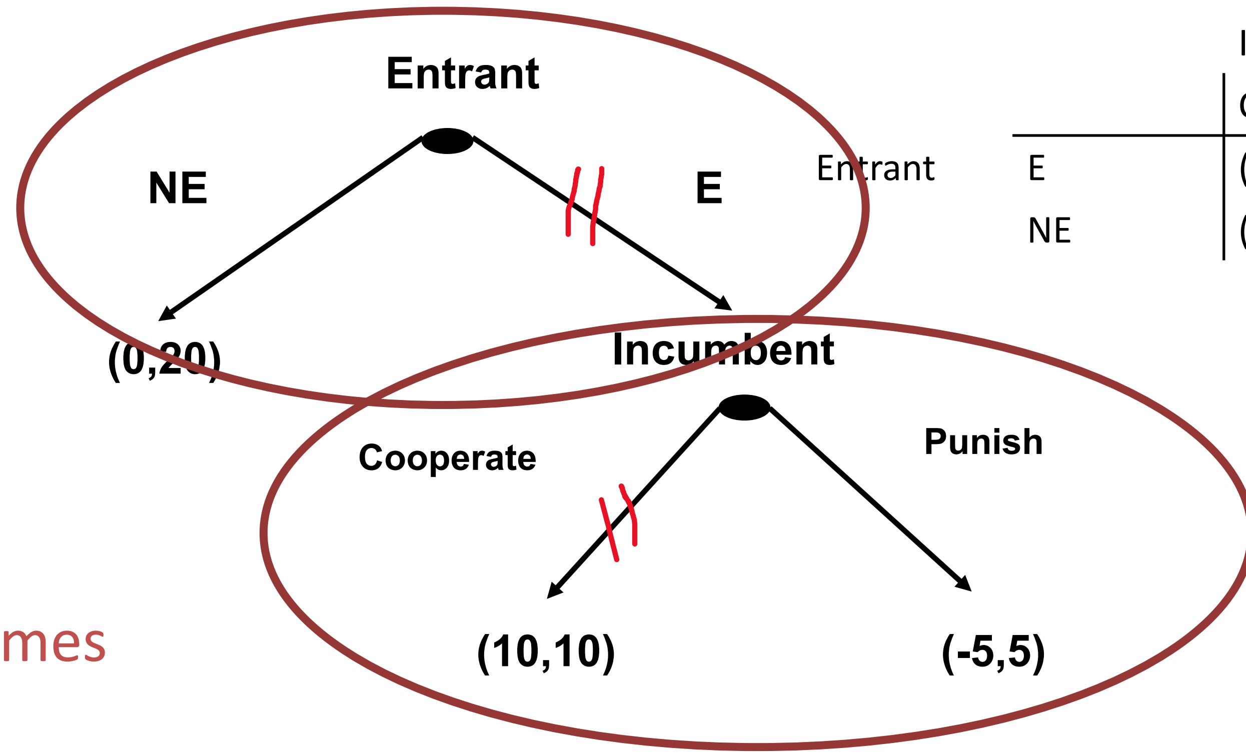
Equilibrium analysis



Equilibrium analysis



Equilibrium analysis – Subgame Perfect Equlibrium



		Incumbent	
		C	P
Entrant	E	(10,10)	(-5,5)
	NE	(0,20)	(0,20)

subgames

(Enter; Cooperate if Enter) is the only Subgame Perfect equilibrium

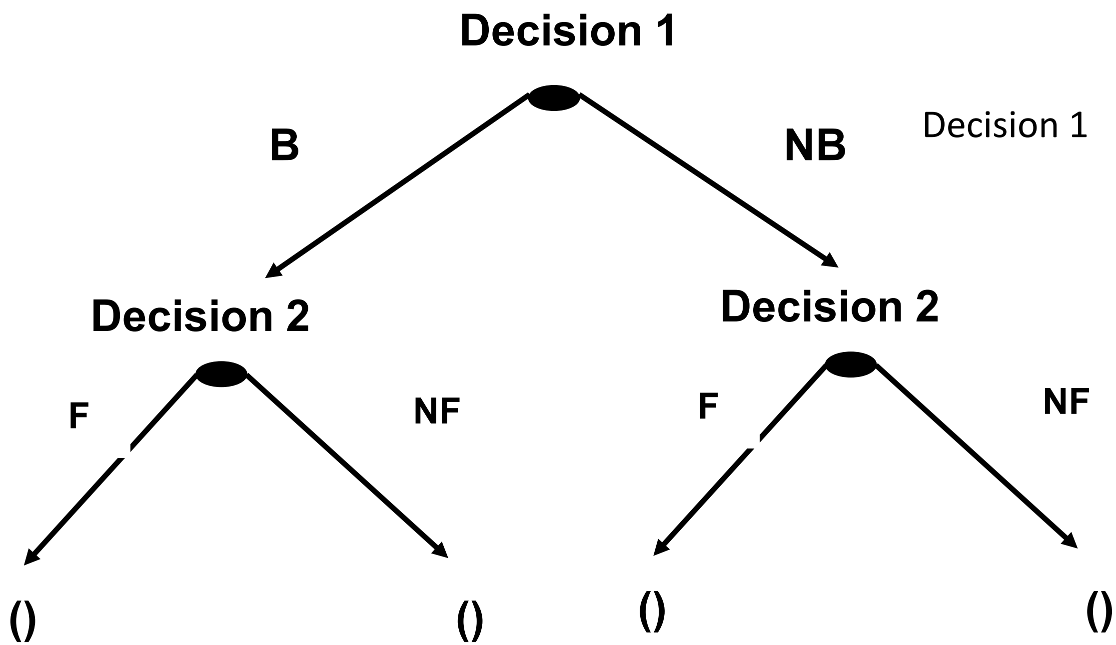
Equilibrium analysis – Subgame Perfect Equlibrium

- Solving the game in this way highlights that we assume that players are rational and forward looking.
- Moreover, just as they did last week each player looks after themselves – they are self-interested.
- Note that the SPE is a Nash Equilibrium, but not all NE are SPE (see the original market entry game)

Commitment

- Vikings land on a beach, after landing they can either burn their boat or leave it intact
- After making their decision they confront villagers nearby. At this point the Vikings can choose to either fight or not fight
- If they burn and fight the Vikings get 200 and the villagers get 0. If they burn and not fight the Vikings and villagers get 100 each. If they do not burn and fight the payoffs are 50 for the Vikings and 150 to the villagers. Finally, if they do not burn and do not fight both parties get a payoff of 100
- Draw the extensive form of this game

Commitment



		Decision 2	
		Fight	Not fight
Decision 1	Burn	(200)	(100)
	Not burn	(50)	(100)

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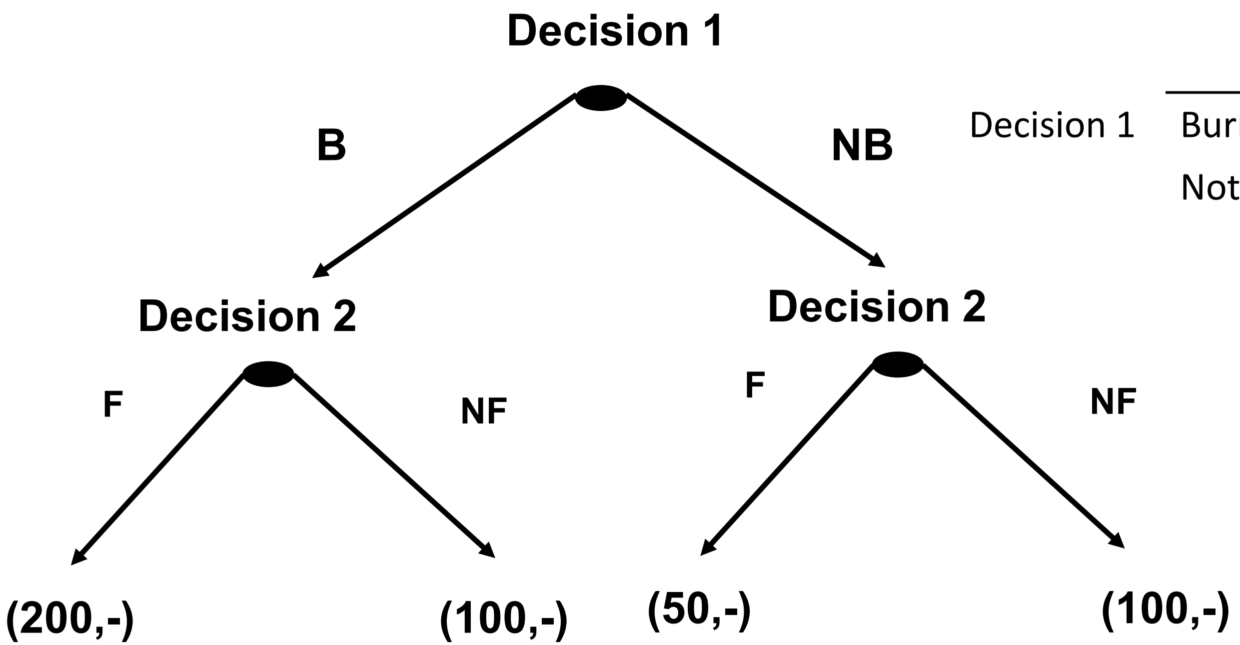
Commitment



		Decision 2	
		Fight	Not fight
Decision 1	Burn	(200)	(100)
	Not burn	(50)	(100)

50

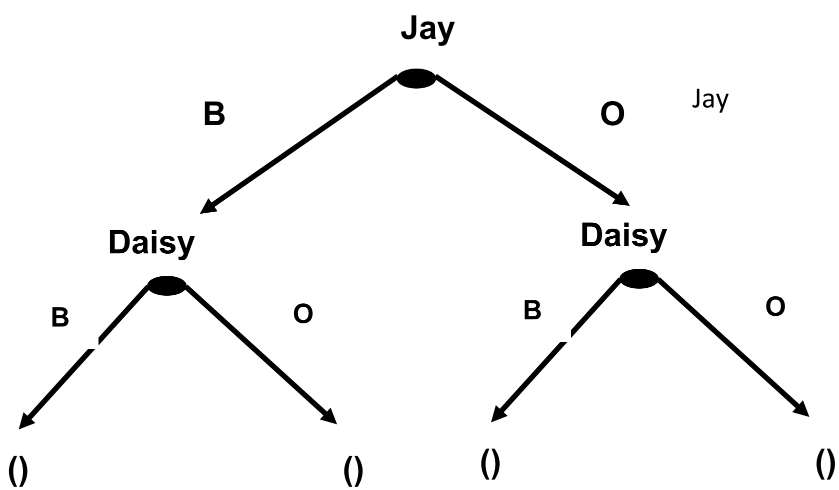
Commitment

- There is a payoff from cutting some options –payoff from making a credible commitment
- By burning their boat the Vikings made a very clear statement that they were not able to undo so the commitment was credible.
- Are there analogies from the business world?
  - Signing a contract?
  - Constructing a large factory or plant? What might this effectively commit a firm to?
  - Making an irredeemable investment in R&D?
- *Usually we think that having a greater range of choices available is better, but this is not always true. You may gain a strategic advantage by limiting choices*

Dating game – see Canvas for recording

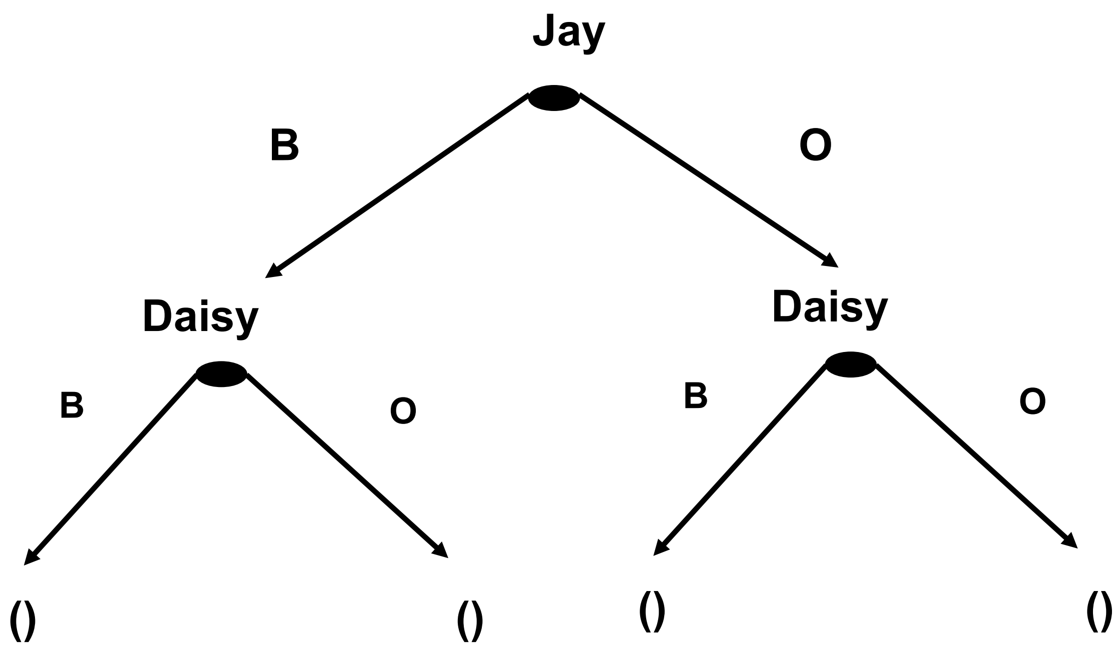
- Jay and Daisy are trying to organise a date. *Jay prefers the opera while Daisy is a UFC (boxing) fan. This is a coordination problem with payoffs below.*
- *Assume Jay makes a choice and then informs Daisy of his choice. At that point, Daisy makes her decision.*

Dating game



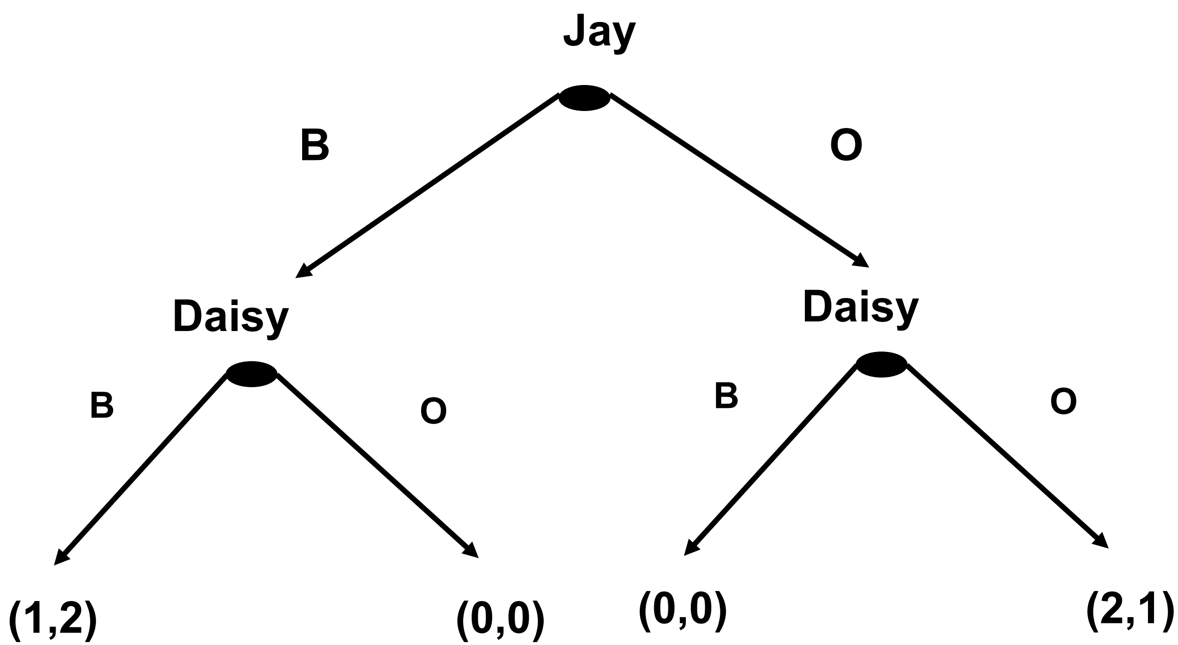
		Daisy	
		B	O
Jay	B	(1,2)	(0,0)
	O	(0,0)	(2,1)

First mover advantage



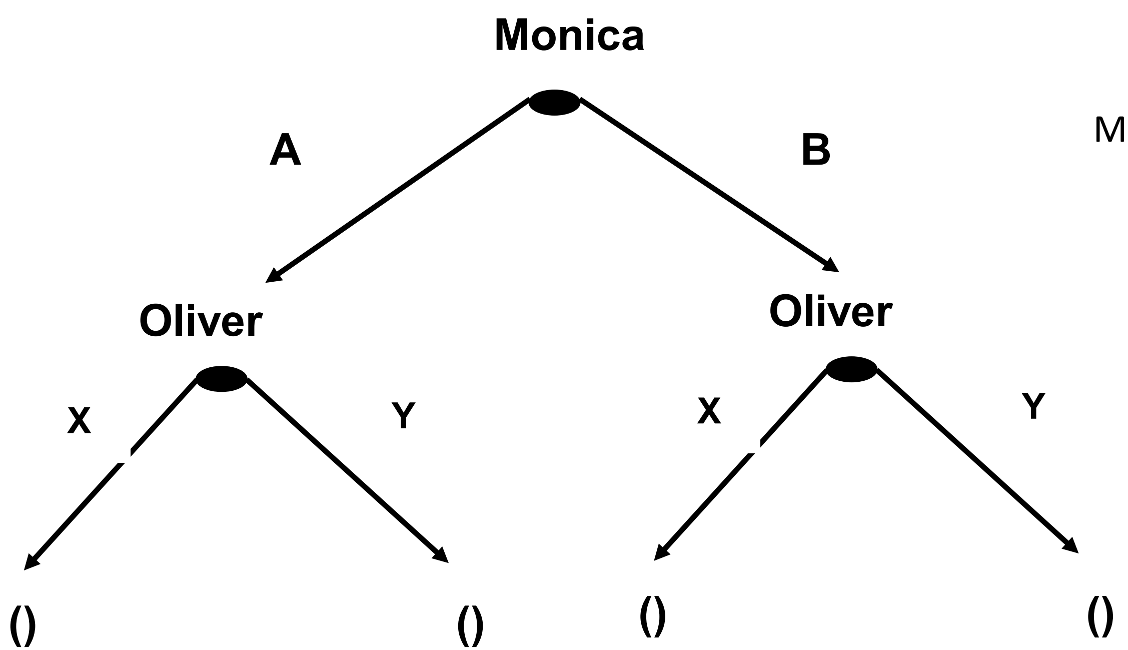
		Daisy	
		B	O
Jay	B	($\underline{1}$,$\underline{2}$)	(0,0)
	O	(0,0)	($\underline{2}$,$\underline{1}$)

First mover advantage



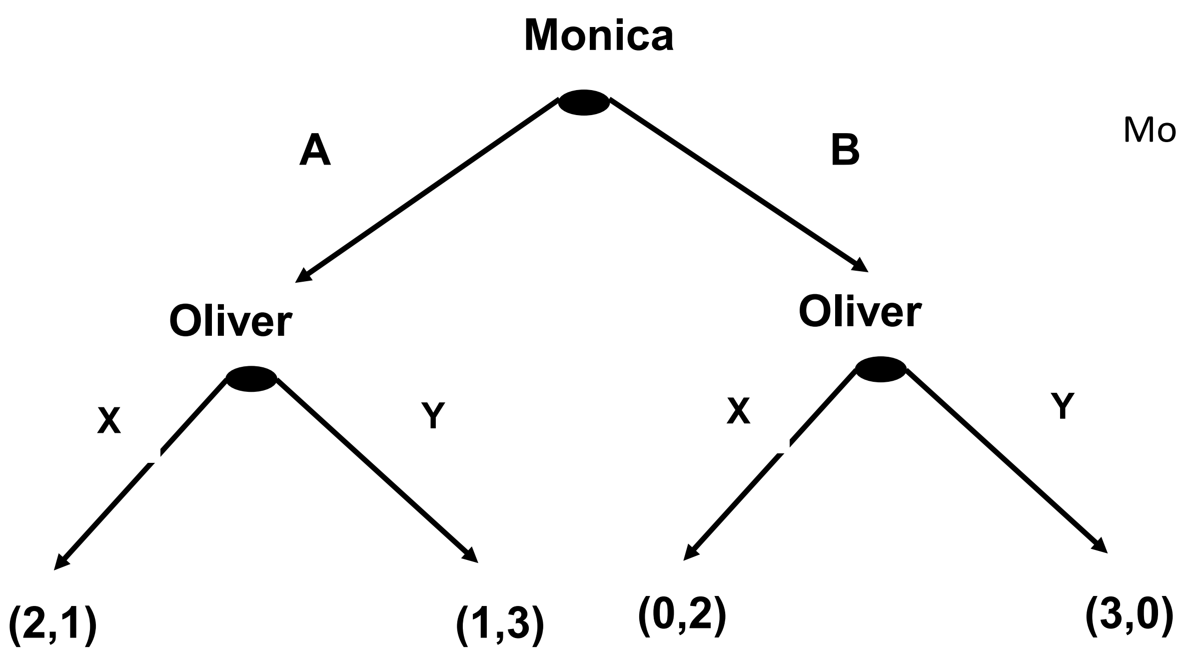
		Daisy	
		B	O
Jay	B	$(\underline{1},\underline{2})$	(0,0)
	O	(0,0)	$(\underline{2},\underline{1})$

Second mover advantage



		Oliver	
		X	Y
Monica	A	(2,1)	(1,3)
	B	(0,2)	(3,0)

Second mover advantage



		Oliver	
		X	Y
Monica	A	(2,1)	(1,3)
	B	(0,2)	(3,0)

First and second mover advantage

- Sometimes it is better to go first, other times it is better to learn from the mistakes of others
- There is an advantage from being the first mover if a firm can commit to an action. Then, the follower must adapt to the strategy of the leader:
  - *A firm builds a hotel first*
  - *A firm chooses how much output to produce and a rival responds*
  - *Leader makes a choice over technology*
- Sometimes, it is not the first mover who wins
  - *For example, Apple, Microsoft or the iPhone were not the first movers*
  - *Examples: investment free riding, group assignments advertising new products*

Lessons from game theory

- Understanding your rivals – actions and consequences
- Ask – what would my rival do? That is, place yourself in their shoes
- Advantage of moving first or second depends on setting

For the exam you need to know:

- Solve for NE and SPE
- Draw normal and extensive form games
- Explain commitment, first and second mover advantage