DUOPOLY

STATIC COMPETITION: HOMOGENEOUS GOODS

Lets find the Nash equilibrium of a game where firms choose prices. The game has 2 players, who simultaneously chose prices, under the following assumptions.

Assumptions:

i. Homogenous goods
ii. static competition (i.e., it is a one-shot game)
iii. firms choose prices
iv. marginal cost=c and no FC (which implies CRT).

The first step to study this game is to figure out how does the demand function, faced by each firm, look like. Denote by $D_1(P_1,P_2)$ the quantity demanded from firm 1 when they charge price P_1 and their rival, firm 2 charges P_2.

How does $D_1(P_1,P_2)$ look like? These 2 firms are selling homogeneous or identical goods. Homogenous products are indistinguishable from each other by the consumer. Buyers simply choose the cheapest brand (an example are IBM clones, vegetables) since they are perceived identical they do not care which one they purchase. To simplify the model assume the market demand is: Q(P)=10-P. Then:

$$D_1(P_1,P_2) = \begin{cases} 10 - P_1 & \text{if } P1<P2 \\ (10 - P_1) / 2 & \text{if } P1=P2 \\ 0 & \text{if } P2<P1 \end{cases}$$

If firm 1 offers the product cheaper than firm 2, firm 1 sells to all buyers willing to buy at that price. If both firms charge the same price, they split sales. If firm 1 charges a higher price than firm 2 then no customer buys form firms 1 (notice, this makes sense since they offer identical goods).

What about profits? Profits are the markup of each firm, $(P_1 - c)$, times the quantity sold by each firm, $D_1(P_1,P_2)$, namely the quantity firm 1 sells when it charges price P_1 and firm 2 charges P_2.

$$\pi(P_1,P_2) = (P_1 - c) D_1(P_1,P_2)$$

Observe the strategic interdependence among firms by looking at their profit functions. The optimal price for firm1 depends on the price charged by firm 2.

Find the Nash equilibrium.
To find an equilibrium just assume a pair prices P_1 and P_2 are a candidate for equilibrium and try to rule out all cases which one of the players would have an incentive to deviate.

Case 1: $p_i<c$ (namely, either price is lower than marginal cost). In such case, one of the firms would sell $D(p_i)=10-p_i$ units and make a loss of $(c-p_i)$\$ per unit. Can this be an equilibrium behavior? To rule it out find a profitable deviation. For example, the firm making losses would increase the price to avoid selling at a loss.

Case 2: $p_1>p_2>c$. Firm 1 gets no profits, but they could get positive profits if they charged p_2 (or less), since there is a profitable deviation no pair of prices such $p_1>p_2>c$ can be part of an equilibrium.

Case 3: $p_1=p_2>c$. Both sell $(10-p_1)/2$. However, by charging one cent less, they lose \$(10-p)/200 but gain the other half of the market: $\$p_1(10-p_1)/2$ hence such pair of prices cannot form an equilibrium.

Case 4: $p_1>p_2=c$. Firm 2 could increase price to $p_1 - 1$ cent.

Case 5: $p_1=p_2=c$. Equilibrium.

Conclusion:

1. Equilibrium prices of the game equal marginal cost.
2. The 2 firms compete so aggressive that the get no profits.
3. 2 firms are enough to restore the competitive outcome (P=mc + zero profits).

KEY MARKET CHARACTERISTICS

Our next task is to look at the key assumptions of the previous model. We would like to see why do we get an extreme prediction in the pricing game, namely, 2 firms are enough for prices to go to marginal costs and drive profits to zero. By removing different assumptions, one at a time, we learn their role behind our prediction, consequently we can learn which basic market conditions lead to different outcomes. The assumptions are:

1. the strategic variables are price.
2. homogeneous goods
3. constant marginal cost
4. static game

1. STRATEGIC VARIABLE: Prices vs Quantities

We assumed firms set prices (and let demand determine the sales). We could instead assume firms set output levels (and let market prices adjust to clear the market at their target output). This distinction did not matter for the monopolist, whatever she set was inconsequential for the profits and the market outcome. However, in this strategic setting (namely, when there are several sellers) it does matter what the strategic variable is. Whether firms determine prices or quantities has an impact on the market outcome.

How do we interpret the different strategic choices? Pricing can be thought as a short run decision. Quantity setting on the other hand can be interpreted as capacity choice, namely, a long run decision. For instance, the choice of the number of beds in a hotel, the number of tables in a restaurants, capital or fixed investment in a firm, or output quotas in a cartel (like OPEC).

The Nash Equilibrium, of a quantity competition game, is a pair of quantities (q_1^{NE},q_2^{NE}), such that when firm 1 sells q_1^{NE}, firm 2 prefers selling q_2^{NE} and vice versa. Each quantity is a best response to the other. Nobody has an incentive to deviate from those quantities. Although we have all the tools to solve the game, we will not fully solve it. We will just discuss or conjecture how the equilibrium will look like, in comparison to the price competition game.

In the price competition game when I take your price as given, I can easily undercut your price slightly and grab the whole market. As long as your price is no lower than marginal costs I have an incentive to do so. That is why no price higher than marginal cost can survive in equilibrium. In contrast, when we compete in quantities, I take your output (or capacity) as given. When I take your quantity as given I can sell more, but in contrast to the price competition game, I cannot wipe you out of the market; your quantity is given, and it does not decline nor disappear no matter how aggressive I become (i.e. even if I sell more and more). As a consequence I do not have such an incentive to be aggressive (I can't capture the whole market by a slight price decline). In equilibrium quantities are such that both firms enjoy profits, although less than half of the profits a monopolist would get.

Another way to think through what is going on, is to think of my quantity choice as the choice made by a monopolist who takes as given that the opponent already "dumped" his output in the market. How do I maximize profits? As usual, by setting MR=MC (where MR is the MR that stems from the demand that is leftover for me once you dumped your output). It is natural to conjecture such behavior leads to a positive markup and profits, the same way the monopolist output choice does.

Hence, predictions under different assumptions are in stark contrast. There is a lesson out of the conflicting predictions. Each model is capturing a different type of decision. Why is quantity competition more friendly (firms get higher profits)? The quantity choice has an embedded commitment attached to it, which is absent in the pricing game. No matter how much I sell your quantity is set. In the pricing game instead, by undercutting your price I make your sales vanish, I can grab the whole market. Competing in quantities I can't do so. Hence the distinction between the two strategic variables is: **commitment**.

Quantity competition is **softer,** firms get higher profits. Is there any **insight** into the result? Yes, as we will see repeated times, the ability to **commit to a strategy** makes firms better off. In this case by assuming they can set quantities which cannot be undercut,, we remove the incentive for the opponent to be aggressive and try to grab the whole market.

Message:

1. We got conflicting observations: once we change the strategic variables (form prices to quantities) we get different equilibrium predictions.
2. Price competition is **tougher** than quantity competition. Think why.

3. Under price competition two firms are enough to destroy profits, p=c identical to the **competitive** outcome.

2. Homogenous vs Differentiated Goods

One of the key assumptions in the previous model was that goods are homogenous. Homogenous goods are perfect substitutes, since you cannot distinguish them you just get the cheapest. Lets check what would happen if firms instead sell imperfect substitutes, differentiated products. Product differentiation creates consumer loyalty, different products are not considered identical by buyers.

Products are perceived as different by buyers when they objectively or subjectively differ. For instance, a mini van is quite different, and appeals to different buyers, than a sport car. A compact Hyundai and a compact Honda are not regarded as identical products. Lack of perfect information creates differentiation. Even if 2 alternative are identical (in terms of quality and price) the elasticity of substitution will not be high (namely, they are imperfect substitutes) if part of the population is uniformed about such close alternatives. Example: Car insurance, most consumers are unaware of all the available alternatives (premiums and solvency of the insurer) probably due to costly search (takes time and effort to get many quotes). Subjective Preferences can create product differentiation. For example, blind tasting has shown beers are much more difficult to distinguish than consumer loyalty suggests, in spite of that buyers are quite loyal. Another example are generic drugs, they are made of exactly the same chemical components the branded product is. Nevertheless, substitution is less than perfect. When patents expire, generics get in to the market at a large discount, but still a good chunk of consumers stick to the branded and more expensive drug. (After generics enter the market at a discount, the branded drug often increases its price. Can you explain why, in spite of the increased competition the incumbent increases its price?)

To check the consequence of this assumption go back to the simultaneous pricing game, and check whether pricing at marginal cost is a NE of the game. There is no need to fully solve the game, just conjecture that P=c is a NE and show that firms have an incentive to deviate. You should be able to convince yourself that equilibrium prices will be higher than c, hence firms will get positive profits (as oppose to the case in which goods are homogenous).

Conclusion: Product differentiation makes competition softer. Selling non-identical products firms competing in prices get positive profits. Think about the strategic choice of product design: would you like to sell goods identical to your competitors?

3. Constant Marginal Cost

Think about the incentive to undercut your opponent when your marginal cost increases in output. Suppose two rival were charging a price above MC. If the marginal cost is constant then I want to

reduce my price slightly to grab the whole market. However, if my cost increase sharply I may not want to grab the whole market. To fix ideas think we are both charging 10$, we split the market (and MC=5). I have incentives to reduce my price and sell to the whole market at 9.99. Instead, if my MC rises I may not want to, for instance, suppose the MC of selling to the last customer when I undercut you is 25$. Do I want to sell to that buyer? No, I am loosing money on her (and many other buyers). So I am less interested in stealing your customers if it as they become more and more costly to serve (namely, MC increases in output).

Conclusion: Part of the reason firms are so aggressive in the game with constant MC is because we assume firms can serve the whole market as efficiently as they can serve half of it..

4. STATIC GAME

The game above was played once. Many market interactions are one-time relationships, but others involve long run competition. We want to study the role of repeated interaction among firms. This will be subject of the next chapter. We will need new tools to deal with dynamic (and repeated) games. We will see that repeated interaction will help firms discipline each other, by punishing those that play non-cooperatively (tough). In the static game there is no room for revenge (retaliation) that would encourage cooperation.