14.23 Government Regulation of Industry

Class 3

MIT & University of Cambridge

Outline

- Definitions
- Nash Equilibrium
- Monopoly and Perfect Competition revisited
- Duopoly and social welfare
- Cournot, Stackelberg and Bertrand Oligopoly
- Collusion
- Is oligopoly a problem?
- Prisoners' Dilemma and Game Theory

A Nash Equilibrium

The strategies x and y form a *Nash equilibrium* for players 1 and 2 respectively if x is the best response for 1 if 2 has chosen y and y is the best response for 2 if 1 has chosen x.

Monopoly and Perfect Competition

Consider the following example:

Market Demand: P=25-Q

Marginal Cost = Average Cost = 5

Competitive Outcome:

MC=MR=P=5, Q=20; CS=200, PS=0

Monopoly Outcome:

MR=25-2Q=MC=5; Q=10, P=15;

CS=50, PS=100, DWL=50

Cournot Oligopoly

- Consider two identical firms (1 and 2).
- Both set quantity assuming the other firm's quantity is independent of their own choice of output.
- Thus the conjectural variation is zero (i.e. firm 1 assumes $dq_2/dq_1=0$).
- Equilibrium occurs when each firm does not want to change its output having observed what output the other firm has set.

Cournot Oligopoly

Price, $P = 25 - (q_1 + q_2)$; Total costs, $C_1 = 5 q_1$; $C_2 = 5 q_2$;

Profit, $\Pi_1 = (25 - q_1 - q_2) q_1 - 5 q_1$

Differentiate the profit function with respect to q_1 and set equal to zero to solve for marginal revenue=marginal cost.

This gives the reaction or best response function for Firm 1: this gives $q_1 = (20 - q_2)/2$.

Repeat the procedure for the identical Firm 2:

this gives $q_2 = (20 - q_1)/2$

Cournot Oligopoly

- $q_1 = (20 - q_2)/2$ and $q_2 = (20 - q_1)/2$
- $q_1 = q_2 = 20/3$
- $P = 35/3$
- $\Pi_1 = \Pi_2 = 400/9$; PS=800/9
- CS=800/9
- CS+PS=1600/9=177.78

Figure 1 -
A Cournot equilibrium

q_2, Output of firm 2

R_1

Π_{22}

Π_{21}

Cournot Equilibrium

Π_{11}

Π_{12}

R_2

0
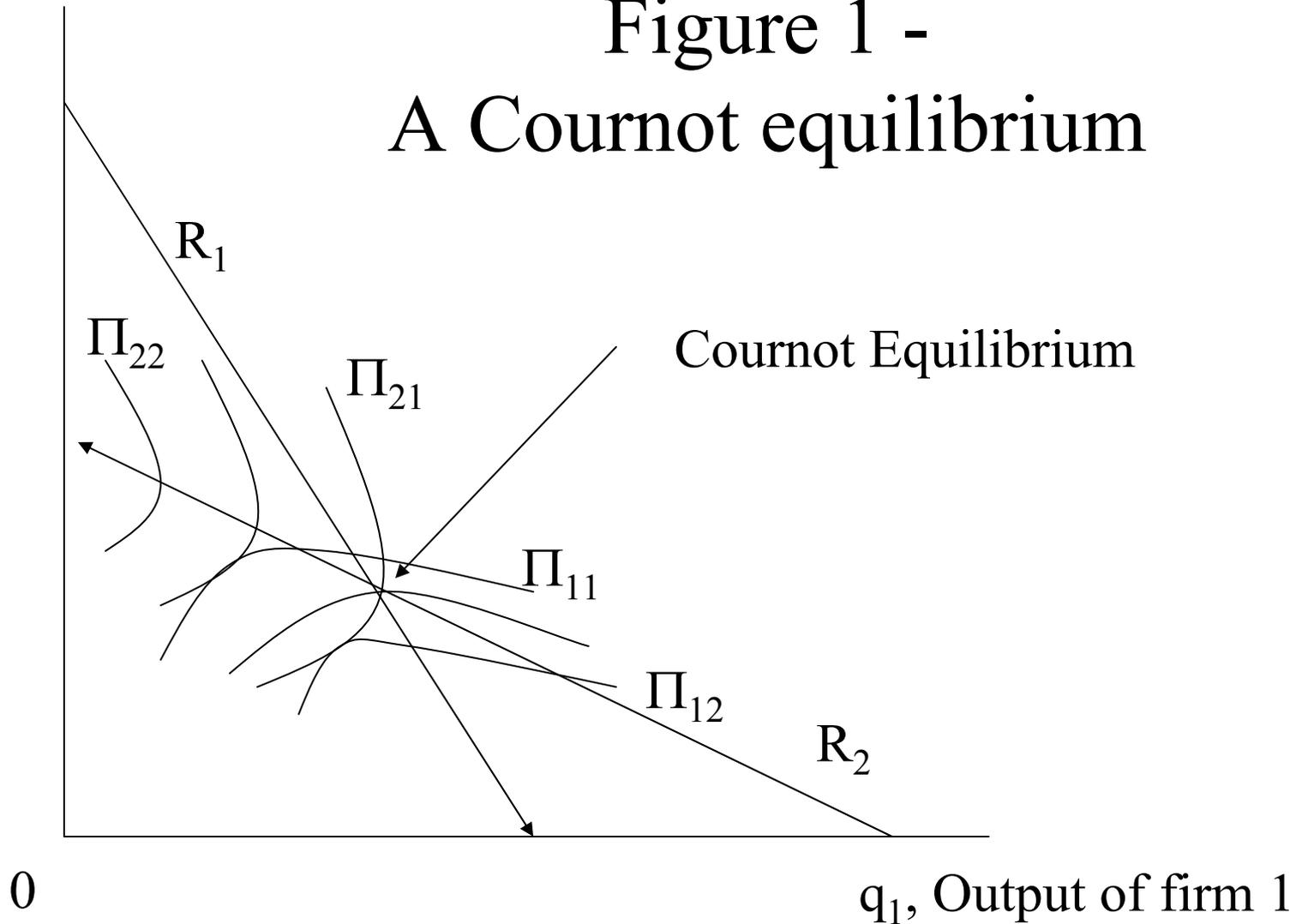
q_1, Output of firm 1

$\Pi_{21} < \Pi_{22}; \Pi_{11} < \Pi_{12}$

A Stackelberg Equilibrium

- Firm 1 is leader, Firm 2 is follower
- Firm 1 knows $q_2 = (20 - q_1)/2$ and maximises
- Firm 2 is a Cournot player
- $q_1 = 10$, $q_2 = 5$
- $p = 10$
- $\Pi_1 = 50$, $\Pi_2 = 25$; PS = 75
- CS = 0.5(15*15) = 112.5
- CS + PS = 187.5

q₂, Output of firm 2

Figure 2 -
A Stackelberg Equilibrium

R₁

Cournot Equilibrium

Stackelberg equilibrium
with 1 as leader

q₂₁

R₂

0   q₁₁   q₁, Output of firm 1
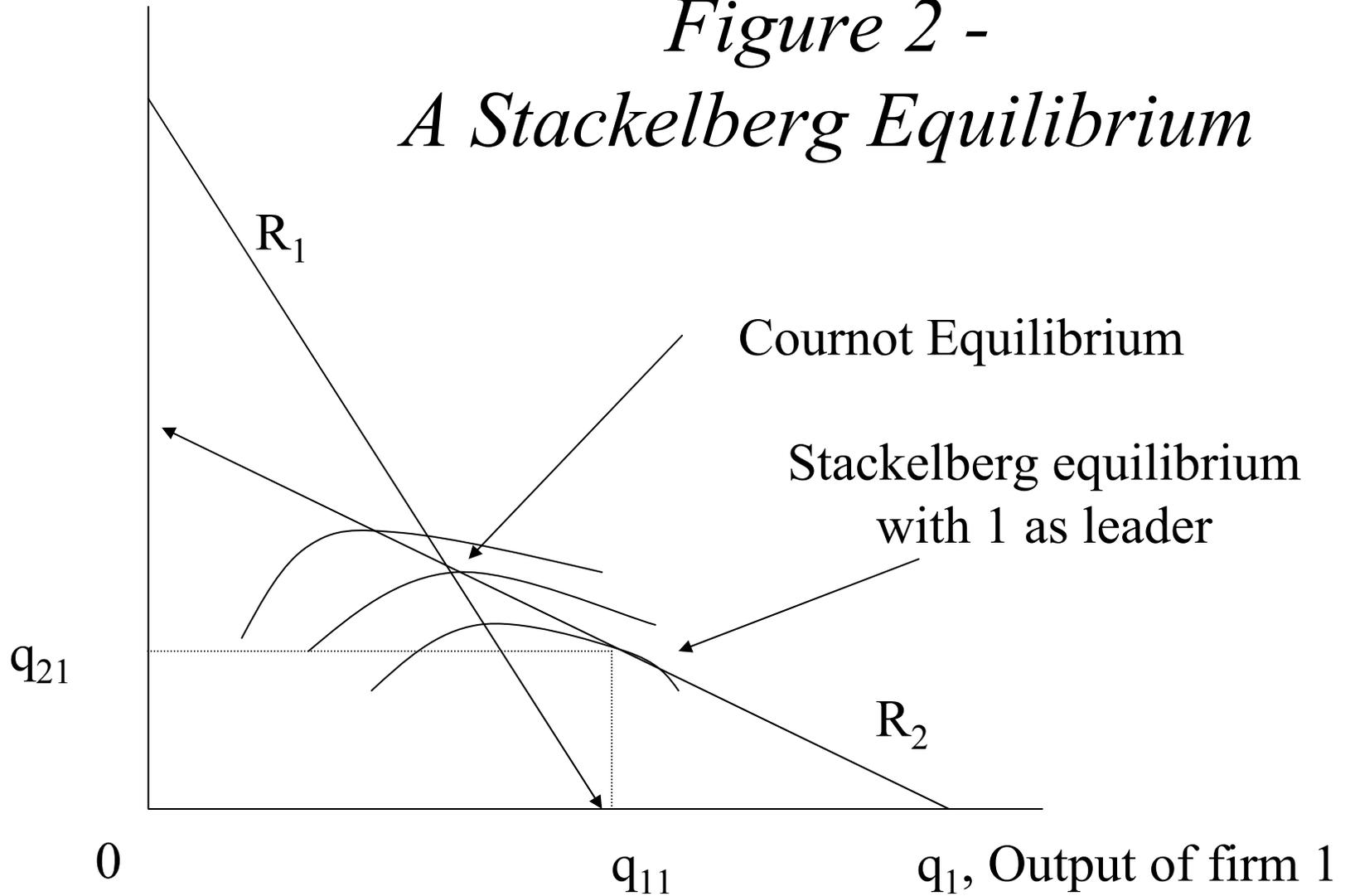
First mover firm can get higher profits than at the Cournot equilibrium.

Bertrand Oligopoly

- Consider two identical firms (1 and 2).
- Both set *price* assuming the other firm's price is independent of their own choice of output.
- Thus the conjectural variation in price is zero (i.e. for firm 1 $dp_2/dp_1=0$).
- Equilibrium occurs when each firm does not want to change its price having observed what the price the other firm has set.
- Price equals marginal cost (=average cost).
- There are zero profits.

Bertrand Equilibrium

- Firm 1 and Firm 2 produce similar but not identical products and compete on price.
- Demands: $q_1 = 20 - p_1 + p_2$, $q_2 = 20 - p_2 + p_1$
- Assume mc=0
- Price reaction functions: $p_1 = (20 + p_2)/2$ and $p_2 = (20 + p_1)/2$
- $p_1 = p_2 = 20$, $\Pi_1 = \Pi_2 = 400$
- If Firm 1 is a leader, $p_1 = 30$, $p_2 = 25$
- $\Pi_1 = 450$, $\Pi_2 = 625$
- You don't want to be the leader!

Figure 3 – The Bertrand Equilibrium
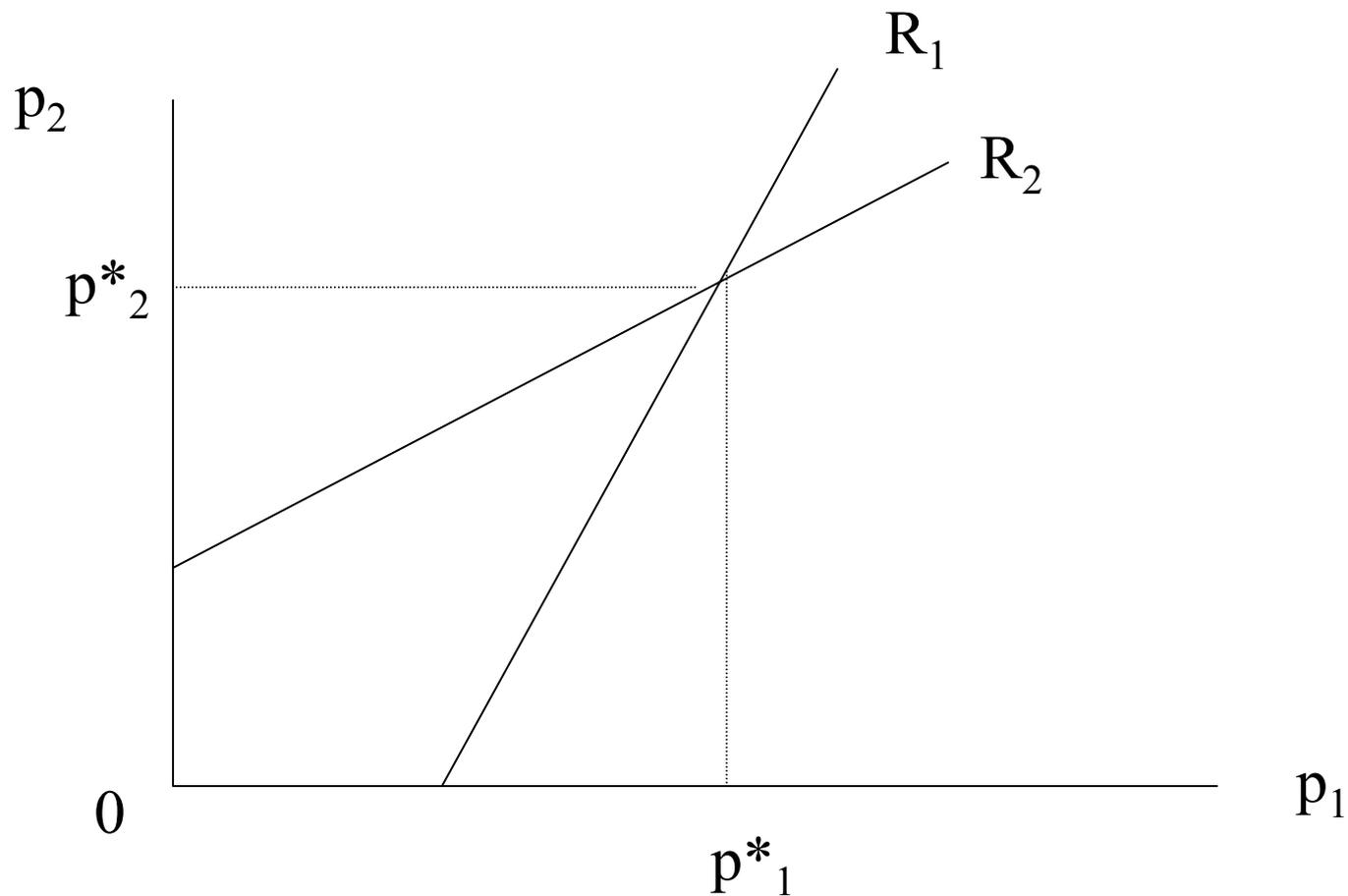
N-firm Cournot Oligopoly

- $Q = q_1 + q_2 + \ldots + q_n$
- MR=MC for each firm i

  $\Pi_i = P(Q).q_i - C(q_i)$

- F.O.C.: $MC_i = P(Q) + q_i \, dP/dq_i$
- $s_i = q_i/Q$, note in Cournot: $dP/dQ = dP/dq_i$
- Rearranging we get: $(P - MC_i)/P = s_i/\eta$
- Note the properties of this equilibrium result!

Cournot and Collusion

- Collusion involves a non-zero conjectural variation.
- This involves co-ordination such that $dq_2/dq_1 > 0$
- Co-ordination of output can come about as a result of an agreement (co-operative behaviour) or as a result of infinite or indefinite repetition or irrational commitments.
- In our original example the collusive outcome is P=15 and $q_1=q_2=5$ and firm profits are 50. If cheating occurs could switch to Cournot oligopoly, profits would drop to 400/9=44. Can get profits of c.55 if set $q_i=20/3$ when $q_j=5$.
- If firm 1 thinks about cheating calculates whether one period gain is greater than multi-period loss:
  - Max gain is 5; loss is 6/R, thus only cheat if R>6/5

Collusion in Practice

- Collusion is very difficult to sustain for long periods in practice.
- This is because collusive equilibria are unstable due to uncertainty, new entry, differences in costs, multiple equilibria.
- Sustained collusion requires communication and probably explicit co-ordination and sophisticated side-payments.
- Not clear that most types of tacit collusion are worth acting on due to Schumpeterian effects.
- Example of UK White Salt market in 1986.

16

Figure 4 - Oligopoly as a normal form game

1 ＼ 2	S1=5	S2=20/3	S3=10
S1=5	(50,50)	(42,55)	(25,50)
S2=20/3	(55,42)	(44,44)	(22,33)
S3=10	(50,25)	(33,22)	(0,0)

Let us consider once again why (44, 44) is the Nash equilibrium and (50,50) is the collusive equilibrium.

Figure 5 - Oligopoly as an extensive form game
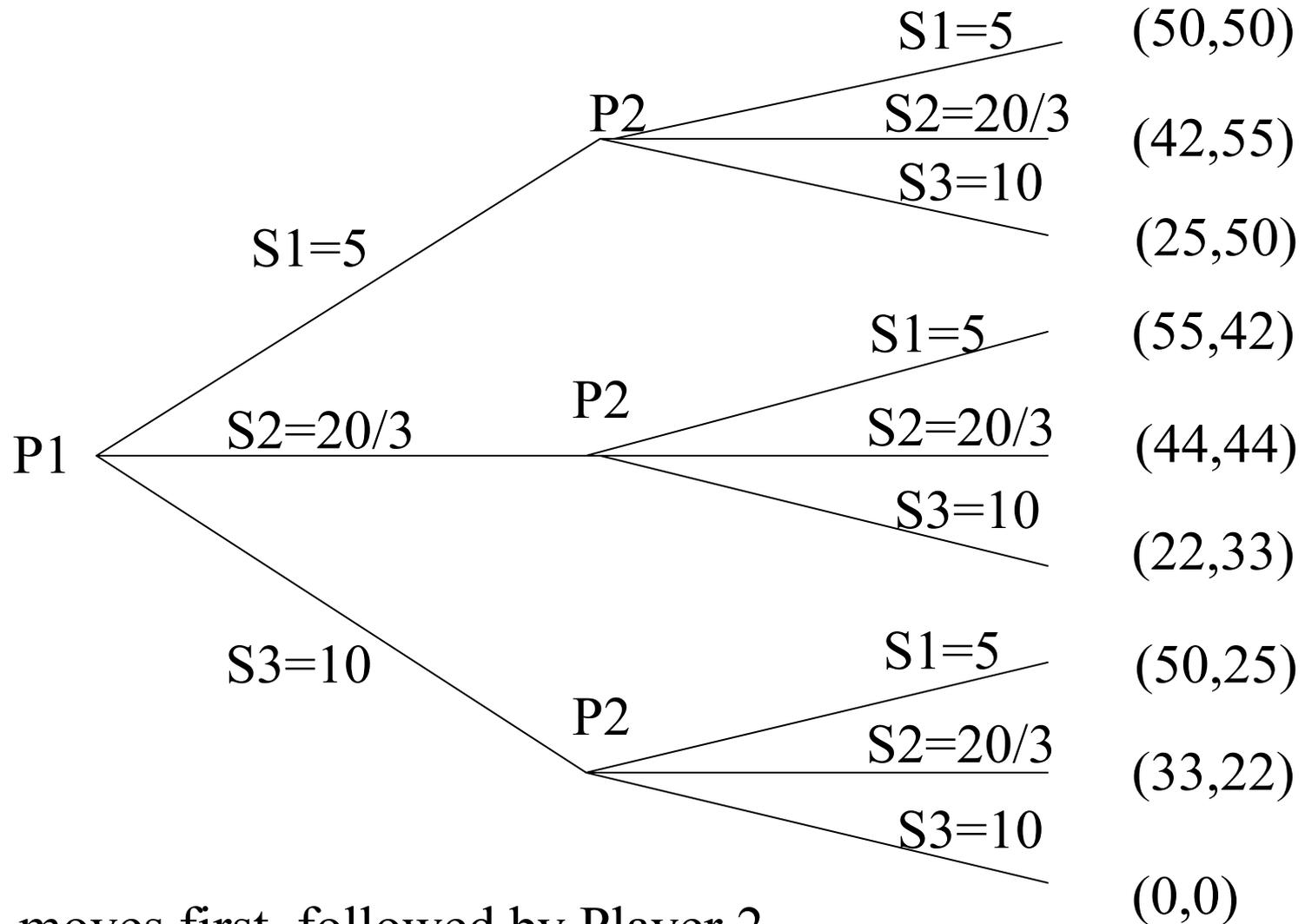
Player 1 moves first, followed by Player 2.
Let us use Cournot model to demonstrate why (50, 25) is the Nash eqm.

18

Figure 6 - The Prisoners' Dilemma

	Don't Confess	Confess
Don't Confess	(10,10)	(2,12)
Confess	(12,2)	(5,5)

(Rows: Prisoner 1; Columns: Prisoner 2)

(x,y): x=return to Prisoner 1, y=return to Prisoner 2.
Higher numbers are better for the Prisoners.

Solving the Prisoners' Dilemma

- Simultaneous moves (5,5) is the likely solution. This is the rational strategy (Nash Equilibrium).

- However (10,10) is superior to (5,5) for both players (Pareto superior).

- Many environmental problems can be characterised as Prisoners' Dilemmas.

- These are solved by social convention, law and repetition.

Conclusions

- Different market structures are associated with different levels of social welfare and deadweight loss.

- Cournot and Bertrand oligopoly are better than monopoly and collusive oligopoly.

- Firms within oligopolies can be thought of as playing games where they attempt to maximise profits by choosing levels of variables under there control in the light of assumed reactions of other firms.

- Economic regulation is important where monopoly exists and conditions make sustained collusion likely.

Next

- Revision of
  Dominant Firms and Entry Deterrence.

- Read VVH Chapter 6.