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Cournot Model, Reaction Curves and Bertrand Model

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Lecture No. & Title:	Lecture – 3(One) Cournot Model, Reaction Curves and Bertrand Model

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1. Introduction

An oligopoly market structure is described as the one where only a small number of firms operate in the market and they have a unique behavioural characteristics compared to firms in other market structures. Since each firm in oligopoly market is affected by the decision of its rivals firms, the oligopolists work collusively with their rival firms. However, each oligopolist tries to monitor the activities of rival firms in order to undercut them and capture larger market share.

Entry barriers like economies of scale, high fixed costs, legal barriers, patents or exclusive resource ownership cause the existence of less number of firms in the market. Thus the firms in an oligopoly have the power influence prices and quantities in the market.

In oligopolistic market, the firms are allowed to exert some degree of market power due to which they earn super-normal profits. This increases efficiency in operations, stimulates innovations and encourages risky investments. These, in turn, might deliver benefits in the long-run like decline in production costs or rise in innovations.

2. Cournot Model and Reaction Curves

Cournot's model of duopoly is one of the oldest theories of the behaviour of individual firm and relates to non-collusive oligopoly. Augustin Cournot, a French economist, published his theory of duopoly in 1838 that remained almost unnoticed until 1880's when Walras attracted the attention of economists

towards the contribution of Cournot. In Cournot model, there are limited numbers of firms that compete in a homogeneous product market. Given the use of different technologies the firms take production decisions independently. At the given level of aggregate output and aggregate market demand the market clearing factors determine the product price. The assumptions of Cournot model are given below:

(i) It is a static model. The strategic variable of the firms is their production level.

(ii) The industry faces an aggregate demand function $Q=f(p)$, where Q denotes the aggregate production and p is the given level of price. This assumption implicitly implies (a) a homogeneous product market, (b) a large number of consumers in the market, and (c) total demand for the product at any given price p.

(iii) There are fixed number of firms in the industry and entry or exit in the industry is restricted.

(iv) All the firms aim at maximizing profits. While taking decision, each firm considers the interaction with competing firms. Thus all the firms take their respective production decisions simultaneously.

(v) Each duopolist believes that regardless of the impact of his actions on the market price, the rival firms will keep their output constant or unchanged at the present level.

(vi) The firms do not reconsider their production related decision to satisfy the expectations of rivals.

(vii) Consumers buy consumption bundles that maximize their utility.

According to Cournot the firms decide to install certain level of capacity for their production and thereafter take production related decisions. It is important to note that under Cournot competition, the level of production will be higher than that of monopoly production. Generally the firms will produce such a level of output that remains somewhere between perfectly competitive output and monopoly output. The market outcome is stable price-quantity equilibrium, where no firm has the incentive to change the level of output. This results in the setting of prices above the marginal costs and thus firms gain super-normal profits.

Cournot takes the case of two identical mineral springs operated by two owners and assumed for the sake of simplicity, that the owners operate mineral springs and sell water without incurring any production cost. Thus, in Cournot's model, cost of production is taken as zero and only the demand side of the market is analyzed. It may be noted that the assumption of zero cost of production is made only to simplify the analysis.

Suppose the demand curve confronting the two producers of mineral water is a straight line MD as shown in Figure 1. Also suppose that ON = ND is the maximum daily output of each mineral spring. Thus, the total output of both the springs is OD = ON + ND. Hence the sale price must fall to zero in order to achieve a long-run equilibrium with zero-profit under perfect competition. Thus, the Cournot model can be presented when the cost of production is positive.

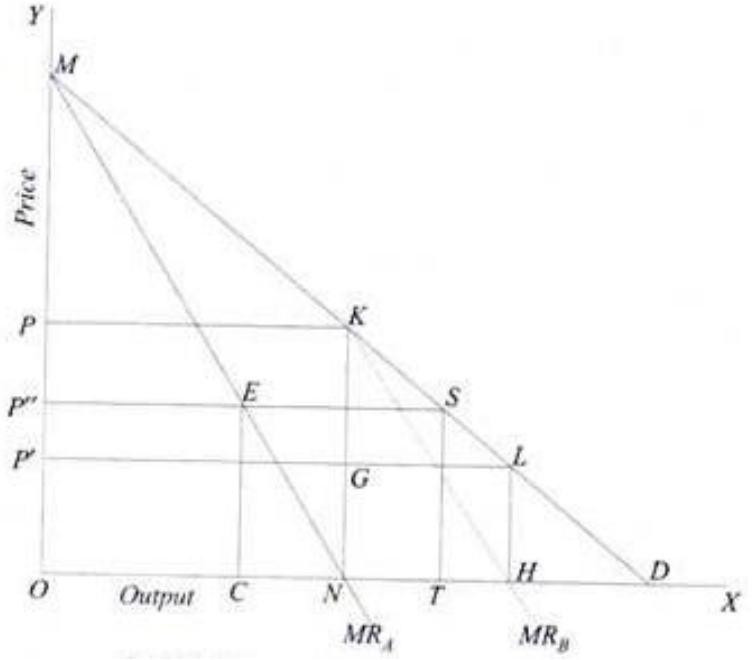

Fig.1 : Cournot's Duopoly Solution

To understand the Cournot equilibrium, let producer A is the first one to start business first. Therefore, initially he will be a monopolist and his daily production will be ON because at ON level of output he will charge OP price due to which his profits will be maximum ONKP. Since the marginal and average costs are zero, the whole of total revenue ONKP will represent profits. Therefore, the marginal revenue curve MR_A of producer A will intersect X-axis at point N.

Suppose firm B, the owner of other spring, also enters into business by operating his spring. Producer B knows that A is producing ON quantity of output. According to the assumption of Cournot model, producer B believes that producer A will continue producing ON level of output (which is ½ of total demand OD), regardless of whatever output he himself decides. Given this belief, the best that producer B can do is to regard segment KD as his demand curve. With demand curve KD, and corresponding marginal revenue curve MR_B, producer B will produce NH quantity of output (which is ½ of ND). Now total

output will ON+NH=OH, due to which price will fall to OP' or HL. Now total profits made by the two producers A and B will be OHLP' which are less than ONKP. Out of total profits OHLP', profits of producer A will be ONGP' and profits of producer B will be NHLG.

Thus the entry of producer B in the market has reduced the profits of producer A. To earn more profits, A will reconsider the situation by assuming that producer B will continue to produce quantity NH. Now the best that producer A can do is to produce ½ of OD-NH due to which his production will fall below his capacity ON.

When B gets information about the reduction of output by A and also finds that his share of total profits is less than that of producer A, he will reconsider his production. Thinking that producer A will continue to produce at his new level of production, B will find that by producing output equal to ½ of OD–New output of A, he will now make maximum profits. Thus producer B will increase his production. Now again this move of producer B will reduce the profits of A.

Therefore, producer A will again reconsider his decision to increase his profits by producing output equal to ½ of OD–Current output of producer B. This process of adjustment and readjustment will continue until total output OT is produced (OT=2/3rd of OD) and each one of them produces equal quantity of output which is equal to 1/3rd of OD. At the end producer A will produce quantity OC and producer B will produce quantity CT and quantity OC equals quantity CT.

Although Cournot model is fairly popular, it contains a contradiction because the stability is by definition a dynamic property.

3. Reaction Functions and Cournot Duopoly Equilibrium

Cournot solution to duopoly problem can be obtained with reaction functions of the two firms. The reaction function approach is a more powerful method of analyzing the oligopolistic markets because it allows the relaxation of the assumption of identical costs and identical demands. This approach is based on the Stackelberg's indifference curve analysis which introduces the concept of isoprofit curves of competitors. An output reaction function that explains the profit-maximizing output of a firm is based on the assumption that the other firm's output remains constant. The profit-maximizing output of a Cournot's duopolist is determined by the market demand at which product price equals the marginal cost. The level of output and total profits is maximized at a price that equals marginal cost (MC). Further additions to output will cause a fall in price below marginal cost and reduction in profits.

Some economists explain duopoly equilibrium by making use of reaction curves. The reaction curves refer to the sellers' own reactions to the moves of his rival. The reaction curves may be output reaction curves or price reaction curves depending upon the situation whether the adjustment viable is output or price. In Cournot model, output is considered as the adjustment variable.

Figure 2 illustrates the output reaction curves of two producers A and B. In this figure MN is the output reaction curve of A and RS is the output reaction curve of B. The output reaction curve MN

of A shows how A will react to any change in output by B. In other words A's output reaction curve shows how much output A will decide to produce for a given output of producer B.

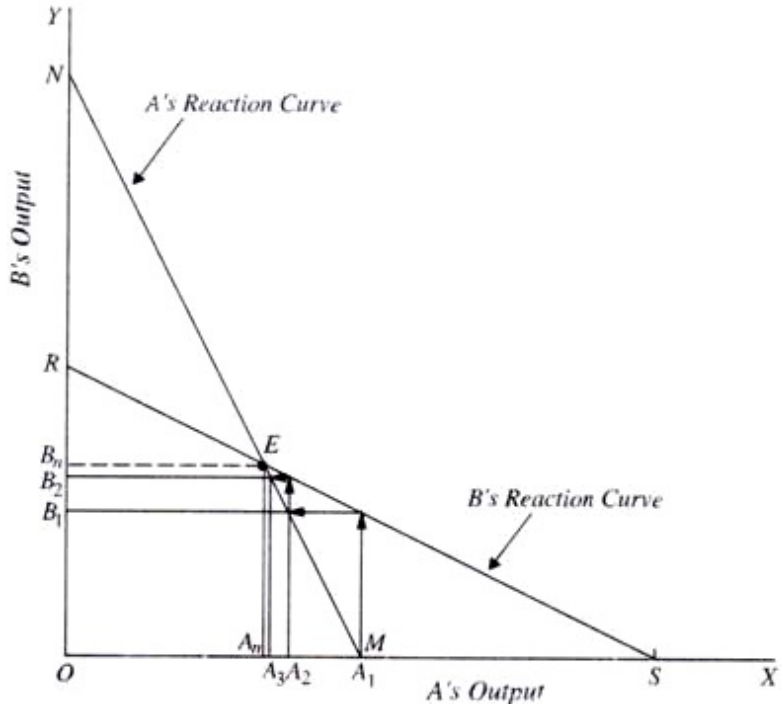

Figure 2: Output Reaction Curves in Cournot Model

In figure2 if firm B produces OB_1 quantity then the reaction curve MN shows that A will produce OA_2 in response to B's output OB_1. Similarly, firm B's reaction curve RS states that if A produces OA_2, B's output reaction curve shows that B will produce OB_2 and so on for all other outputs. The output reaction curves in fig.2 have been drawn as straight lines. Therefore it is assumed that the market demand curve for the product is a straight line and the marginal costs of production of both producers A and B are constant (at zero). Given zero marginal cost, a producer will be forced to produce zero output when the price falls to zero. Thus, the Cournot model can be presented when the cost of production is positive.

It should be noted that output OM is the monopoly output of firm A if firm B does not produce. Then A will produce and sell

OM quantity as a monopolist. On the other hand, A will produce zero output if B produces ON quantity. Thus, while OM is the monopoly output, ON is the perfectly competitive output. Under conditions of perfect competition the price will be zero at output ON and equal to marginal cost which is assumed to be zero in the present case.

Assuming the two producers A and B are identical, total output OR will be equal to OM, and OS will be equal to ON. Thus the output reaction curves, as interpreted above, can be used to explain Cournot's duopoly equilibrium. Each producer assumes that his rival will continue to produce the same level of output regardless of what he might himself decide to produce.

To arrive at Cournot duopoly equilibrium, suppose producer A is the first firm to enter in the market and initially produces output OM which is a monopoly output as output of firm B is zero. Now B also enters into business with the assumption that A will keep his output constant at OM. B's output reaction curve RS states that for output OM of A, he will produce OB_1. But when A observes that B is producing OB_1, he will reconsider his previous output decision.

Now A will assume that B will continue to produce OB_1 level of output. The output reaction curve NM of seller A shows that he will produce OA_2 in reaction to output OB_1 of firm B. Subsequently when producer B observes that A is producing OA_2, he will also readjust his output by assuming that A will continue to produce OA_2. Thus producer B's output reaction curve RS would show that he will produce output OB_2 against

output OA_2 by producer A. Likewise when producer A comes to know that B is producing OB_2 he will again readjust his output to level OA_3. This process of adjustments and readjustments will continue until point E is reached where the two reaction curves intersect each other and firm A and firm B produce OA_n and OB_n respectively.

This way the duopolists attain stable equilibrium at the intersection point E. After reaching the equilibrium point E, none of the producer will feel to make further adjustments in their outputs. The reason is that with B producing OB_n, the profit maximizing level of output by A is OA_n as indicated by his reaction curve NM. similarly with A producing OA_n, the most profitable level of output for B is OB_n as shown by his reaction curve RS. It is thus evident from the reaction curve analysis that Cournot's solution yields a unique and stable equilibrium under duopoly.

4. Bertrand model

Joseph Louis Francois Bertrand a French mathematician criticised the Cournot model and stated that quantity is a wrong strategic variable. He advocated that competition between oligopoly firms strategically sets price rather than quantity. Bertrand argued that even if only two firms compete with each other, their price competition will lead to equilibrium at which the product price equals marginal cost. Bertrand's main criticism to Cournot model is that the oligopolists will end up colluding in prices.

Bertrand argued that if firms choose quantities, Cournot model does not specify the mechanism that determines prices. In a perfectly competitive market, it is irrelevant what variables are decided upon because Smith's "invisible hand" makes the markets clear. However, in oligopoly there is no such device. Therefore, a different mechanism determines the price that allows the markets to clear for a given level of production. Thus it may be more reasonable to assume that a firm decides the prices and production is either sold in the market or stocked. Bertrand's duopoly model can be explained with the help of Figure 3.

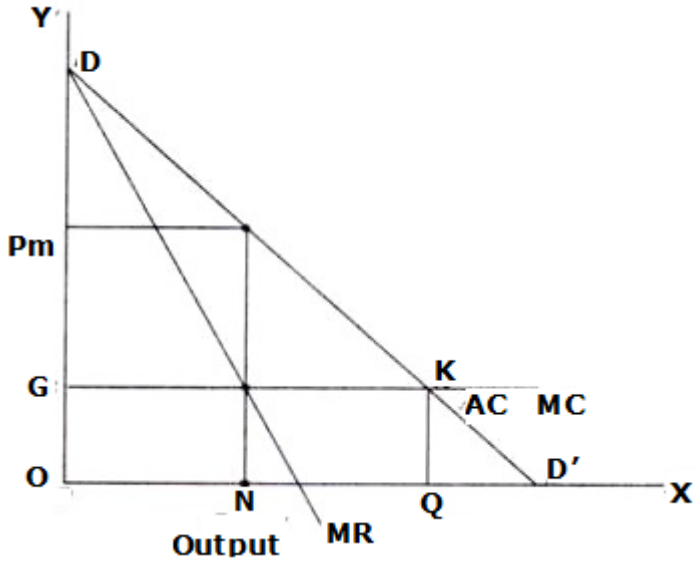

Figure 3: Bertrand's Duopoly Model

Suppose there are two producers A and B. Let DD' is the market demand curve for a homogenous product produced by them. Suppose producer A is the first one to enter the market. He will act as a monopolist and set the price to maximize profits. This monopoly price is Pm at which A produces monopoly output ON which is half of perfectly competitive output OQ. It is assumed that the average and marginal costs are constant and equal to OG.

Now, suppose producer B also starts production of the same product as produced by A. producer B Assumes that A will continue selling at the present price Pm irrespective of whatever price B might set. Further producer B also thinks that he will capture the whole market by slightly reducing his price. Accordingly, B sets a price slightly lower than A's price Pm due to which the product demand diverts to producer B. Consequently A's sales fall to zero. Threatened with the loss of his entire business, producer A will reconsider his price. But while deciding about his new price he assumes that B will continue to sell at the present price. There are two options for producer A. First, he may set his price at the same level as B is now charging. In this case, he will secure half of the market share. Secondly, he may undercut B's price and set a slightly lower price than that of B. In this case, producer A feels that by undercutting price, he will capture the entire market. Thus producer A undercuts B' price and sets his price lower than B's price. This price war will go on until the price falls to the competitive levels which would be equal to the marginal cost of production. Below marginal cost none of them will reduce price because that would cause losses.

In Bertrand's model equilibrium is achieved when due to price war between the duopolists the market price falls to the level of average cost of production and the combined equilibrium output of the duopolists is equal the competitive output. While Bertrand's model solves one institutional difficulty, it raises another problem. In real world it is difficult to find homogeneous product markets. More often than not, there are stable markets where different firms sell their products at different prices and

all of them obtain positive market shares. In these markets slight variations in prices generate slight modifications in market shares of the firm quoting the highest price.

5. Summary

An oligopoly market structure is described as the one where only a small number of firms operate in the market. There are different models of oligopoly. In Cournot model the firms first install capacity then take production related decisions. Equilibrium is achieved at less than perfectly competitive level of output and the quantity sold is the same for both firms.

JLF Bertrand criticised the Cournot model and stated that quantity is a wrong strategic variable. Bertrand's main criticism to Cournot model is that the oligopolists will end up colluding in prices. Bertrand argued that if firms choose quantities, Cournot model does not specify the mechanism that determines prices. In Bertrand model, price war goes on until the market price falls to the level of marginal cost of production.

Some economists explain duopoly equilibrium using reaction curves. Reaction curve approach refers to the reactions of a firm in response to the moves of his rival. The reaction curves may be output reaction curves or price reaction curves depending upon the situation whether the adjustment viable is output or price. Reaction curve analysis shows that Cournot solution yields a unique and stable equilibrium under duopoly.