UNIT EC455, LEVEL 3

OLIGOPOLY

THE ECONOMICS OF EUROPEAN INDUSTRY

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Oligopolistic Conduct and Welfare

Aim

- To explore the implications of various oligopoly models for public policy makers.

Learning Outcomes

You will be able to

- draw reaction functions
- derive reaction functions under Cournot assumptions.
- Calculate welfare losses from a Cournot oligopoly using a numerical example, and contrast the results with that of perfect competition and monopoly.
- Analyse the link between Cournot models and market power.
- Describe the role played by product differentiation in relation to oligopoly models.
- carry out tasks set in the notes.

Further Activities

Having read the notes, attended the lecture and examined some further reading can you synthesise the issues involved in 250 words?

Welfare and (Tight) Oligopoly

To understand the welfare implications of oligopoly we need to examine interdependence between firms in the market. Welfare depends upon the number of firms in the industry and the conduct they adopt.

More formally, in oligopoly models we endogenise assumptions about the conduct of firms and then assess the level of economic performance they offer to society.

We examine 2 models of oligopoly, following Augustin Cournot and Heinrich von Stackelberg and compare these with a competitive and collusive (monopoly) equilibrium. Finally, but briefly, we mention the work of Joseph Bertrand.

Augustin Cournot (1838)

Cournot's model involves competition in quantities (sales volume, in modern language) and price is less explicit. Cournot's initial model assumed competition between 2 firms (a Duopoly) selling mineral water at zero cost. Cournot later dropped these assumptions with no major impact on the results.

The biggest assumption made by Cournot was that a firm will embrace another's output decisions in selecting its profit maximising output but take that decision as fixed, i.e. unalterable by the competitor. This means that each firm is "naively" conjecturing that should either one of them alter their output decisions the other will not react. This assumption has led to the development of the "conjectural variations" approach to the original Cournot model (which assumed a zero conjectural variation).

A Graphical Example of Cournot

We will assume a duopoly situation in which both firms, Firm 1 and Firm 2, have constant marginal costs and zero fixed costs.

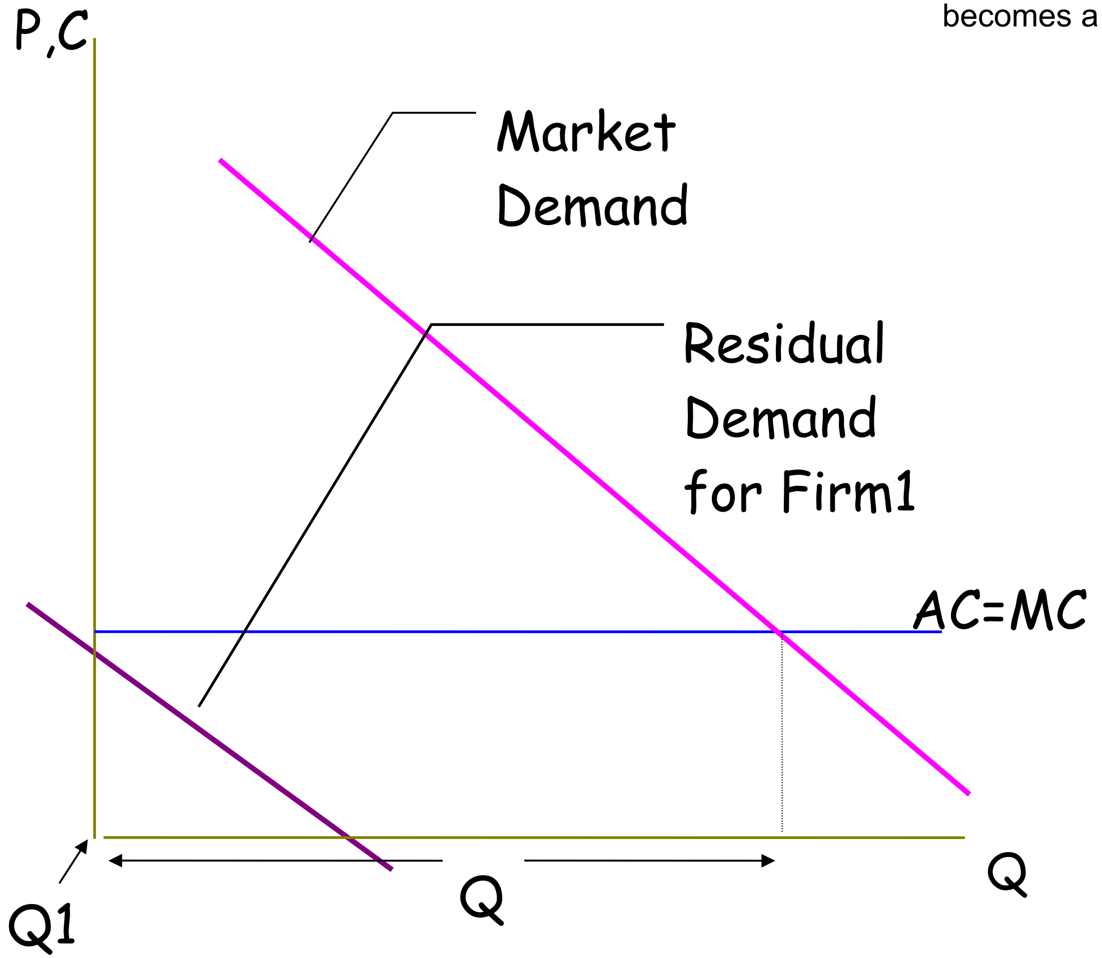
To see how the Cournot (and Stackelberg) model(s) work out we need to understand the idea of the reaction curve.

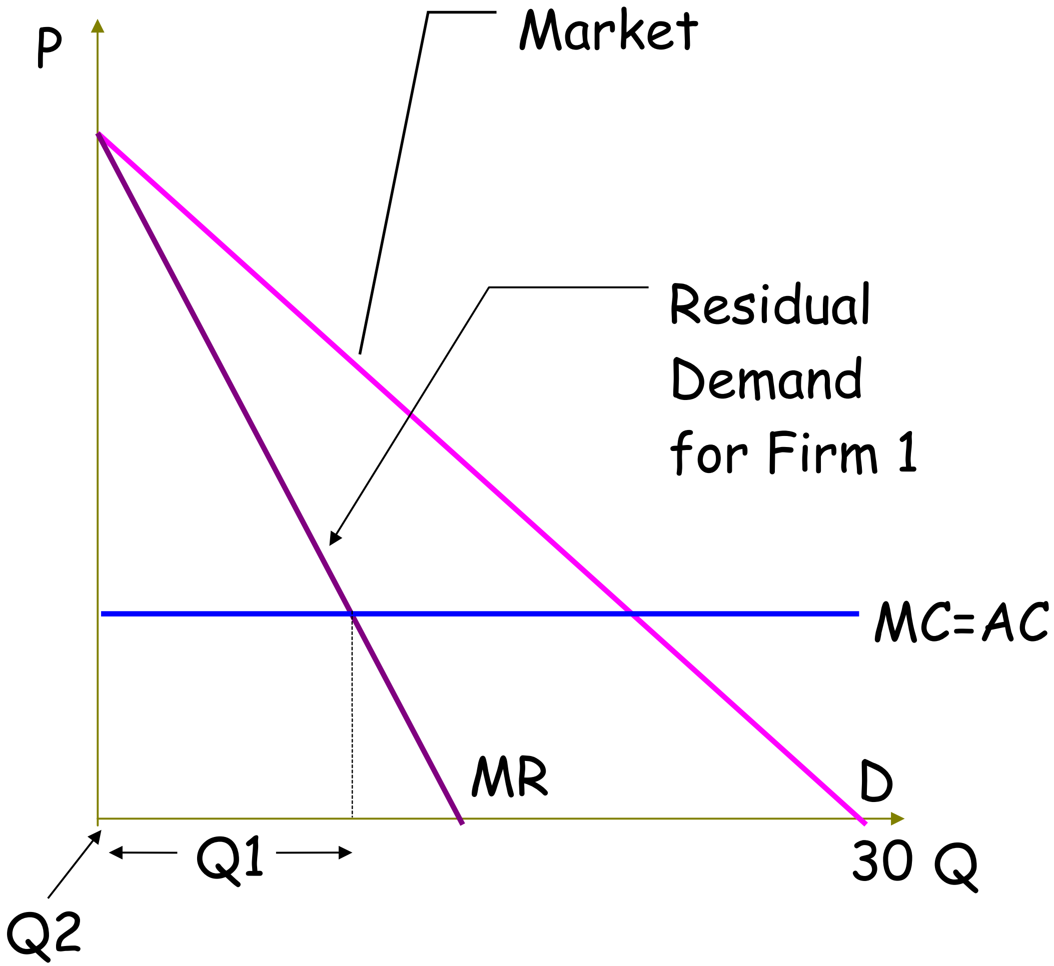
A reaction curve for Firm 1 represents its profit maximising output level given what it believes the other firm will produce. And vice versa for firm 2.

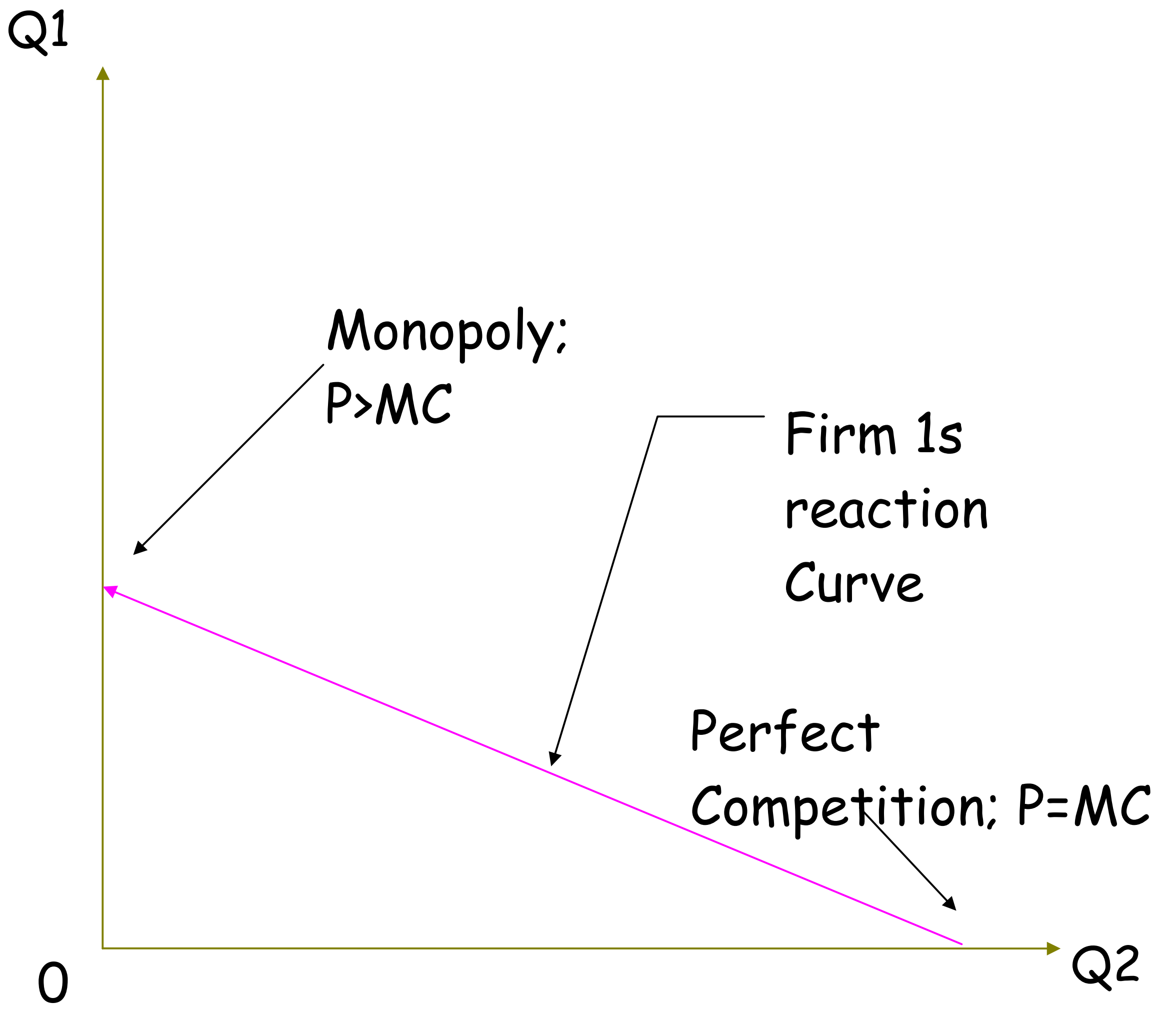
Deriving Reaction Curves

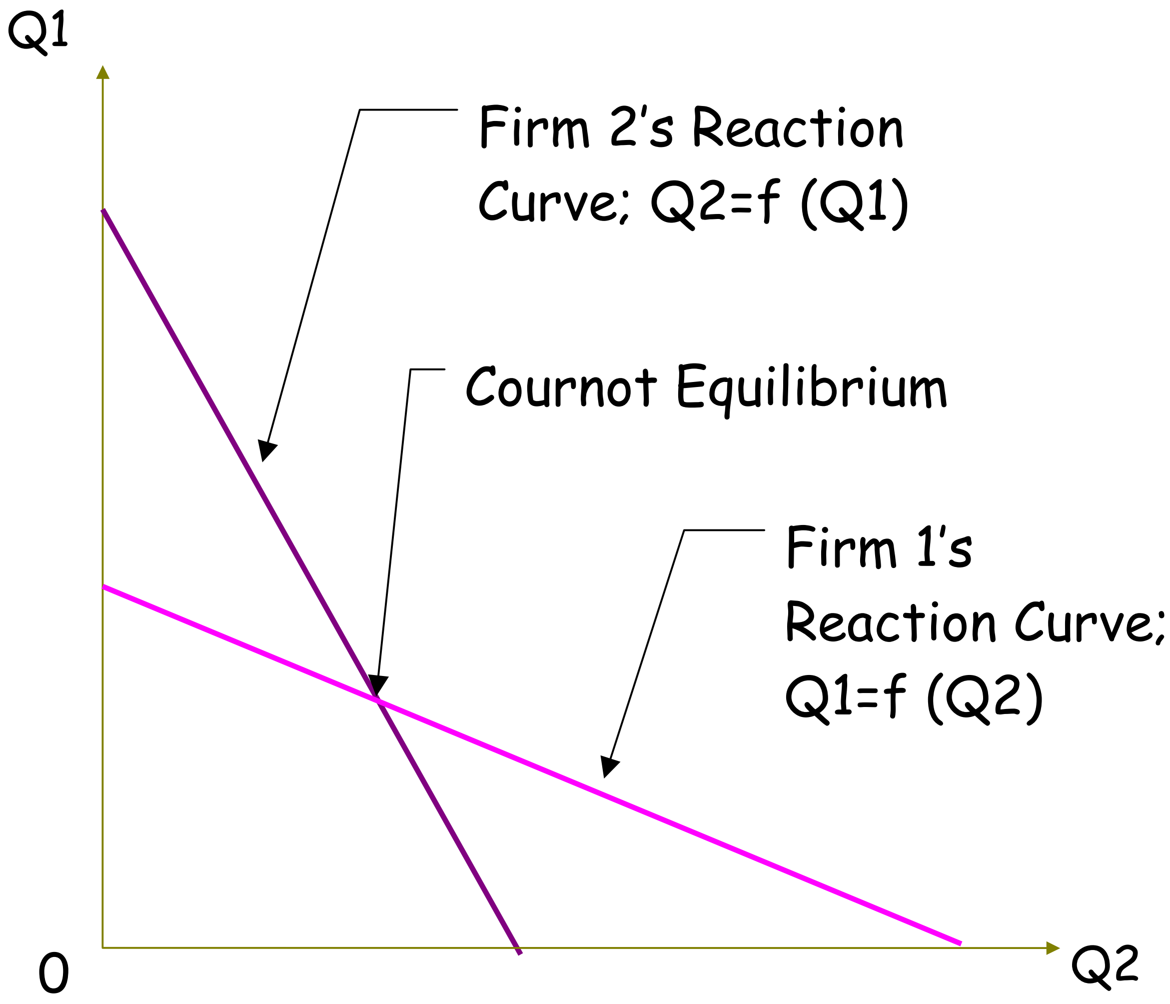
If Firm 1 believes that Firm 2 will supply the entire market then it will supply nothing
Firm 2 is acting as if it is in a perfectly competitive industry.

If Firm 1 believes that Firm 2 will supply zero output it becomes a monopoly supplier.

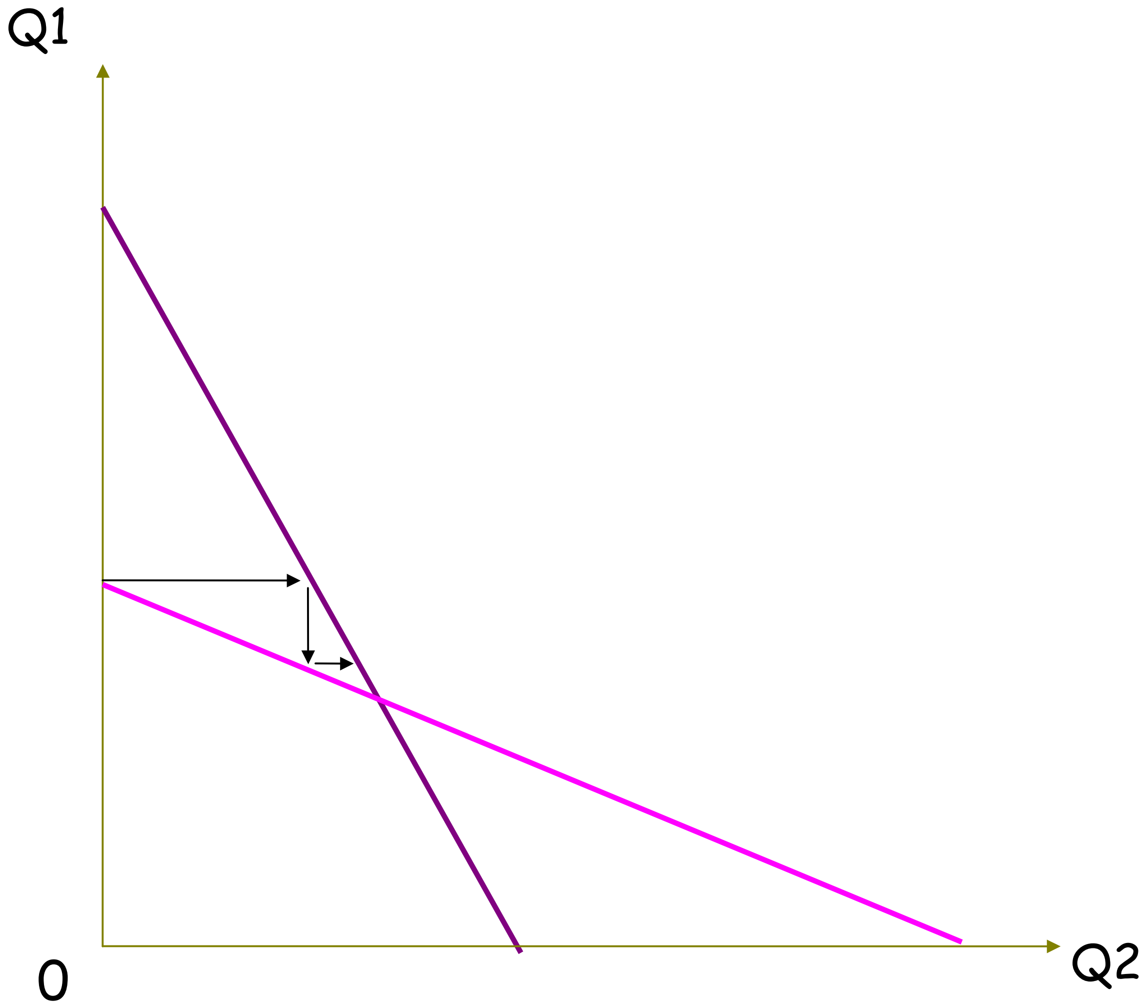



P
Market
Residual
Demand
for Firm 1
MC=AC
MR
D
Q1
30 Q
Q2


Q1
Monopoly;
P>MC
Firm 1s
reaction
Curve
Perfect
Competition; P=MC
0
Q2


Q1
Firm 2's Reaction Curve; Q2=f (Q1)
Cournot Equilibrium
Firm 1's Reaction Curve; Q1=f (Q2)
0
Q2

Convergence to Equilibrium



A numerical example

Assume there are 2 firms who supply salt in the country of Acirema and that entry to that market is blockaded. Further assume that market demand takes the following form

$$P = 30 - Q$$

where $Q = Q1 + Q2$ and $Q1 = Q2$

i.e. industry output constitutes firm 1 and firm 2's output respectively and both firms share the market.

Finally, assume that average (AC) and marginal cost (MC)

$$AC = MC = 12$$

Our task is to find the Cournot (oligopoly) equilibrium in quantity and price and compare this with equilibrium under perfect competition and monopoly. By doing this we can discover the potential welfare outcomes from each model.

To find the profit maximising output of Firm 1 given Firm 2's output we need to find Firm 1's marginal revenue (MR) and set it equal to MC. So,

Firm 1's Total Revenue is

$$R1 = (30 - Q)\,Q1$$

$$R1 = [30 - (Q1 + Q2)]\,Q1$$

$$\underline{= 30Q1 - Q1^2 - Q1Q2}$$

Firm 1's MR is thus

$$\underline{\underline{MR1 = 30 - 2Q1 - Q2}}$$

If MC=12 then

$$Q1 = 9 - \frac{1}{2}Q2$$

This is Firm 1's Reaction Curve.

If we had begun by examining **Firm 2's** profit maximising output we would find its **reaction curve**, i.e.

$$Q2 = 9 - \frac{1}{2}Q1$$

We can solve these 2 equations and find equilibrium quantity and price.

Solving for Q1 we find

$$Q1 = 9 - \frac{1}{2}\left(9 - \frac{1}{2}Q1\right)$$

$\underline{Q1 \quad = 6}$

Similarly,

$\underline{Q2 \quad = 6}$

That is, assuming similar cost structures, equilibrium occurs where both firms supply equal quantities.

Equilibrium Price is given by what demand will bear at this output. In this case

$\underline{P \quad = 18}$

This equilibrium can be compared with that of perfect competition and monopoly.

1. Perfect Competition

Under perfect competition firms set prices equal to MC. So,

$P = \quad 12$

and equilibrium quantity

$Q = \quad 18$

Assuming both supply equal amounts, Firm 1 supplies 9 and so does Firm 2.

2. Monopoly

In this case we need to ask what would be the equilibrium price and output if both firms colluded (assuming that they would not face some regulatory penalty). To understand this we need to consider each firm as part of a multi-plant monopoly.

They would then maximise **industry** profits and share the spoils.

$TR \quad = PQ \quad = (30 - Q)Q \quad = 30Q - Q^2$

$\underline{MR \quad = 30 - 2Q}$

As MC equals 12 industry profits are maximised where

$30 - 2Q = 12$

$\underline{Q = 9}$

So

$\underline{Q1 = Q2 = 4.5}$

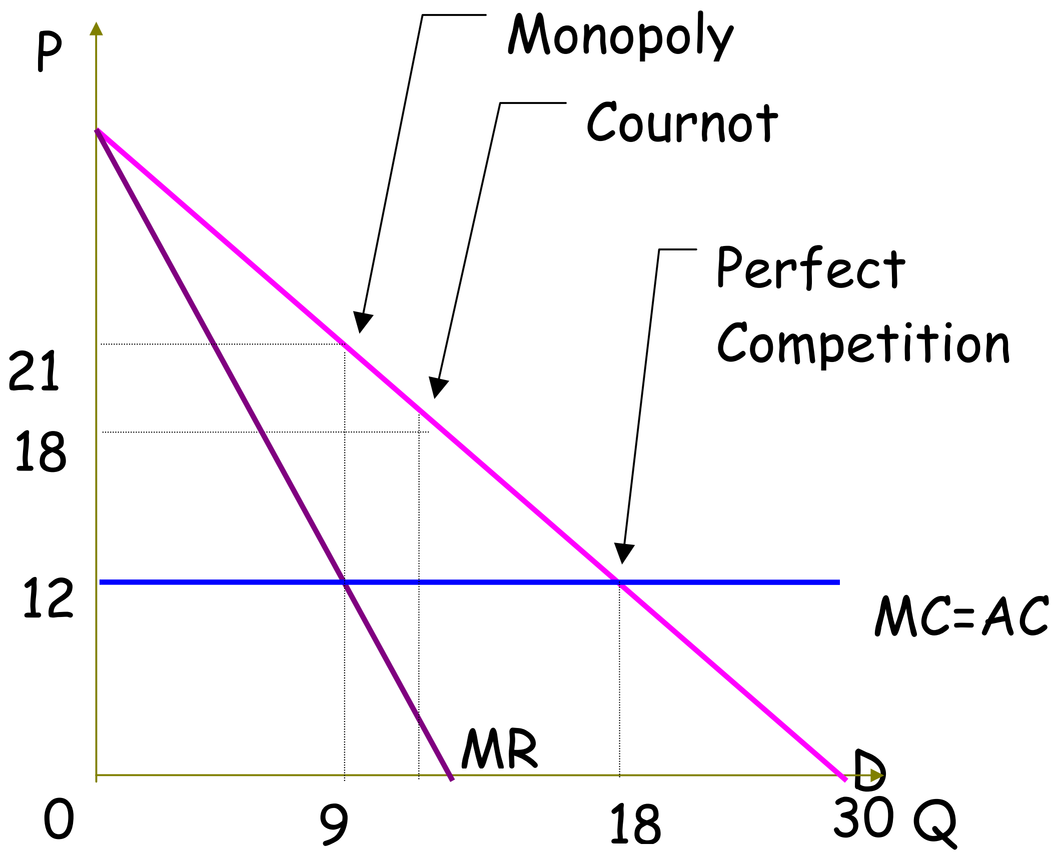
Equilibrium price

$\underline{P = 21}$

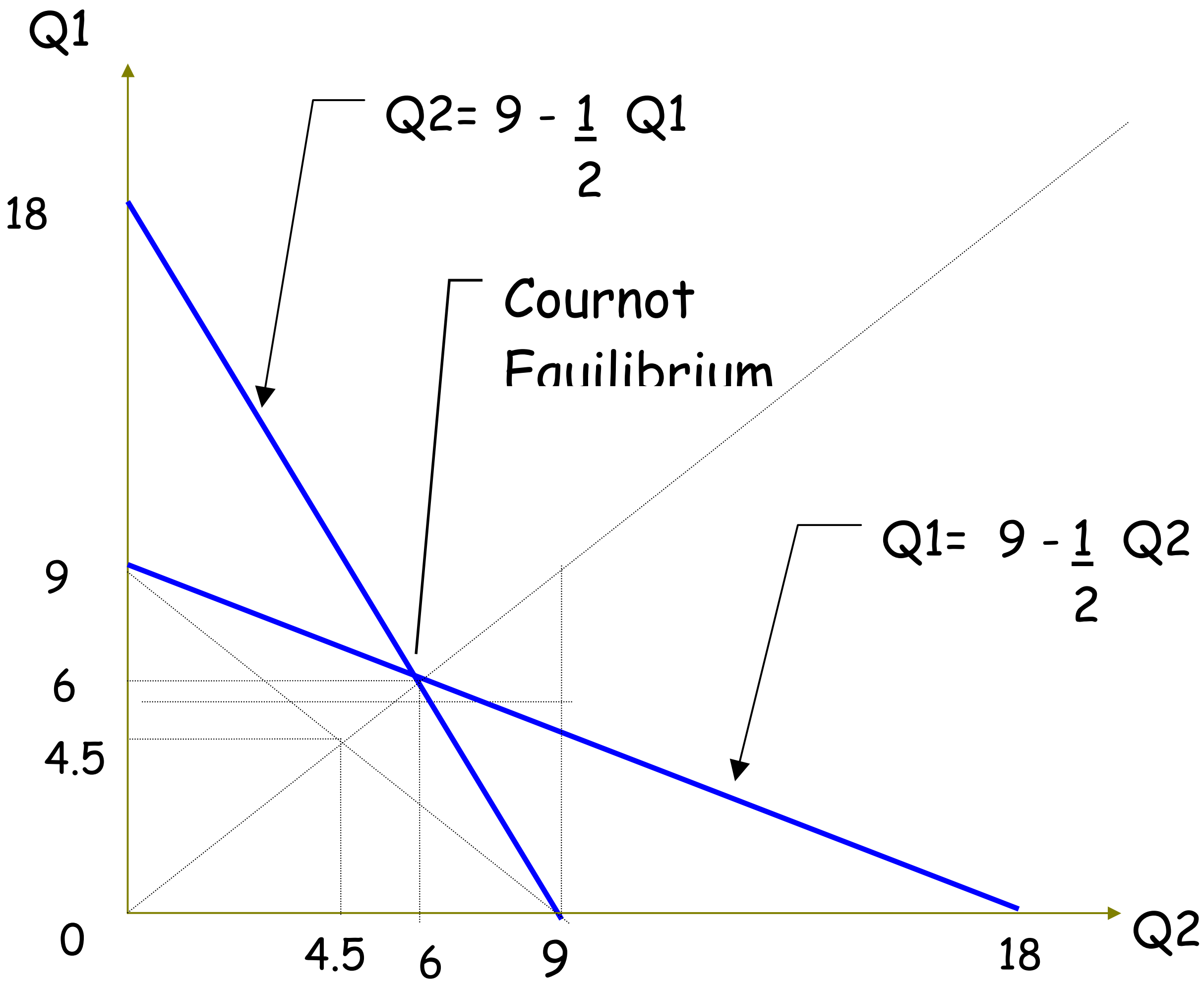
We can use this information to show that two firms operating under Cournot assumptions offer a better welfare outcome than under monopoly.

We first use the traditional monopoly diagram and then show the outcome using reaction curves.

Cournot Equilibrium compared using a traditional Monopoly diagram



Cournot Equilibrium compared using Reaction Curves



A further point that must be considered is that if the number of firms increases then the Cournot equilibrium approaches the competitive equilibrium.

In our example the Cournot equilibrium output was 2/3s that of the perfectly competitive output. It can be shown that if there were 3 firms acting under Cournot assumption then they would produce 3/4s of the perfectly competitive output level. More generally, the equilibrium rate of output under Cournot assumptions, Q, is

$$Q \quad = nq \quad = \quad \frac{n \,.\, Q_{pc}}{(n+1)}$$

where n = number of firms
q = individual firm output
Q_{pc} = output under perfect competition

Heinrich von Stackelberg (1934)

Stackelberg's duopoly model assumed that one firm acts as a dominant firm in setting quantities. Dominance implies knowledge of the way competitors will react to any given output set by the leading firm (in the Cournot model neither firm had the opportunity to react). A dominant firm can then select that output which yields the maximum profit for itself.

We can use our numerical example to show the welfare outcome under Stackelberg's assumption of one dominant firm and one (passive) follower. We will assume that Firm 1 is the dominant firm and thus has prior knowledge of Firm 2s reaction curve.

So, Total Revenue for Firm 1 is as under Cournot

$$R1 \quad = \underline{30Q1 - Q1^2 - Q1Q2}$$

But Firm 1 knows Firm 2s reaction curve so

$$R1 \quad = 30.Q1 - Q1^2 - Q1.(9 - \frac{1}{2}Q1)$$

$$R1 \quad = 21.Q1 - \frac{1}{2}Q1^2$$

Thus,

$$MR1 \quad = 21 - Q1$$

which when equated with MC (=12) to find Firm 1s equilibrium output gives

$$12 \quad = 21 - Q1$$

$$\underline{\underline{Q1 \quad = 9}}$$

$$\underline{\underline{Q2}} \quad = 9 - \frac{1}{2}Q1 = \underline{\underline{4.5}}$$

Equilibrium price for this combined output is

$$P = 30 - Q$$

$$\underline{P = 16.5}$$

Thus, we can see that in a duopoly framework Stackelberg assumptions offer better welfare outcomes than Cournot.

Questions

1. ***Can you position the Stackelberg equilibrium on the above diagrams?***
2. ***What levels of abnormal profit do you associate with each equilibrium position?***
3. ***What would happen to the Cournot and Stackelberg equilibria if the marginal cost of Firm 1 was 10 whilst Firm 2's MC remained unchanged?***

What does all this mean?

In terms of the SCP approach these oligopoly models are addressing the role of conduct (albeit in a simple way) as well as structure. There is clearly a link between these variables and economic performance.

We can predict that if a duopoly exists, and the volume of homogenous goods sold is the main competitive weapon, then it would be better for society if the market operated under Stackelberg assumptions about behaviour. So, if the Government were to consider privatising or liberalising an industry so that two firms were to make up an industry it would be better to allow one firm to have dominance.

If Cournot behaviour prevails then firm numbers becomes important.

Interestingly, if product differentiation prevails then this may increase the level of welfare loss.

The implication of this is that market power still matters and the academic debate is now couched in terms of the nature of conjectural variations within industries, i.e. there is more sophisticated analysis of behaviour.

Unequal sized firms and Firm market Power

(You can follow the argument used in the next 3 sections in Chapter 5 of Martin S, 1994)

If costs differ across firms, as implied in question 3 above, then market power will differ from firm to firm. We know that the Lerner Index of market power shows that there is a relationship between the mark up over the competitive price and price elasticity of demand as shown below.

$$\frac{P - c}{P} = \frac{1}{e}$$

This shows that when elasticity is large, a small increase in price leads to a large decline in sales, suggesting that the monopolist cannot raise price as high above marginal cost as if e were small.

Extending this idea to oligopoly where firms have unequal market shares, the market power of firm i is

$$\frac{P - c_i}{P} = \frac{S_i}{e}$$

Where S is firm i's market share.

In Cournot oligopoly modelling each firm is acting independently and fails to understand what the other is doing. However, the fact that firm i has a very large market share (i.e. S_i approaches 1), and has little understanding of what its rivals are doing is of little consequence for market price. Big firms have more control over price than little ones and so, have more market power.

Industry performance and unequally sized firms.

If we aggregate each firms market share we get an equation such as that below where H = the Herfindahl index of market concentration and C̄, the industry average marginal cost.

$$\frac{P - \bar{C}}{P} = \frac{H}{e}$$

Clearly, there is interdependence in this market, but no cooperation. Each firm restricts its output given what it anticipates the other to do. In addition, each firm believes that it will not affect a rival's revenue if it puts more onto the market. However, with fewer firms in the market output restrictions are greater which pushes up prices. As a consequence independent decision making effects are more limited – these push prices down. With Cournot oligopolists, more concentrated market structures give rise to higher than average industry market power. This was a principal result of Cowling and Waterson (1976).

Varying Reactions

There has been much criticism of the 'naïve' Cournot model in which each firm believes that its rivals will hold their output constant (a zero conjectural variation). This criticism can be overcome by introducing a new parameter, α, which measures the elasticity of rivals' output with respect to firm i's output, namely

$$\alpha_i = \frac{\Delta q_{-i} / q_{-i}}{\Delta q_i / q_I} = \frac{q_i}{q_{-I}} \cdot \frac{\Delta q_{-i}}{\Delta q_I}$$

where q_{-i} is the output of all firms except i.

If α_i = 0 then we have the basic Cournot assumption.

If α_I = 1 then firm i will believe that a reduction or increase in output of 1 per cent will be mirrored by its rivals.

α_I = -1 then firm i will believe that a reduction or increase in output of 1 per cent will be offset by symmetrically opposite responses by its rivals.

For n firms with unequal costs, the general case becomes

$$\frac{P - c_i}{P} = \frac{\alpha_i + (1 - \alpha_i)S_i}{e}$$

So the extent to which rivals' output can alter firm i's market power depends crucially on i's market share. Firm i will have market power so long as

$$\alpha_i + (1 - \alpha_i)S_I > 0$$

e.g. if S_i = 0.9 then the left hand side of the above equation will be positive so long as α_i does not fall below –9. This means that if firm i's rivals are small in relation to the market, they must meet a 1% reduction in i's output with a 9% increase in their own output.

But what market power does a firm have if S_i = 0.1 and α_i = -0.9?

Finally, we can extend the analysis to the industry level.

$$\frac{P - \bar{C}}{P} = \frac{\alpha + (1 - \alpha)H}{e}$$

If α = 1, the industry average degree of market power is the inverse of e, as under monopoly.

If α is between 0 and 1, the market power index rises as H rises

Joseph Bertrand (1883)

Bertrand argued that a major problem with the Cournot model is that it failed to make price explicit. Indeed, he showed that if firms compete on price when goods are homogenous, at least in consumer's eyes, then a price war will develop such that price approaches marginal cost.

However, when firms produce differentiated products such that all market sales do not disappear for a slightly higher priced firm, then equilibrium at above the competitive price is possible.

In such differentiated product models results much closer in spirit to Cournots may be obtained.

Bertrand and Product differentiation

2 firms have fixed costs of £20 and zero variable costs face the same demand curves

$Q_1 = 12 – 2P_1 + P_2$

$Q_2 = 12 – 2P_2 + P_1$

Note that the quantity each sells falls at it raises its own price but rises as its rival increases their price.

Here we are going to calculate each firm's reaction function, which in this case represents a firms profit maximising price given what it expects its rivals price to be.

For Firm 1Total Revenue (R_1)

$R_1 = P_1Q_1$
$R_1 = 12P_1 – 2P_1^2 + P_2P_1$

Marginal Revenue

$MR_1 = 12 – 4P_1 + P_2$

In this case MC = 0, so establishing the profit maximising condition and solving for P_1.

$P_1 = 3 + 0.25P_2$

And similarly

$P_2 = 3 + 0.25P_1$

Equilibrium Price = 4 and Quantity = 16, ($Q_1 = Q_2 = 8$).

Comparisons with a Collusive Equilibrium

Here the firms maximise industry profits, so

$\pi_1 = P_1 Q_1 – 20 = 12P_1 – 2P_1^2 + P_2P_1 – 20$

$\pi_2 = P_2 Q_2 – 20 = 12P_2 – 2P_2^2 + P_1P_2 – 20$

Note that under collusion $\pi = \pi_1 + \pi_2$
So

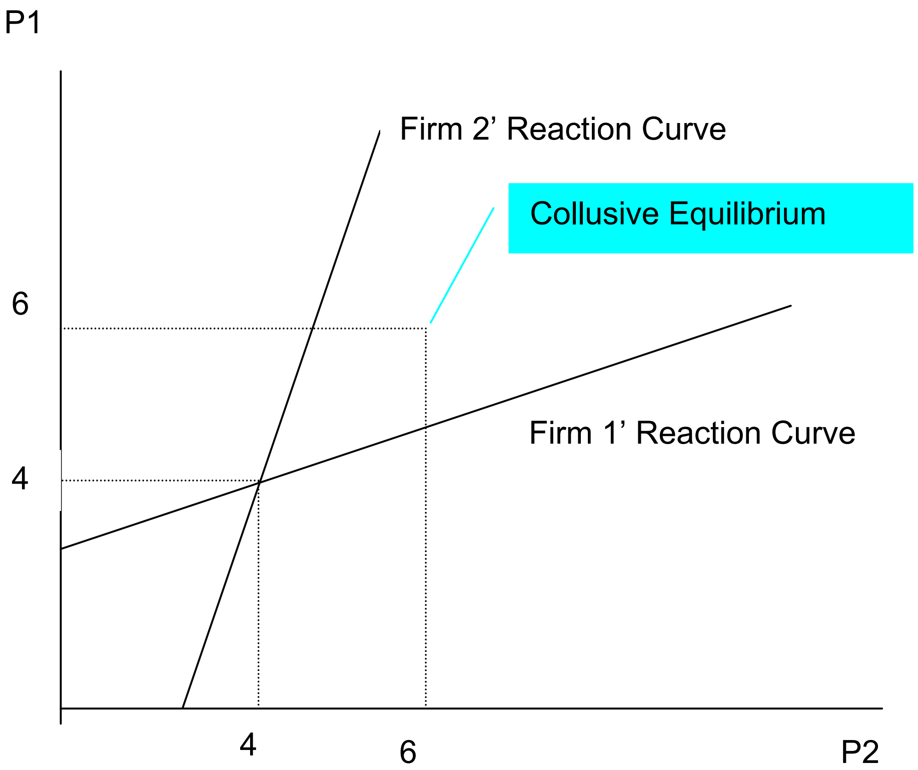
$\pi = 24P – 4P^2 + 2P^2 – 40$

and π is maximised where

$\Delta\pi/\Delta P = 24 – 4P = 0$

P = 6

And Q1 = Q2 = 6.



Reading

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Martin S (1994) *Industrial Economics. Economic Analysis and Public Policy*, Maxwell Macmillan International, Oxford.

Shepherd, W.G. (1990) *The Economics of Industrial Organisation*, Prentice Hall International, London. Ch 12. Probably the simplest explanation

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