Game theory can help us understand firms interactions

How can game theory help us to understand firms' interactions? Discuss the differences between quantity and price competition.

Part I. Introduction

Game theory analysis is a useful tool to study the behaviour of firms in oligopolistic markets- the fundamental economic problem of competition between two or more firms. In this essay I will focus on two of the most notorious models in oligopoly theory; Cournot and Bertrand. In the Cournot model, firms control their level of production, which influences the market price. In the Bertrand model, firms decide on what price to set for a unit of product, which affects the market demand. Competition in oligopoly markets is a setting of strategic interaction which is why it is analyzed in a game theoretic context.

Both Cournot and Bertrand competition are modelled as strategic games. In addition, in both models a firm's revenue is the product of a firms part of the market multiplied by the price. Furthermore, a firm incurs a production cost, which is dependant on its production level. In the simplest model of oligopolistic competition firms play a single game, where actions are taken simultaneously. All firms produce homogenous goods and demand for this good is linear and the cost of production is fixed per unit. In this market a Nash equilibrium in pure strategies exists in both the Cournot and Bertrand models. However, despite the many parallels between the models, the Nash equilibrium points are extremely different. In Bertrand competition, Nash equilibrium drives prices down to the same level they would be under perfect competition (p= MC), while in Cournot competition, the price at Nash equilibrium is unquestionably above the competitive level.

Part II. Cournot and Bertrand Competition

In 1838 Augustin Cournot published ‘ Recherches sur les Principes Mathematiques de la Theorie des Richesses’, a paper that laid out his theories on competition, monopoly, and oligopoly. However Joseph Louis François Bertrand concluded that Cournots equilibrium for duopoly firms was not accurate. He went on to argue ‘ whatever the common price adopted, if one of the owners, alone, reduces his price, he will, ignoring any minor exceptions, attract all of the buyers, and thus double his revenue if his rival lets him do so’.

Cournot had originally arrived at his equilibrium by assuming that each firm took the quantity set by its competitors as given, evaluated its residual demand and then put its profit maximizing quantity on the market. Here, each firms profit function is stated in terms of the quantity set by all other firms. Next, Cournot would partially differentiate each firms profit function with respect to the original firms quantity then set each of the resulting expressions to zero. In the case of a duopoly, Cournot could plot the equations in rectangular coordinates. Here, equilibrium is established where the two curves intersect. By plotting the first order conditions for each firm (i. e. the profit maximizing output of each firm given the quantities set by rivals) Cournot was able to solve for functions that gave the best reaction for each firm depending on the other firms’ strategies. In game theory this is known as a ‘ best response function’. At the intersection of the best response functions in Cournot competition, each firm’s assumptions about rival firm’s strategies are correct. In game theory this is know as a Nash equilibria.

Therefore in modern literature market rivalries based on quantity setting strategies are referred to ‘ Cournot competition’ whereas rivalries based on price strategies are referred to as ‘ Bertrand competition.’ In each model, the intersections of the best response functions are referred to ‘ Cournot-Nash’ and ‘ Bertrand Nash’ equilibria consecutively, representing a point where no firm can increase profits by unilaterally changing quantity (in the case of Cournot) or price (in the case of Bertrand). The major conflict between Bertrand and Cournot Competition therefore lies in how each one determines the competitive process which leads to different mechanisms by which individual consumers’ demands are allocated by competing firms. That is, Cournot assumes that the market allocates sales equal to what any given firm produces but at a price determined by what the market will bear, but Bertrand assumes that the firm with the lowest price is allocated all sales.

Being that Bertrand Competition and Cournot competition are both models of oligopolistic market structures, they both share many characteristics. Both models have the following assumptions; that there are many buyers, there are a very small number of major sellers, products are homogenous, there is perfect knowledge, and there is restricted entry. Nonetheless, despite their similarities, their findings pose a stark dichotomy. Under Cournot competition where firms compete by strategically managing their output firms are able to enjoy super-normal profits because the resulting Market price is higher than that of marginal cost. On the other hand, under the Bertrand model where firms compete on price, the limited competition is enough to push down prices to the level of marginal cost. The idea that a

duopoly will lead to the same set of prices as perfect competition is often referred to as the ‘ Bertrand paradox.’

In Bertrand competition, firms 1’s optimim price depends on where it believe firm 2 will set its prices. By pricing jus below the other firm it can obtain full market demand (D), while maximizing profits. However if firm 1 expects firm 2 to set price a price that is below marginal cost then the best strategy for firm 1 is to set price higher at marginal cost. In basic terms, firm 1’s best response function is p1″(p2). This provides firm 1 with the optimal price for ever possible price set by firm 2.

The diagram below shows firm 1’s reaction function p1″(p2), with each firms strategy show on both the axis’s. From this we can see that when p2 is less than marginal cost (i. e. firm 2 chooses to price below marginal cost), firm 1 will price at marginal cost (p1= MC). However, when firm 2 prices above marginal cost firm 1 sets price just below that of firm 2.

In this model both firms have identical costs. Therefore, firm 2’s reaction function is symmetrical to firm 1’s with respect to a 45degree line. The result of both firms strategies is a ‘ Bertrand Nash equilibrium’ shown by the intersection of the two reaction functions. This represents a pair or strategies (in this case price strategies) where neither firm can increase profits by unilaterally changing price.

An essential Assumption of the Cournot model is that each firm will aim to maximize its profits based on the understanding that its own output decisions will not have an effect on the decisions of its rival firms. In this model price in a commonly know decreasing function of total output.

Furthermore, each firm knows N, the total number of firms operating in the market. They take the output of other firms as given. All firms have a cost function ci(qi), which may be the same of different amongst firms. Market price is set at a level so that demand is equal to the total quantity produced by all firms and every firm will take the quantity set by its rivals as a given, evaluate its residual demand, and then behaves a monopoly.

Like in Bertrand competition, we can use a best response function to show the quantity that maximizes profit for a firm for every possible quantity produced by the rival firm. We observe a Cournot equilibrium when a quantity pair exists so that both firms are maximizing profits given the quantity produced by the rival.

Part III. Conclusion

In reality, neither model is ‘ more accurate’ than the other as there are many different types of industry. In some industries output can be adjusted quickly, therefore Bertrand competition is more accurate at describing firm behaviour. However, if output cannot be adjusted quickly because of fixed production plans (i. e. capacity decisions are made ahead of actual production) then quantity-setting Cournot is more appropriate.