Industrial Organization
Product Differentiation

We know that most industries and the products that they manufacture cannot in honesty be thought of as homogenous, consequently making irrelevant the idea behind models such as perfect competition. Its consequence you have been told could be modelled by Monopolistic Competition. However in the latter set of literature, we have not discussed products might be differentiated, or the impetus for the outcome of product differentiation as a equilibrium choice. We will discuss this now.

1 Horizontal & Vertical Differentiation & the Characteristics Approach

Before we deal with product differentiation, as is always mandatory in economics, we have to define what we mean by differentiation, and here there are 2 key ideas, **Horizontal Differentiation** and **Vertical Differentiation**. What do they mean?

- **Horizontal Differentiation**: This is when consumers' evaluation of different goods are different such that for a good x with two characteristics, for one consumer may weight the first characteristic heavier than the second, while the other associates the weights the other way around. For example, one car enthusiast may look first for the BHP for his truck, another may be more concerned with MPG. In fact there may be negative correlation between consumer preferences. Consider the quality of manufacture of a car, some consumers may not care at all about it, while another may be particular about gaps between fittings. Then if one firm's car has poor quality in order to deliver cheap products, while another has high quality control, the correlation of preferences is negative. We call this type of difference in evaluation that generate differentiation among firms as horizontal differentiation.

- **Vertical Differentiation**: Just as consumers' evaluation may differ, it may be the same. Consider the same example, but we are now concerned with fuel

efficiency. Holding all else constant, it is often without dispute that consumers would always prefer a more fuel efficient car, or be at worse indifferent. Then all consumers will always prefer the company that manufactures fuel efficient cars. This then generates vertical differentiation.

Since products are characterized by more than one feature, typically the ideas of vertical and horizontal differentiation can be found together in one product. Consider the features of a car above, the idea of quality, fuel efficiency, and power are all features of a car, and it will on the aggregate contribute to the preferences of consumers between one firm's product over another's. In that case, wouldn't it be better to think of a product not just itself on the aggregate, but as the characteristics it possess, which is what is suggested by the **Characteristics Approach**. So it is not the car the consumer chooses, but the sum of the valuation of the features it has. In other words, it is not the demand for the product we are concerned with, but the demand for the characteristics. To be more precise, since quality and design are not quantifiable features, they are typically thought of as features that are not observable, and difficult for consumers to relate. Therefore, the characteristic approach focuses on quantifiable features, BHP, MPG, number of seats, cargo capacity etc.

If we were to think of the contribution of each of these features as weighted components in an individuals utility or consumers willingness to pay for a feature, it allows us to provide a very general treatment of product differentiation. Consider the following, if we treat each product as different, and there is n products, in understanding consumers' choice over the products, we would have to estimate the cross price elasticities of the n products or n^2. To see how large this can get, consider the catalog of different configurations of a personal computer available from each firm, then all firms! But if we were to shrink this concerns to only characteristics, we would have to contend with a smaller number of m features, and consequently $n \times m$ elasticities.

How important is this to firms considering a strategy of appealing to differing segments of the general car market for example? By estimating the willingness to pay for particular features by differing segments of the market, a firm could then target the features towards the segment of the total personal computer markets, for example college students, business executives, families, etc. It also allows them to choose to

differentiate vis-a-vis the choice of their competitors.

2 Product Differentiation & Market Power

Consider two record stores located on the opposing extremes along a kilometer long stretch of road. Both of the stores has the exact same stock, titles and offers the same prices. Do you think consumers living along this stretch of road would have the same preference between the stores? It is unlikely that consumers would view the two stores to be the same even though for all intent and purpose based on what you have learned in economics, they are the same. The key difference as you may imagine is that it depends on where the consumer in question is living along, i.e. her location in relation to the stores. Even if it is costless to travel from where she lives to either store, it is likely different in terms of time it would take her to get to either, and that itself can be thought of as cost. This means no one consumer is the same as the other, not even in the same apartment, since if you want to be fine, it depends on whether the roommates or members of the family are located within the department in relation to the door. You should get the idea about location.

This is a common analogy of product differentiation since it is easy to see that the example generalizes to situations where,

1. Consumers has to pay for transport, i.e. there is cost of transportation.
2. We can always think of the distance as the degree of difference in the measure of a product's characteristics, and consumers differ in the manner and degree in which their preference for the characteristics differ.

That is the idea can involve cost of travel or cost of choice between the products, and generalizes to characteristics.

Consider the following example where the characteristic in question is the mileage of a automobile, i.e. miles per gallon(mpg) or kilometers per liter. Then consumers differ in their preference for this characteristic since there is a tradeoff between mpg and bhp. We will focus on only mpg. Let's construct the model.

Assumptions:

1. Denote mpg as a measure between 0 to 1, where 0 is for low fuel efficiency, and 1 is highly efficient.
2. Two firms where each choose the extreme locations in terms of mpg.
3. Consumers are evenly located in terms of their preference between 0 and 1. Suppose that there are n consumers.
4. Firms compete on prices, and choose their price simultaneously. And label the price of the two firms as p_1 and p_2.
5. Constant marginal cost for both firms at c. (Important: Ask yourself what if marginal cost are not the same, but still constant.)

This is a possible setup for the **Hotelling Model**. We will examine the implications of the model.

Let's examine the choice facing a consumer located at point x in terms of her preference for fuel efficiency (think of her position on preference be dependent implicitly on her real location in relation to where she lives relative to her work). Think of the travel cost to the firm located at point 0 to individual on x (let's just call her x) as the cost to her in terms of monthly fuel consumption bill which is related to where she is located, and let that cost be t per unit of fuel efficiency. Then the price x has to pay to purchase firm 0's car is $p_1 + xt$. An alternative conception of what the location means is that x is how consumers value mpg, with individual located close to 0 as those who are environmentally unconscious while 1 would be those who are very conscious of their carbon footprint. The effective or real price of buying a car for someone located at the extreme of $x = 0$ buying from firm 1 is just p_1, while for someone located at $x = 1$, the real price of buying from firm 1 is $p_1 + t$. The analogous price of buying from firm two by someone located at x is that $p_2 + t(1 - x)$. This is because someone located at x must travel or values the car manufactured by firm 2 by a distance of $1 - x$. Recall we have normalized the lowest mpg to 0.

Suppose each consumer located along the unit line buys one unit of the car either from firm 1 or firm 2. The question then is who do they buy the vehicle from, and not

how much they buy (1 unit is the highest utility maximizing quantity for all consumers). To determine who are firm 1's consumers and who would choose firm 2, we have to find the consumer who is indifferent between the two firms. This consumer would find purchasing from either firm yields the same cost, which translates to,

$$\begin{aligned} p_1 + x^R t &= p_2 + t(1 - x^R) \\ \Rightarrow x^R &= \frac{p_2 - p_1 + t}{2t} \qquad (1) \\ \Rightarrow 1 - x^R &= \frac{p_1 - p_2 + t}{2t} \qquad (2) \end{aligned}$$

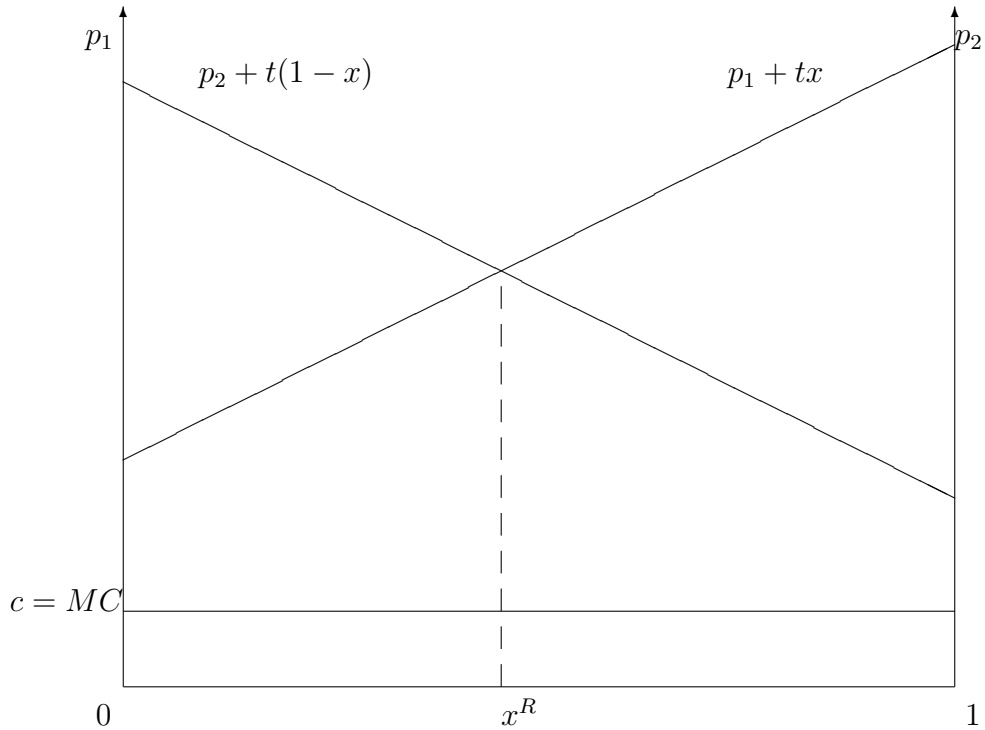
This then means that any consumer with preferences located to the left of x^R would buy from from 1 located at 0, while any consumer located to the right of x^R. If we were to squeeze everyone distributed together, i.e. thing of one person as $\frac{1}{n}$, we describe this as a unit mass of individuals. Further, lets assume that the distribution is uniform along the 1 kilometer mpg measure. Then the the demand for firm 1 is x^R, and the demand for firm 2 is $1 - x^R$. The diagram depicting the idea behind the Hotelling Model is in figure 1 below.

There are several key notes which we will note as we determine what is the optimal pricing strategy of each firm, and if the outcome would be as in Bertrand Price competition. The first point you may note is that the price set by both firm 1 and 2 can be above their marginal cost. The rationale is that as perceived by their consumers, the goods are different even though in all other respect besides mpg, they are the same. From equation (1) and (2), the inverse demand for firm 1 is

$$\begin{aligned} p_1 &= p_2 + t(1 - 2x) \qquad (3) \\ p_2 &= p_1 - t(1 - 2x) \qquad (4) \\ p_2 &= p_1 + t - 2t(1 - x) \qquad (5) \end{aligned}$$

Note that both firm 1's and firm 2's inverse demand is decreasing in the distance from its own location, 0 and 1 respectively. Further, their prices are dependent on each other's choice, so that if their competition prices higher, they would infact be encouraged to raise their prices(But this last interpretation is not completely correct since the inverse demand, or the demand per se is not a reaction function). At what price would they set their output. What is certain is that the equilibrium price will be greater than its marginal cost. It is true that as long as their prices are below

Figure 1: Hotelling Model



their competitors, their market share rises, but at the same time, the marginal gain in profit will eventually fall, and this concern would ultimately terminate with each firm pricing somewhere above their marginal cost of production. Given that the problem is symmetric, both firms should intuitively price above the marginal cost and the price they each set should be the same. We will now determine if our intuition is correct or otherwise.

How is such a price determined? We will discuss this now. The profit function for firm 1 and firm 2 for which they will maximize is,

$$\max_{p_1} \pi_1 = \max_{p_1} (p_1 - c)x = (p_1 - c)\left(\frac{p_2 - p_1 + t}{2t}\right) \tag{6}$$

$$\max_{p_2} \pi_2 = \max_{p_2} (p_2 - c)(1 - x) = (p_2 - c)\left(\frac{p_1 - p_2 + t}{2t}\right) \tag{7}$$

If they then maximize their individual profits, we would be able to see how they would respond to each other, i.e. the reaction function given the price they believe their

competition would choose. It is easy to find the reaction,

$$R_1(p_2) = p_1 = \frac{p_2 + t + c}{2} \tag{8}$$

$$R_2(p_1) = p_2 = \frac{p_1 + t + c}{2} \tag{9}$$

Substituting (9) into (8) we obtain the equilibrium,

$$p_1^* = t + c = p_2^* \Rightarrow x^R = \frac{1}{2} \tag{10}$$

Which is exactly what we have suggested, that the price is greater than the marginal cost of production c, and the indifferent consumer is located right in the middle of the fuel efficiency spectrum. Further since neither of the firms would have an incentive to deviate from this pricing strategy, this equilibrium is a Nash Equilibrium. This is possible because of the "transportation"cost causing consumers to view products that for all other features are alike, but differ on one, fuel efficiency. In fact what this model says is that the greater the cost of going to anyone particular firm, the greater would the price of the good could be, while the lower the "transportation"cost the lower would the prices be. This corresponds to the slope of the demand that each firm faces, where t is the slope, so that the higher t is, the greater is the slope of the demand, and based on what we have learned from perfect competition to monopoly, this corresponds to greater ability of firms to extract rents. On the other hand, as t tends towards 0, we would have the perfect competitive, or Bertrand Competitive outcome. Which leads us to the key point below.

The greater the degree of product differentiation, the greater the degree of market power.

Then Hotelling Model in effect has solution to the Bertrand Paradox.

3 Product Positioning

The previous discussion presumed that we knew about where along the mpg differentiation that the producers would choose, and that it would be at the opposing extreme. The complete Hotelling Model in truth has those choices as endogenous to the concerns of the firm, where the firm chooses where they to position their product, before choosing the optimal price. Then we know this problem for a two stage game can be solved using backward induction. We will now examine how firms might choose a possible "location"or position of the product in the spectrum of possible locations.

Before we get to the technical part of the model, we will examine the intuitive arguements just as we have done prior. When a firm chooses where along the spectrum of possible levels of differentiation, they have to consider what they action would mean to their competitors and their consequent induced behavior, that is there is a strategic element to the choice. Suppose first that firm 1 believes that firm 2 would locate somewhere between 1 and 0.5. What does it mean for firm 1's market share? There are essentially two effects, **direct effect** and **strategic effect**.

Given the location of firm 2, say at l_2, it always makes sense for firm 1 to locate closer beginning from the origin of point 0. This is because if it stayed where it was, firm 2 would capture a larger share of the market, or that the indifferent consumer would be to the left of the mid point. Consequently firm 1 would want to locate closer to firm 2. This is what we mean by direct effect.

However, the firms know that as they locate closer, in the second period the consumers would think of them to be more similar than we had previously discussed. To see this, in the extreme when both firms locate right with each other at point 0.5, then for all intent and purpose consumers would deem the two firms to be the same, and we know under price competition with homogenous goods, we obtain the Bertrand Paradox, and firms actually price at the marginal cost. This gives us the following conclusion.

If price competition is intense, then firms tend to locate far apart (high degree of product differentiation). If price competition is not intense, then firms tend to locate close to the center (low degree of product differentiation)

In terms of the previous model, let the "distance"of firm 1 and 2 be a and b, where both $a, b \in [0, 1]$, that is they locate between 0 and 1 inclusive, and $a + b = 1$. Then we can characterize the distance a consumer is to either firm is $(x - a)^2$ to firm 1 and for firm 2 it is $((1 - b) - x)^2$. Notice that the distance is squared. This is because if transport cost is linear in distance, there is no pure strategy in the second stage pricing competition with the exception when both firms are located at the middle. Then the indifferent consumer is characterized by the following,

$$p_1 + (x - a)^2 t = p_2 + ((1 - b) - x)^2 t \tag{11}$$

The process of determining the optimal price is as before. However, this new price will be dependent on the location of each firm. **Find the equilibrium price, and profit and prove that the relationship between profit and distance of the firms from each other is negative**.

What if the distribution of the consumers is not uniform on the spectrum of differentiation in mpg as in our example. **What if the distribution of consumers along the spectrum of possible product position is not uniform?**

4 Imperfect Information & Switching Costs

For the purpose of examining market power, we do not distinguish between whether the products are physically differentiated or are different so that the above discussion will still hold true. However, in another situation where for all intent and purpose the products are the same, due to imperfect information (and where finding out more about the products involves additional cost) of the product and its characteristics, consumers perceive them to be different, or when switching between the products involves a switching cost. Under this type of situation, we may also think of it as product differentiation.

4.1 Search Cost & Switching Cost

Suppose there are two firms who sells the same products, but consumers who are homogenous are not aware of the pricing (and who cannot communicate with each other about the prices). Of couse they can find out about the price, but it would involve travelling to the two stores, i.e. there is a positive search cost of say s. Suppose the stores know that the consumers are willing to buy one unit of the good at a price of p^M. Since both firms know that if they both choose to price at the monopoly price of p^M, the consumer would forsake the search and buys from the first store she enters. Does either firm has an incentive to deviate and undercut? If either of the stores undercuts, it is cutting into its profits. As long as the other chooses not to compete on prices, consumers has to travel to find out. Unless the store undercuts such that the final price is such that together with the search cost, it is less than or equal to the willingness to pay, consumer would not bother to search. Further if their marginal cost is substantially high (or that the search cost is substantially high) such that the marginal cost together with the search cost is greater than the willingness to pay, the deviating firm would actually make a loss, and thus supporting the equilibrium for pricing at the monopoly price of p^M. **Ask yourself what if marginal cost is low? Would repeated interaction allow the firms to obtain the monopoly profits?**

Consider another example of Linux versus Windows OS. Do you think there is cost of switching between the two operating systems? In fact, for the typical individual, this cost is substantial. In that case, we can think of switching cost as equivalent to search cost above, so that its existence, especially when it is high would allow firms to extract consumer surplus as in a Monopoly.

The greater the value of search costs or switching costs, the greater the sellers' market power tends to be.

When consumers have differing search cost, with some having high search cost, while other having low, or virtually nonexistent search cost, we will find price dispersion where stores or firms choose to sell at high prices extracting all the rents or low prices depending on the segment of the search cost market. The former aims to sell to the high search cost consumers, while the latter sells to low search cost ones, and gains from quantity of sales. This is often referred to as the **Tourist-Locals Model**. In

fact, airlines are known to sell the same ticket for the same flight on the same day to differing individuals at differing prices. Why? Do you think it is more typical for business travellers to make trip arrangements at short notice. While the regular individual planning for a vacation has months to prepare and search out the best deal?