University of Zurich[UZH]

Leseaufträge «Mikroökonomik I»

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Unit 3:

- Oligopol

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- **Chapter 14 – Imperfect Competition**
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CHAPTER

14

IMPERFECT COMPETITION

The English are known for a fascination with the weather and house prices. Recently you could add energy prices to the list. The average household gas and electricity bill almost doubled between 2005 and 2013 from an average of under £700/year to over £1,300/year.[1] During this same period wages were relatively stagnant but the profits of the 'big 6' energy companies stayed remarkably high.

Against this backdrop the leader of the opposition Labour party, Ed Miliband, announced at his party's 2013 conference a bold new policy. If elected into power his party would freeze energy prices for at least 20 months. It became immediately clear that this was a vote-winning policy. It will almost certainly be remembered as the highpoint of Miliband's political career.

The beauty of the proposed solution is that it seems so blindingly simple! If energy prices are rising too quickly then freeze them. Problem solved. But if the problem was that easy to solve, why had no one thought of it before? They had. As we mentioned in Chapter 2, governments have a long history of trying to artificially fix prices. Rarely does such intervention work.

Something, though, was clearly not working in the UK energy market. If artificially fixing prices would not solve the problem, then what would? To answer that question we need to look at what happens in markets where the supply side is dominated by a small number of big firms.

[1]Information on energy prices and the profits of energy companies are available from the regulator Ofgem at www.ofgem.gov.uk.

The Cournot Model

We begin with the simplest case, the so-called **Cournot model**, in which each firm assumes that its rivals will continue producing at their current levels of output. Named for the French economist Auguste Cournot, who introduced it in 1838, this model describes the behaviour of two firms that sell bottled water from mineral springs.

Cournot model oligopoly model in which each firm assumes that rivals will continue producing at their current output levels.

The central assumption of the Cournot model is that each duopolist treats the other's quantity as a fixed number, one that will not respond to its own production decisions. This is a weak form of interdependence, indeed, but we will see that even it leads to an outcome in which the behaviour of each firm substantially affects its rival.

Suppose the total market demand curve for mineral water is given by

$$P = a - b\,(Q_1 + Q_2) \tag{14.6}$$

where a and b are positive numbers and Q_1 and Q_2 are the outputs of firms 1 and 2, respectively. Cournot assumed that the water could be produced at zero marginal cost, but this assumption is merely for convenience. Essentially similar conclusions would emerge if each firm had a constant positive marginal cost.

Let us look first at the profit-maximization problem facing firm 1. Given its assumption that firm 2's output is fixed at Q_2, the demand curve for firm 1's water is given by

$$P_1 = (a - bQ_2) - bQ_1 \tag{14.7}$$

which is rewritten to emphasize the fact that firm 1 treats Q_2 as given.

As Equation 14.7 shows, we get the demand curve for firm 1 by subtracting bQ_2 from the vertical intercept of the market demand curve. The idea is that firm 2 has skimmed off the first Q_2 units of the market demand curve, leaving firm 1 the remainder to work with.

If Q_2 were equal to zero, firm 1 would have the entire market demand curve to itself, as is indicated by D in Figure 14.10. If Q_2 is positive, we get firm 1's demand curve by shifting the vertical axis of the demand diagram rightward by Q_2 units. Firm 1's demand curve is that portion of the original demand curve that lies to the right of this new vertical axis, and for this reason it is sometimes called a *residual demand curve*. The associated marginal revenue curve is labelled MR_1. Firm 1's rule for profit maximization is the same as for any other firm that faces a downward-sloping demand curve, namely, to equate marginal revenue and marginal cost. Marginal cost in this example is assumed to be zero, so the profit-maximizing level of output for firm 1 is that level for which its marginal revenue curve takes the value of zero.

The equilibrium outputs for a Cournot duopoly can be deduced from the residual demand diagram. Given that firm 2 is producing Q_2, firm 1 maximizes its profits by producing where marginal revenue equals marginal cost. Marginal revenue for firm 1 is given by $\mathrm{MR}_1 = (a - bQ_2) - 2bQ_1$. Marginal revenue has twice the slope as demand, so marginal revenue intersects zero marginal cost at half the distance from the $Q_1 = 0$ axis to the horizontal intercept of the demand curve. By symmetry (the two firms are identical so they must behave the same), $Q_2 = Q_1$, which means that each of the three segments shown on the horizontal axis in Figure 14.10 has the same length. And this implies that each firm produces output equal to one-third of the distance from the

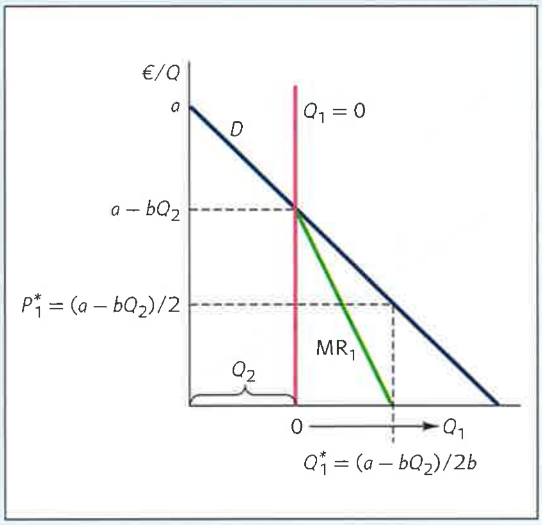


FIGURE 14.10
The Profit-Maximizing Cournot Duopolist
The Cournot duopolist's demand curve is obtained by shifting the vertical axis rightward by the amount produced by the other duopolist (Q_2 in the diagram). The portion of the original market demand curve that lies to the right of this new vertical axis is the demand curve facing firm 1. Firm 1 then maximizes profit by equating marginal revenue and marginal cost, the latter of which is zero.

origin to the horizontal intercept of the demand curve. The demand curve $P = a - bQ$ has a horizontal intercept of $Q = a/b$; hence, $Q_1 = Q_2 = a/(3b)$.

A more general approach is to set marginal revenue equal to marginal cost and solve for the output of firm 1 in terms of the output of firm 2. Given that, in this example, marginal cost is zero we set $(a - bQ_2) - 2bQ_1 = 0$ to get

$$Q_1^* = \frac{a - bQ_2}{2b} \tag{14.8}$$

Economists often call Equation 14.8 firm 1's **reaction function**, and denote it by $Q_1^* = R_1(Q_2)$. This notation is suggestive because the reaction function tells how firm 1's quantity will react to the quantity level offered by firm 2.

reaction function a curve that tells the profit-maximizing level of output for one oligopolist for each amount supplied by another.

Because the Cournot duopoly problem is completely symmetric, firm 2's reaction function has precisely the same structure:

$$Q_2^* = R_2(Q_1) = \frac{a - bQ_1}{2b} \tag{14.9}$$

The two reaction functions are plotted in Figure 14.11. To illustrate the workings of the reaction function concept, suppose firm 1 initially produced a quantity of Q_1^0. Firm 2 would then produce the level of output that corresponds to Q_1^0 on its reaction function. Firm 1 would respond to that output level by picking the corresponding point on its own reaction function. Firm 2 would then respond by picking the corresponding point on its reaction function, and so on. The end result of this process is a stable equilibrium at the intersection of the two reaction functions.

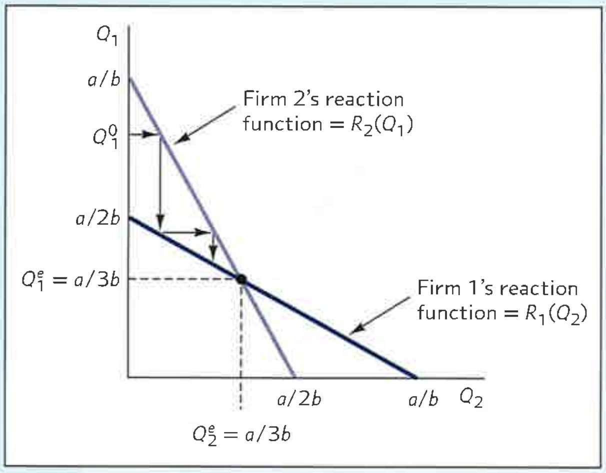
To solve algebraically for firm 1's equilibrium level of output, we substitute $Q_1^* = Q_2^*$ into its reaction function and solve:

$$Q_1^* = \frac{a - bQ_1^*}{2b} \tag{14.10}$$

This yields equilibrium $Q_1^* = a/3b$.

As already discussed, when both firms are producing $a/3b$ units of output, neither firm has any incentive to change output. Hence the outcome is stable. Note that this also means the equilibrium outcome constitutes a Nash equilibrium for the Cournot duopolists. To appreciate this point, recall (see Chapter 3) that a Nash equilibrium is a combination of strategies such that no player has any incentive to change strategy. In Cournot equilibrium we have two players, the duopolists, who have no incentive to change output.

FIGURE 14.11
Reaction Functions for the Cournot Duopolists
The reaction function for each duopolist gives its profit-maximizing output level as a function of the other firm's output level. The duopolists are in a stable equilibrium at the point of intersection of their reaction functions.

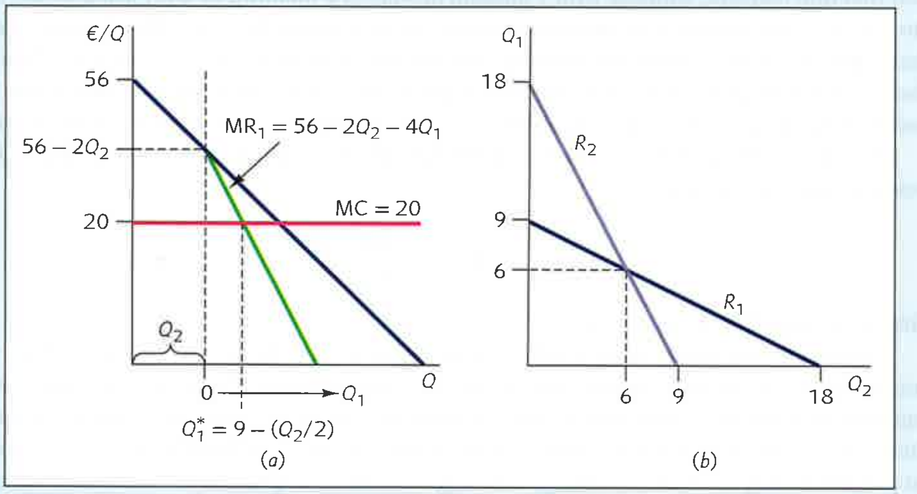


How profitable are the Cournot duopolists? Since their combined output is $2a/3b$, the market price will be $P = a - b(2a/3b) = a/3$. At this price, each will have total revenue equal to $(a/3)(a/3b) = a^2/9b$. And since neither firm has any production costs, total revenues and economic profits here are one and the same.

EXAMPLE 14.1 Cournot duopolists face a market demand curve given by $P = 56 - 2Q$, where Q is total market demand. Each can produce output at a constant marginal cost of 20/unit. Graph their reaction functions and find the equilibrium price and quantity.

Figure 14.12(a) shows the residual demand curve facing firm 1 when firm 2 produces Q_2 units. Firm 1's marginal revenue curve has the same vertical intercept as its demand curve and is twice as steep. Thus the equation for firm 1's marginal revenue curve is $\text{MR}_1 = 56 - 2Q_2 - 4Q_1$. Equating MR_1 to marginal cost (20), we solve for firm 1's reaction function, $Q_1^* = R_1 = 9 - (Q_2/2)$. By symmetry, firm 2's reaction function is $R_2 = 9 - (Q_1/2)$. The two reaction functions are shown in Figure 14.12(b), where they intersect at $Q_1 = Q_2 = 6$. Total market output will be $Q_1 + Q_2 = 12$. Consulting the market demand curve, we see that the market price will be $P = 56 - 2(12) = 32$. ◆

FIGURE 14.12
Deriving the Reaction Functions for Specific Duopolists
Panel (a) shows the profit-maximizing output level for firm 1 (Q_1^*) when firm 2 produces Q_2. That and the parallel expression for firm 2 constitute the reaction functions plotted in panel (b).



EXERCISE 14.4 Repeat Example 14.1 with the two firms facing a market demand curve of $P = 44 - Q$.

You may be wondering why the Cournot duopolists assume that their own production decisions will be ignored by their rivals. If so, you have asked a penetrating question, the same one posed by Cournot's critic, the French economist Joseph Bertrand. Let us now consider his alternative solution to the duopoly problem.

The Bertrand Model

Bertrand's insight was that from the buyer's perspective, what really counts is how the prices charged by the two firms compare. Since the duopolists are selling identical mineral water, every buyer will naturally want to buy from the seller with the lower price. The **Bertrand model** proposed that each firm chooses its price on the assumption that its rival's price would remain fixed. On the face of it, this assumption seems no more plausible than Cournot's, and since prices and quantities correspond uniquely along market demand curves, it may seem natural to wonder whether Bertrand's assumption even leads to a different outcome. On investigation, however, the outcomes turn out to be very different indeed.

Bertrand model oligopoly model in which each firm assumes that rivals will continue charging their current prices.

To illustrate, suppose the market demand and cost conditions are the same as in the Cournot example. And suppose firm 1 charges an initial price of P_0^1. Firm 2 then faces essentially three choices: (1) it can charge more than firm 1, in which case it will sell nothing; (2) it can charge the same as firm 1, in which case the two firms will split the market demand at that price; or (3) it can sell at a marginally lower price than firm 1, in which case it will capture the entire market demand at that price. The third of these options will always be by far the most profitable if price is above marginal cost.

As in the Cournot model, the situations of the duopolists are completely symmetric in the Bertrand model, which means that the option of selling at a marginally lower price than the competition will be the strategy of choice for both firms. Needless to say, there can be no stable equilibrium in which each firm undersells the other. The back-and-forth process of price-cutting will continue until it reaches its natural economic limit—namely, marginal cost, which in the mineral water example is zero. (If instead we had considered an example in which both firms have the same positive marginal cost, price would have fallen to that value.) Once each firm has cut its price to marginal cost, it will have no incentive to cut further. With each firm selling at marginal cost, the duopolists will share the market equally.

EXAMPLE 14.2 Bertrand duopolists face a market demand curve given by $P = 56 - 2Q$. Each can produce output at a constant marginal cost of 20/unit. Find the equilibrium price and quantity.

The solution is that both firms price at marginal cost $P = \text{MC} = 20$. Industry output is determined by market demand: $20 = 56 - 2Q$ implies $Q = 18$. The firms split the market equally, so each firm produces half of industry output $Q_1 = Q_2 = Q/2 = 9$. ◆

EXERCISE 14.5 If the market demand curve facing Bertrand duopolists is given by $P = 10 - Q$ and each has a constant marginal cost of 2, what will be the equilibrium price and quantity for each firm?

So we see that a seemingly minor change in the initial assumptions about firm behaviour—that each duopolist takes its rival's price, not quantity, as given—leads to a sharply different equilibrium.

ECONOMIC NATURALIST 14.5

Why are house prices so high and mortgage rates so low?

If it sounds a bit disconcerting that we have two different models that give radically different conclusions, it need not be. In some markets the Cournot model is most apt and in others the Bertrand model.

The Cournot model is most apt if firms independently decide how much to produce, and then sell their goods. The important thing is that production takes place *before* price is determined. In this case the firm has little incentive to undercut a rival because it would soon run out of goods to sell.

The Bertrand model is most apt if firms compete over price, and then produce the amount demanded. In this case production takes place *after* price is determined. The firm has an incentive to undercut a rival because it would be able to produce and then sell as much as required.

To illustrate the differences, compare house sales to mortgage sales. It takes a long while to produce a new house—one needs to obtain planning permission, build the property, etc. In this market quantity is determined well before price. Sure, house buyers haggle over the price with the building firm. But, the firm has no incentive to drop the price too much because it only has a fixed number of houses to sell. This is Cournot competition.

The mortgage company does not face such a constraint. It can easily raise additional money to lend to a creditworthy buyer. Quantity, therefore, is determined after price. That gives mortgage companies an incentive to undercut rivals by offering lower interest rates. This is Bertrand competition. ■