# 10. Market Power

Perfect Competition

Monopoly

- Market power is the ability of a firm to increase profits by setting a price above marginal cost.
- Most real-world firms acquire some degree of market power by producing goods that have no perfect substitutes.
- The degree of substitution between the outputs of different firms is reduced by differences in
  - product characteristics
  - location
  - customer service
  - and by informational asymmetries.



## 10.1 Perfect Competition

- In models of perfect competition every firm is assumed to be a price taker,...
- so in the competitive model, firms cannot increase profits by changing the price.
- In real-world competitive markets, any firm can set whatever price it chooses.
  - (E.g., there is no law that requires the farmer to accept the market price for his crop.)

- But it would be foolish for a competitive firm to deviate from the market price.
  - In competitive markets, many firms produce identical goods, and each firm serves a small share of the market.
  - If the firm raises its price, its sales will drop to $0$.
  - The firm can sell as much as it wants to at the market price, so if it reduces its price, its profits must go down.
- Consequently the price-taker assumption for competitive markets is without loss of generality.



## 10.2 Monopoly

- Stated most simply, a monopoly is a firm that is the only seller of a good.
  - No other firm sells the same good or a close substitute.
- In the standard model, monopolies do not interact strategically with other firms that sell different products to the same customers.
  - Example: Suppose Firm $A$ is the only firm that rents apartments in a neighborhood $X$.
    - And suppose that A's rental rate influences the profits of a large number of food shops in $X$,
    - but no food shop can affect the profits of Firm $A$,
    - then we can model $A$ as a monopoly.
    - Firm $A$ could choose its profit-maximizing price without regard to possible responses of food shops.

- **Example: Suppose Firm $A$ is the only firm that rents apartments in a neighborhood $X$.**
  - **If there were another firm $B$ that sold condominium apartments in the same neighborhood,**
  - **then it would be inappropriate to model firm $A$ as a standard monopoly,...**
  - **because the pricing strategy of each firm would affect the profits of the other.**
  - **Firm A could not choose its profit-maximizing price without considering the pricing strategy of Firm $B$.**



- **Monopolies do not interact strategically with their customers.**
  - **The pricing strategy of a monopoly usually affects the utility of its customers.**
  - **But we assume the presence of a large number of small buyers,...**
  - **so that the purchasing strategy of a single buyer does not affect the profits of the monopoly.**
  - **Monopolies are normally modeled as price setters,**
    - **(equivalently, they may be thought of as controlling quantities by setting prices),**
  - **but in the standard model, buyers are modeled as price takers.**

# The standard monopoly model with the monopoly as a price-setter.

- Let the market demand of all buyers be represented by the demand function $q = q(p)$, where buyers take the monopoly-set price $p$ as given.
  - We assume that for some $\bar{p} > 0,\ q(\bar{p}) = 0$,
  - and that $q'(p) < 0$ for $0 < p < \bar{p}$.
- The monopoly faces a total cost function given by $C(q)$.
- Then the monopoly's profit function is given by

$$\pi(p) = pq(p) - C(q(p)) .$$



- The monopoly price is given by

$$p_m = \operatorname*{argmax}_{p \geq 0} \pi(p) .$$

- The foc for an interior optimum is

$$q(p) + pq'(p) - C'(q)\, q'(p) = 0.$$

or

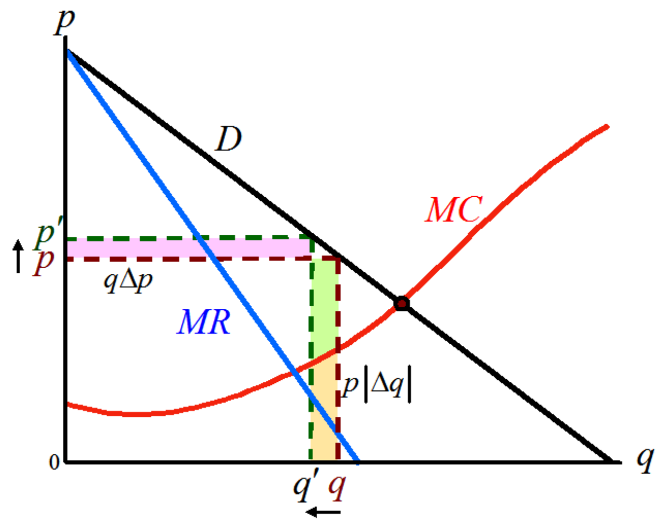
$$q(p) - (p - C'(q))|q'(p)| = 0.$$

[Why use the absolute value?]

- If $p$ increases and $q$ falls and if we set $|q'(p)| \equiv |\Delta q| / \Delta p$, then

$$q\Delta p - (p - C'(q))|\Delta q| = 0.$$

- Intuition? Monopolist's tradeoff?






- Recall that the foc was

$$q(p) + pq'(p) - C'(q)\, q'(p) = 0.$$

- But if we treat revenue $R$ as a function of quantity $q$, we can write

$$R(q(p)) \equiv pq(p)\,,$$

and differentiating with respect to $p$ yields

$$R'(q)\, q'(p) \equiv pq'(p) + q(p)\,,$$

- Substituting into the foc and dividing by $q'(p)$ yields the common expression

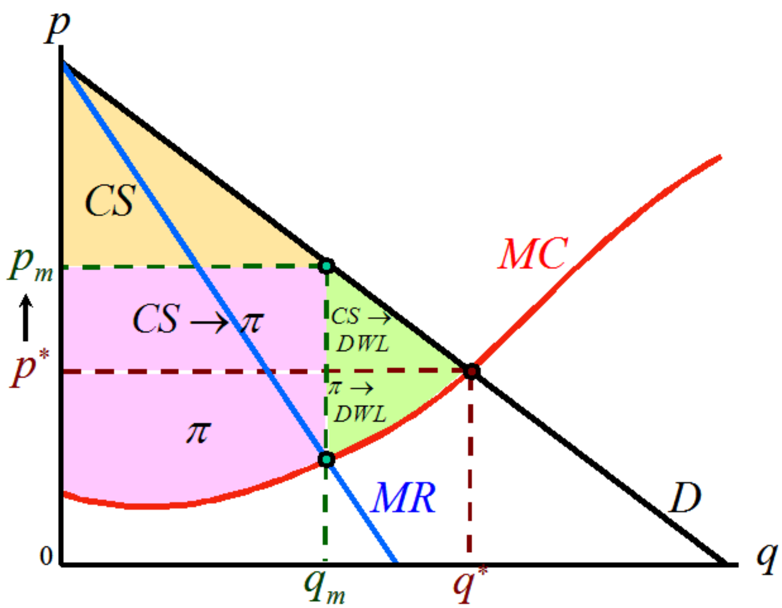
$$R'(q) = C'(q)$$

or $\mathrm{MR} = \mathrm{MC}$.

- Then $p_m$ is either one of the solutions of the foc or the corner solution $p_m = \bar{p}$ ($q = 0$), whichever yields the greatest monopoly profits.

- But we rule out the corner solution $p = 0$ in advance, because at $p = 0$ revenues are $0$ and costs are maximized.

- **In the standard graph (below), the monopolist raises her price from the competitive price $p^*$ to the monopoly price $p_m$.**
- **The monopolist captures part of consumer surplus CS as profits $\pi$.**
- **But part of the social surplus becomes deadweight loss, DWL.**






Problem 40.MM. ***Suppose demand is given by***

$$q(p) = 30 - p \text{ for } 0 \leq p \leq 30$$

***and costs by***

$$C(q) = 120 \log(1 + q) \text{ for } q \geq 0.$$

***Find the monopoly price. What is the value of the deadweight loss caused by the monopoly?***

- **We can write the inverse demand function as $p = 30 - q$, so that $R(q) = 30q - q^2$ and**

$$R'(q) = 30 - 2q.$$

- **Also,**

$$C'(q) = \frac{120}{1 + q}.$$

- Therefore, any interior solutions of the profit maximization problem must satisfy

$$30 - 2q = \frac{120}{1+q}$$

or

$$q^2 - 14q + 45 = 0.$$

- The solutions are $q_1 = 5$ and $q_2 = 9$.

- Profits are given by

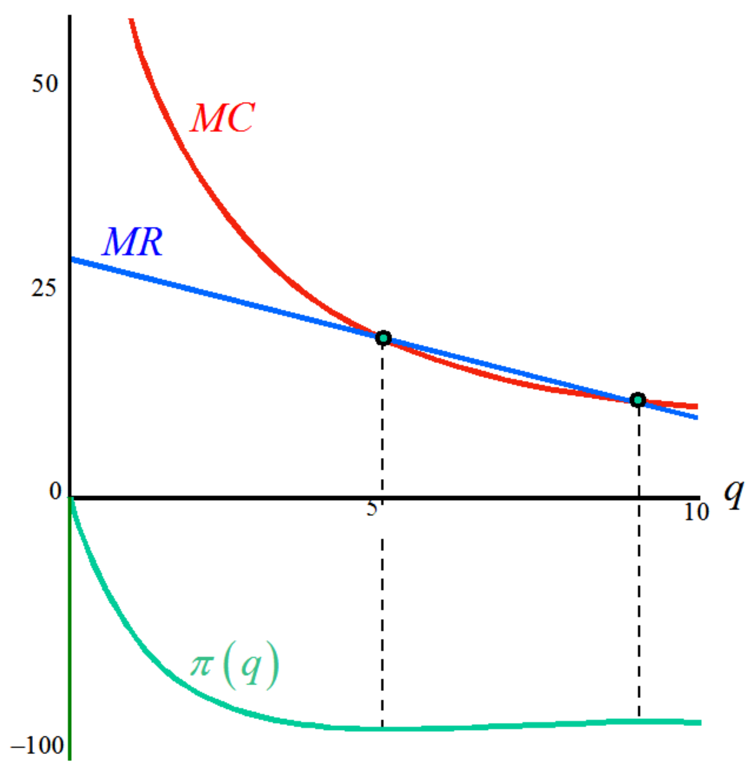
$$\pi(q) \equiv R(q) - C(q) \equiv 30q - q^2 - 120\log(1+q)\,,$$

so that $\pi(5) = -90.0$, $\pi(9) = -87.3$ and, last but not least, $\pi(0) = 0$.

- Therefore, $q_m = 0$ and $p_m = 30$.



- The analysis of the example is captured on the graph below.



- Of course, all of this can be computed directly from the profit function $\pi(p)$.

- We have

$$\pi(p) \equiv pq(p) - C(q(p))$$

or

$$\pi(p) \equiv 30p - p^2 - 120 \log(31 - p) .$$

- The foc is

$$30 - 2p + \frac{120}{31 - p} = 0,$$

whose solutions are $p_1 = 21$ and $p_2 = 25$.

- Both $p_1$ and $p_2$ yield negative profits, whereas the corner solution $p = 30$ ($q = 0$) yields $0$ profits.



- The outcome of the standard monopoly model may be obtained from as the outcome of strategic interaction in a game between the monopoly and a small number of customers.
  - Consider the following-two stage game:
    - A monopolist sets the price of his good.
    - Then his customer(s) decide(s) how much to buy at those prices.
  - The subgame-perfect equilibrium yields the same results as standard monopoly model.
  - In SPE, the customer's strategy requires a best response to every possible price,
  - so the customer is a price-taker, even if he is the only customer.

## Rent-seeking

- The profit-maximizing pricing strategies of nondiscriminating monopolies cause them to be inefficient.
  - Monopolists raise the price above the competitive level in order to transfer consumer surplus to monopoly profits.
  - But this excludes consumers from the market (or limits their demand) and causes a loss of consumer surplus that is not captured by the monopolist.
- In this regard, perfectly discriminating monopolists are efficient.
  - They can charge each buyer her willingness-to-pay and serve everyone willing to pay the marginal cost or more.



- Monopoly status is usually an unowned resource rather than a property right.
- Therefore, the attempt to achieve or maintain monopoly status is likely to waste real resources and is a separate cause of inefficiency.
- The use of real resources in an attempt to obtain or maintain monopoly status is a form of rent-seeking.
- When monopoly status is conferred as a legally enforceable property right (as with patents and copyrights), rent-seeking behavior may be discouraged...
  - but certainly not eliminated.
  - In the US, costly disputes over intellectual property rights are common.

DEFINITION 10.1. Rent-seeking *is the costly (nonproductive) attempt to transfer resources from other persons to oneself.*

- **Rent seeking is inefficient in that it reduces social surplus. Why?**
- **Example: "beauty contest" for mobile telephone spectrum.**
  - **In some countries (e.g. US, UK and Germany), spectrum for the use of mobile phones was allocated by auction.**
  - **In other countries (e.g. France and Spain), spectrum was allocated in a "beauty contest" in which firms were required to convince regulators that they would provide the best service to the public.**
  - **Applicant firms spent vast sums on the beauty contest.**



## A Beauty-Contest Model

- **Suppose there are $n$ firms in a beauty contest of spectrum in which the winner would obtain monopoly profits $\pi$.**
- **Suppose the firms hire consultants, lawyers, lobbyists and publicists in order to increase their odds of winning.**
- **Let us assume that the probability $p$ that a given firm will win the license is given by:**

$$p = \frac{x}{x + Y},$$

**where $x$ is the amount the firm spends on its application, and $Y$ is the total amount that all other firms spend on their applications.**

- **The firm's net expected profits from the application will be**

$$\tilde{\pi}(x) = p\pi - x \equiv \frac{x}{x + Y}\pi - x.$$

- The first-order condition for net-profit maximization is

$$\frac{1}{x+Y}\pi - \frac{x}{(x+Y)^2}\pi - 1 = 0,$$

- so if there is an interior maximum, optimal value of $x$ must be:

$$x^* = \sqrt{\pi Y} - Y.$$

- Any symmetric Nash equilibrium must satisfy

$$Y = (n-1)\,x^*.$$

  Why?

- Substituting, we have

$$nx^* = \sqrt{\pi(n-1)\,x^*}$$

  which yields

$$x^* = \frac{n-1}{n^2}\pi.$$



- Each firm has an equal chance of winning, so expected net profits must be

$$\tilde{\pi}^* = \frac{\pi}{n} - x^* \equiv \frac{\pi}{n} - \frac{n-1}{n^2}\pi \equiv \frac{\pi}{n^2} > 0,$$

  which confirms that the solution for spending will be interior. Why?

- Let $X^* \equiv nx^*$ denote total spending on the beauty contest by all firms. This spending is completely nonproductive, a dead-weight loss caused by rent-seeking.

- Therefore, total social surplus $S$ generated by the potential monopoly profits $\pi$ is not $\pi$ itself but $\pi - X^*$. We have

$$S = \pi - X^* = \pi - nx^* = \frac{\pi}{n}.$$

- So if, for example, there are *4* firms trying to win the beauty constest, *75* percent of potential monopoly profits (and potential social surplus) will be lost to rent-seeking.

- **Rent seeking may be associated with monopolies and market power in many contexts.**
  - **Incumbents attempt to keep entrants out of the market.**
  - **Entrants attempt to break into the market.**
  - **Efforts to prevent patent and copyright infringement.**
  - **Efforts to avoid or evade patent and copyright protection.**
  - **Patent races (part of the cost is productive).**
  - **Beauty contests for contracts (rather than auctions).**



- **Costly rent-seeking behavior is often manifested in the costs of consultants, lawyers, lobbyists, publicists and highly-paid employees of the firms involved.**
- **Rent-seeking may, of course, may generate bribery, but bribery is a transfer and does not imply direct social costs.**
- **Empirical work suggests that losses from rent-seeking is far greater than losses from the deadweight-loss triangles.**
  - **see: James R. Hines, Jr., "Three Sides of Harberger Triangles,"** *The Journal of Economic Perspectives*, **Vol. 13, No. 2. (Spring, 1999), pp. 167-188.**

# 10.3 Static Models of Oligopoly

- **When there are a small number of firms producing related goods for the same market (an oligopoly), the firms interact strategically with one another.**
  - **Each firm's strategy affects the demand curves of all other firms.**
  - **Consumers are modeled as passive.**
  - **Game theory is the best mechanism we have to explore the strategic interaction.**
  - **About 30 years ago, game theory replaced older methods such as "conjectural variation" for exploring the behavior of oligoplists.**



- **When a small number of firms produce a homogeneous good, game-theoretic results depends heavily on whether the firms set prices or quantities.**
- **This is unlike the case of monopoly, where price-setting and quantity-setting are equivalent.**
- **With price-setting oligopolies, different firms can set different prices out of equilibrium, and this produces extreme competition.**
  - **With homogeneous goods, a firm can undercut a competitor's price by $\varepsilon$ and grab the entire market, provided only that the price is above its own marginal cost.**
  - **Competition is less extreme if goods are differentiated and not perfect substitutes.**

- With quantity-setting oligopolies, firms accept the same market price for their output, in or out of equilibrium, and that reduces the competition.
  - The market price is a function of the total quantity produced, so the strategy of each firm affects the market price.
  - Firms are price setters only indirectly, and each firm affects the price for all firms.



## Bertrand Duopoly

- Competition between two price-setting firms producing a homogeneous good.
- Firms have constant returns to scale, with $\mathrm{MC} = c$.
- Market demand is represented by a continuous demand function $q = q(p)$ defined on $\mathbb{R}_+$, where buyers take the price $p$ as given.
  - We assume that for some $\bar{p} > 0,\ q(\bar{p}) = 0$,
  - and that $q'(p) < 0$ for $0 < p < \bar{p}$

- Consumers buy only from the lowest-price firm, and if both set the same price, then they split demand equally between the firms.
  - Let $p_1$ and $p_2$ be the prices set by firms 1 and 2.
  - Then the demand facing firm 1 is

$$q_1(p_1, p_2) = \begin{cases} q(p_1) & \text{for } p_1 < p_2 \\ q(p_1)/2 & \text{for } p_1 = p_2 \\ 0 & \text{for } p_1 > p_2 \end{cases},$$

    and the demand facing firm 2 is analogous.
  - If $p = \min\{p_1, p_2\}$ ,then for any $p_1$ and $p_2$,

$$q_1(p_1, p_2) + q_2(p_1, p_2) = q(p),$$

    the market demand.
- Profits for firm 1 are:

$$\pi_1 = (p_1 - c)\, q_1(p_1, p_2),$$

  with $\pi_2$ analogous.



PROPOSITION 10.1. (Bertrand Equilibrium) *If both firms set prices simultaneously, then $p_1 = p_2 = c$ is a unique Nash equilibrium. This means that in Bertrand equilibrium, as in pure competition, prices equal marginal cost and profits are zero.*

PROOF.

- $p_1 = p_2 = c$ is a Nash equilibrium
  - At $p_1 = p_2 = c$ each firm sells $q(c)/2$ units, but earns 0 profits, because price equals cost.
  - If firm 1 raises its price, it will lose its sales and continue to earn zero profits.
  - If firm 1 lowers its price, it will gain all sales and lose money on each one.
  - Consequently, firm 1 has no incentive to deviate. Neither does firm 2.

- **No equilibrium can have $p_1 < c$ or $p_2 < c$.**
  - **In that case the firm setting the lower price (or both firms if prices were the same) would lose money and deviate.**
- **No equilibrium can have $p_1 = c$ and $p_2 > c$.**
  - **In that case, firm *1* could raise prices to $c < p_1' < p_2$ and earn positive rather than zero profits.**
  - **Likewise, we cannot have $p_1 > c$ and $p_2 = c$ in equilibrium.**
- **No equilibrium can have $c < p_1 \leq p_2$.**
  - **In that case firm *2* could deviate and undercut $p_1$ by a small amount with $c < p_2 < p_1$ and increase profits.**
  - **Likewise, $c < p_2 \leq p_1$ is not possible in equilibrium.**
- **This rules out every possibility for an equilibrium aside from $p_1 = p_2 = c$, which therefore must be unique.**

■



PROBLEM 41.MM. ***Suppose that in the Bertrand Game all prices must be expressed in dollars and cents (fractions of cents are not allowed). Find a Nash equilibrium when the costs are $c_1$ and $c_2$ with $c_1 \leq c_2$. Is it unique?***

# Cournot Duopoly

- Suppose that in France there are exactly two profit-maximizing firms, L'Eau and N'Eau, that produce bottled water. Their products are homogeneous.
- Firms have constant returns to scale, with $\text{MC} = c$.
- The French people (who think that drinking free tap water is "pas classe") have a demand function for bottled water given by

$$q(p) = \begin{cases} a - bp & \text{for } 0 \leq p \leq \frac{a}{b} \\ 0 & \text{for } p > \frac{a}{b} \end{cases}.$$



- The two firms choose their levels of production, $q_L$ and $q_N$ simultaneously, and let the market determine the price.
- Setting quantity supplied equal to quantity demanded gives us

$$q_L + q_N = q(p),$$

- and solving for $p$ yields the market price as a functon of the firms' production levels:

$$p(q_L, q_N) = \begin{cases} \frac{1}{b}(a - q_L - q_N) & \text{for } q_L + q_N \leq a \\ 0 & q_L + q_N > a \end{cases}.$$

- To simplify the algebra without changing the character of the solution, we assume that $c = 0$.

- Profits for L'Eau are

$$\pi_L \equiv p q_L \equiv \frac{1}{b}(a - q_L - q_N)\, q_L.$$

- For $q_N \geq a$, $\pi \leq 0$ so that $q_L = 0$ must be the best response.

- For $q_N < a$, the first-order condition for profit-maximization is

$$0 = \frac{1}{b}(a - 2q_L - q_N)$$

so that L'Eau's best response is

$$q_L = \frac{a - q_N}{2},$$

which generates positive profits and therefore dominates the corner solution $q_L = 0$.



- We have the analogous best-response function for N'Eau, so that the equilibrium must satisfy

$$q_L = \frac{a - \frac{a - q_L}{2}}{2}$$

or

$$4q_L = a + q_L,$$

which yields

$$q_L^* = q_N^* = \frac{1}{3}a,$$

so that

$$p^* = \frac{1}{3}\frac{a}{b}.$$

- It follows that

$$p^* > c \; [= 0]$$

and

$$\pi_L^* = \pi_N^* > 0,$$

which means that both the equilibrium price and profits are above the competitive level.

PROBLEM 41.MM. ***Show that in the Cournot game between $n$ identical firms,***

$$q_i^* = \frac{1}{n+1}a$$

***and***

$$p^* = \frac{1}{n+1}\frac{a}{b}.$$

***Show also that this yields the monopoly solution for $n = 1$ and approaches the competitive solutions as $n$ gets large.***



## Duopoly with Product Differentiation

- **Consumers are uniformly distributed along a street, whose length is normalized to $1$.**
  - **We assume that $z$ consumers live on any segment of the street of length $z$.**
  - **Let $t$ denote a consumer's cost of round-trip travel per unit distance; i.e. a consumer's cost of travelling the distance $z$ along the street and back to his home again is $tz$.**
- **At each end of the street is a firm that sells spring water, $A$ on the left and $B$ on the right.**
  - **Both firms have zero costs.**
  - **The two firms compete in prices.**

- **The value of a bottle of spring water to the consumer is $v$. Each consumer wants to buy at most one bottle of spring water.**
  - **If the consumer must travel the distance $z$ to buy a bottle of spring water, then his willingness to pay for it is $v - tz$.**
  - **We are free to interpret $z$ as a measure of the difference between the consumer's ideal product and the product being sold: the larger is $z$, the less he likes the product being sold.**
  - **Consequently, we can view $A$ and $B$ as firms producing two different products, with the location of consumers as a measure of their relative preferences for the two products.**



- **What is $A$'s best response to the price $p_B$ adopted by $B$?**
  - **Suppose $A$ sets price $p_A$. Let $x$ represent the distance of a consumer from $A$, so that $1 - x$ is his distance from $B$.**
  - **Assume that $v$ is very large (all consumers must buy one unit).**
  - **The consumer will buy from $A$ if $v - tx - p_A \geq v - t(1 - x) - p_B$**
  - **The person at $x = 0$ will buy from $A$ if and only if**

$$p_A \leq p_B + t$$

**where as the person at $x = 1$ will buy from $A$ if and only if**

$$p_A \leq p_B - t.$$

- So if

$$p_B - t < p_A \le p_B + t$$

some consumers will buy from $A$ and some from $B$.

- Suppose the consumer at $\bar{x}$ is indifferent between the two firms.
- Then it must be true that

$$p_A + t\bar{x} = p_B + t(1 - \bar{x})$$

so that

$$\bar{x} = \frac{1}{2t}(p_B + t - p_A)\,.$$

- Therefore in the case that both firms have positive demand, the demand from $A$ must be $\bar{x}$ , because all the consumers with $x < \bar{x}$ will also buy from $A$.



- Therefore we can write the $A$'s demand as

$$q_A(p_A, p_B) \equiv \begin{cases} 1 & \text{for} \quad p_A \le p_B - t \\ \frac{1}{2t}(p_B + t - p_A) & \text{for} \quad p_B - t < p_A \le p_B + t \\ 0 & \text{for} \quad p_A > p_B + t \end{cases}$$

- $B$ sells to all consumers to whom $A$ doesn't sell, so $B$'s demand is given by

$$q_B(p_A, p_B) = 1 - q_A(p_A, p_B)\,.$$

PROBLEM 41.MM. *For this example, find $A$'s best response to $p_B$. Then find the Nash equilibria of the game between $A$ and $B$. How does the result change if $v$ is small, so that some consumers may choose not to buy from anyone? For what values of $v$ does this occur?*