Theoretical Questions in the Virtual Corporate Reality Model

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Background

Virtual Corporate Reality (VCR) is a classroom simulation of a differentiated products oligopoly market designed to enhance students' understanding of game theory concepts in the economics of industrial organization.

The Model:

- The products are located in a 1-dimensional space on a circle of unit circumference.
- Consumers are uniformly distributed around the circle.
- Consumers are only interested in one feature of the products, which is indicated by a product's location on the circle.
- The model has many other applications other than geographical location.

The **market share** of each product is the fraction of consumers that buy it. The borders of each product's market share on the circle are located where a consumer is indifferent between this product and the nearest alternative product.

The indifferent consumer derives the same consumer surplus from both the product on the left of her and the product on the right of her.

Each consumer most prefers the product located at her location and derives maximum consumers surplus from it. The disutility of the consumer that is not buying her ideal product increases linearly as the distance between the consumer and the product grows. Consumers surplus is further diminished by the price the consumers pay for the product.

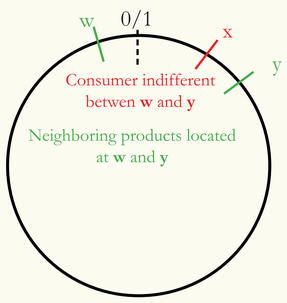


Figure 1: If a consumer located at x buys a product located at w and pays price p_w, she receives consumer surplus

$$V - 200d(w,x) - p_w$$

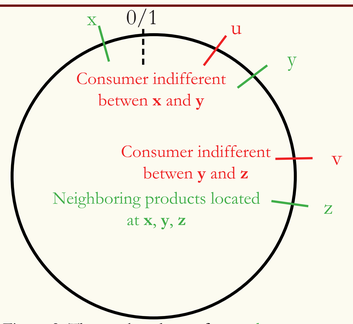


Figure 2: The market share of a product at y with neighboring products at x and z and indifferent consumers at u and v is given by:

$$d(u,v) = \frac{d(x,y)+d(y,z)}{2} + \frac{p_z + p_x - p_y}{400}$$

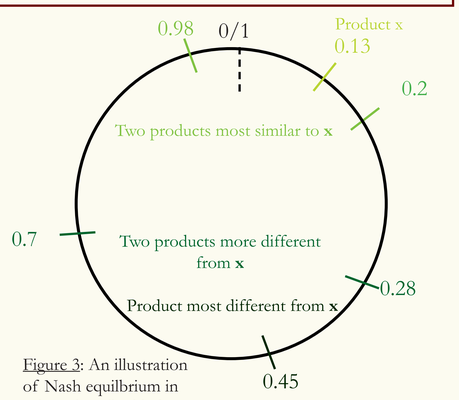


Figure 3: An illustration of Nash equilbrium in prices, described below

Profit:

The profit from each product with marginal cost c and fixed cost F is given by:

$$\pi_i = N[\frac{d_{i,i-1}+d_{i,i+1}}{2} + \frac{1}{400}(p_{i-1}+p_{i+1}-2p_i)][p_i - c] - F$$

- For a multiproduct firm, profits from all products are summed up.
- When solving for the Nash equilibrium, only adjacent products' prices appear in the best-response condition after taking the derivative with respect to each product

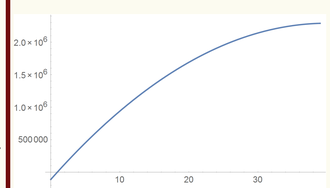


Figure 4: The total number of consumers in the market determines the size of the market. In VCR, it is a quadratic function of the number of products (n), which reaches its maximum at $n = 40$.

	Scenario 1 (*less competitive*)			Scenario 2 (*more competitive*)		
Location	Owner	Nash equilibrium price	Profits ($\times 10^6$)	Owner	Nash equilibrium Price	Profits
0.1	A	$99.86	$7.105	A	$79.47	$5.654
0.2	A	$106.81	$7.705	B	$87.89	$6.340
0.4	B	$97.54	$8.283	C	$92.11	$7.822
0.6	C	$83.33	$6.284	D	$80.53	$6.073
0.75	D	$65.78	$9.795	E	$60.00	$8.931

Figure 5: An example of Nash equilibrium pricing: Notice that a multiproduct firm faces less competition because it internalizes the price effect of its own products.

Nash Equilbrium Prices in VCR:

- The strategic variable is price and the strategy space of all firms is [0; ∞]. The payoff function is firm's profit.
- The best response is found by taking first-order conditions of profits and solving a system of equations (one for each FOC).
- Firms price at Nash equilibrium where no firm can increase its payoff (profits) by changing its price given that all other firms' prices.
- Note that introduction affects all Nash equilibrium prices, with the product furthest away being least affected.

Exploration of Questions

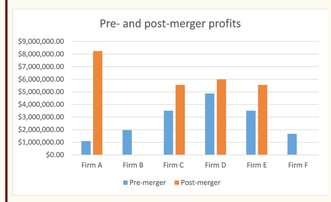
When does entry become unprofitable?

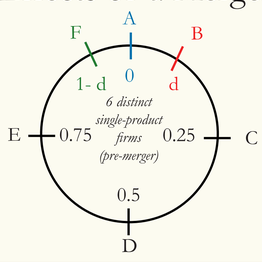
Consider n firms with zero relocation cost. They will follow the principle of "maximum differentiation" to minimize price competition, and locate evenly around the circle, at distances 1/n from each other. Firms will only enter the market if they can recoup their entry costs, thus earning at least zero economic profit. As entry continues, however, there will come a point where n is so large that all firms earn negative profits under Nash equilibrium. This threshold will tell us how many different single-product firms the market can support, at the point where entry is no longer profitable.

Our results show that this threshold is n = 30, meaning that the market can support 29 different single-product firms. Notice that this value of n is smaller than the maximum value shown in Figure 4.

If one of those firms at the threshold becomes a multiproduct firm, it can internalize the price effect of its own nearby products and thus choose to set higher prices and earn higher profits under Nash equilibrium. Then the question becomes at what point this firm no longer finds it profitable to introduce another product. We find that a multiproduct firm will have 50 products for a total of 78 products in the market. Notice that this is one product below the number of products that make the market size negative.

Effects of a Merger on Prices and Profits





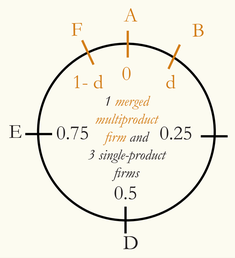


Figure 6: A merger will suppress prices for all but the merged firm and drive profits down. The immediate neighbors of the new multi-product firm (firms C and E) will feel the greatest effect, whereas firm D located furthest away at 0.5 would be least affected.

Credible spacial preemption through location choice (shielding)

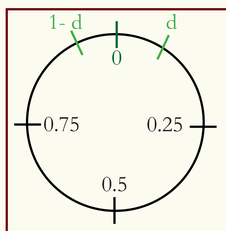
Kenneth Judd (1985) descries a scenario in which the incumbent has products at every hour around the clock (circle) (at 12:00, 1:00, 2:00, etc) and examines two strategies of entry prevention:

Strategy 1: The incumbent threatens to stand fast if the entrant introduces a product at 12:30.

Strategy 2: The incumbent threatens to stand fast if the entrant introduces the exact same product as the incumbent at 12:00 (a direct attack).

Result 1: Introduction at 12:30 drives equilibrium prices and profits down for the two existing products at 12:00 and 1:00. Thus, with low exit costs and intense local competition, "Exit" is the dominant strategy for the incumbent firm's product at 12:00.

Result 2: The price for the two goods at 12:00 will drop to marginal cost and neither the entrant nor the incumbent will make profits. However, the incumbent stands to gain more if she withdraws her 12:00 product because that would drive the price of the competitor's product at 12:00 back up and increase the market share of the incumbent's products at 1:00 and 11:00.



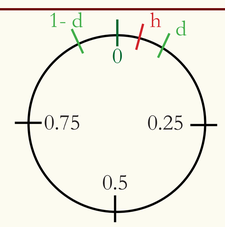


Figure 7: Entry/exit game set-up in our analysis

Stage 1: The market has 4 symmetrically located firms and the firm at 0 chooses whether to introduce products at d and 1 - d.

Stage 2: An outside entrant (or, one of the existing firms) decides whether to introduce product at h.

Stage 3: Entrant (at h) and incumbet (at 0) make simultaneous stay/exit decision.

Stage 4: Firms compete in price and earn profits.

Our results: Our setup is described in FIGURE 7. Unlike in Judd's scenario, however, the incumbent only starts out with one product at the top of the circle and both the incumbent and the entrant have a choice of exactly where to introduce. We examine whether the incumbet can protect her market share from entry by "shielding" with introductions around her product. We find that there are multiple values of d and h for which both players stay in the stage 3 subgame. Thus, the incumbent does not have a credible threat of forcing the entrant out, but it is also profitable for her to stay. This distinction from Judd's conclusion will be the source of future work.

Sources:

Judd, Kenneth L. 1985. "Credible Spatial Preemption." The RAND Journal of Economics, 1985. vol. 16 (2) p. 153-166.

Salop, Steven C. 1979. "Monopolistic Competition with Outside Goods." The Bell Journal of Economics, 1979, vol. 10 (1), p. 141-156.