Monopoly Product Variety and Quality

Reference: Pepall, Richards, and Norman, chapter 7

OJ Insanity


NO PULP
SOME PULP
LOTS OF PULP
CALCIUM
CALCIUM
FIBER
HEALTHY KIDS
LIGHT'N HEALTHY
LOW ACID
HEALTHY HEART WITH OMEGA-3
LIGHT'N HEALTHY
ANTIOXIDANT ADVANTAGE
Tropicana
PURE PREMIUM

Introduction

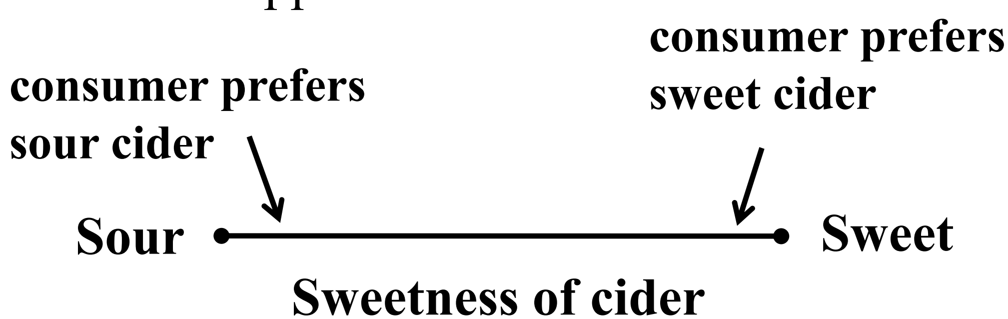
- Firms often produce different varieties of essentially the same product to sell to consumers with different tastes ➔ product differentiation
- One type of product differentiation is called horizontal differentiation: **consumers** rank products differently
  - some people like durians, others can't stand them
  - some people prefer a McDonald's Big Mac to a Burger King Whopper
  - people prefer a petrol station near their home
- An important question in this context: is the level of product variety that is chosen by a monopolist too much or too little?

Introduction

- For other types of products, consumers agree on how good a product is
- **All consumers** rank the products similarly
    - everyone agrees that Duracell batteries are better than a no-name brand because they last longer
    - a Jaguar is better than a Toyota Vios
- This is called vertical differentiation
- An important question here is: is the quality level chosen by a monopolist too high or too low?
- In this section we address these questions for a monopoly market
- Later in the course we will consider how competition affects both horizontal and vertical product differentiation

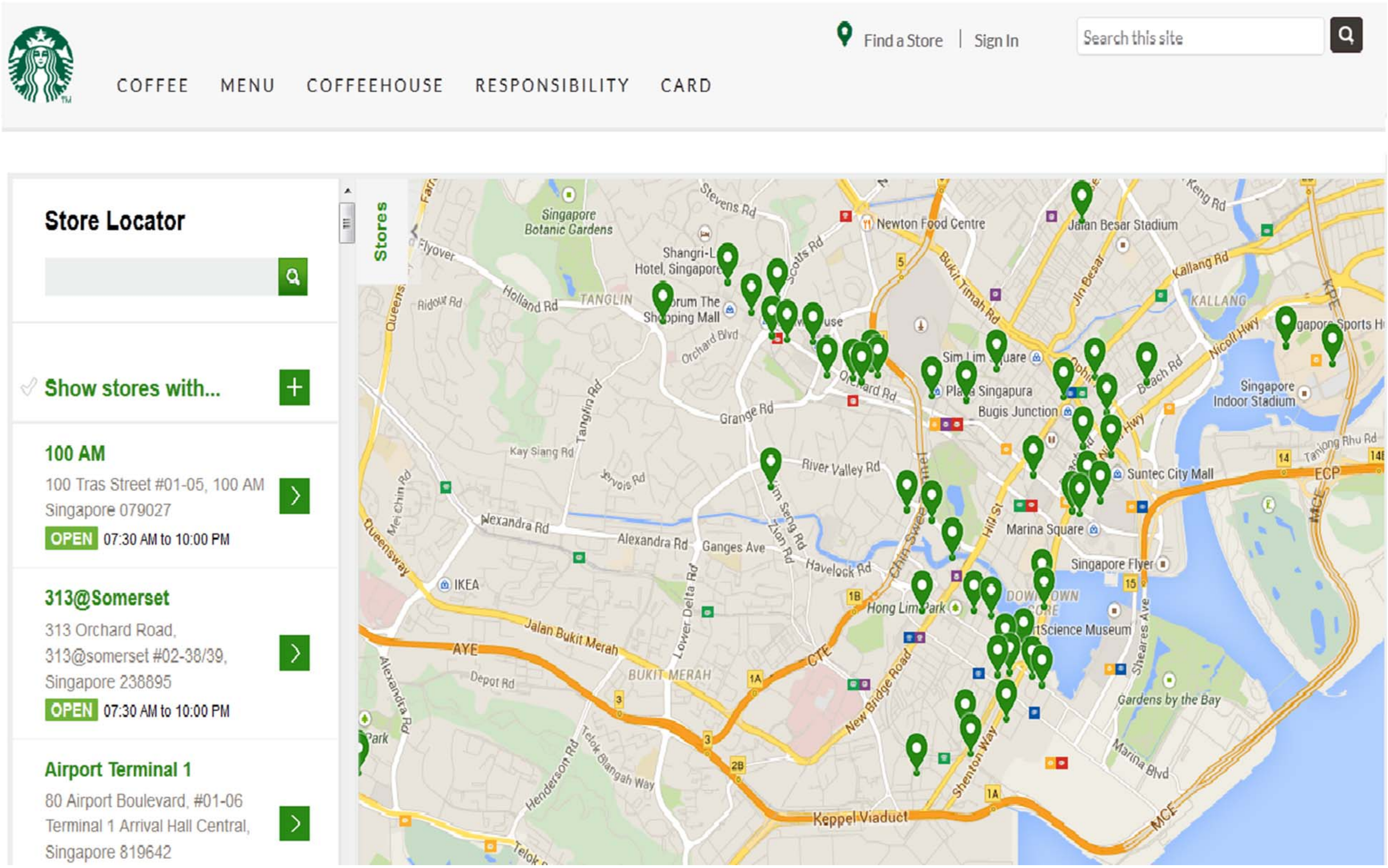
Location-based models of Horizontal Differentiation

- **Location-based models** are models in which the heterogeneous preferences of consumers are represented by location on a line or circle
- Location can represent:
  - **geography** – physical location
  - **time** – departure time of a flight
  - **product characteristics** – crunchiness of a cereal
- Hotelling's (1929) Linear City Model
  - ex. sweetness of apple cider



- A firm chooses a product type by choosing a location

Ex. Starbucks

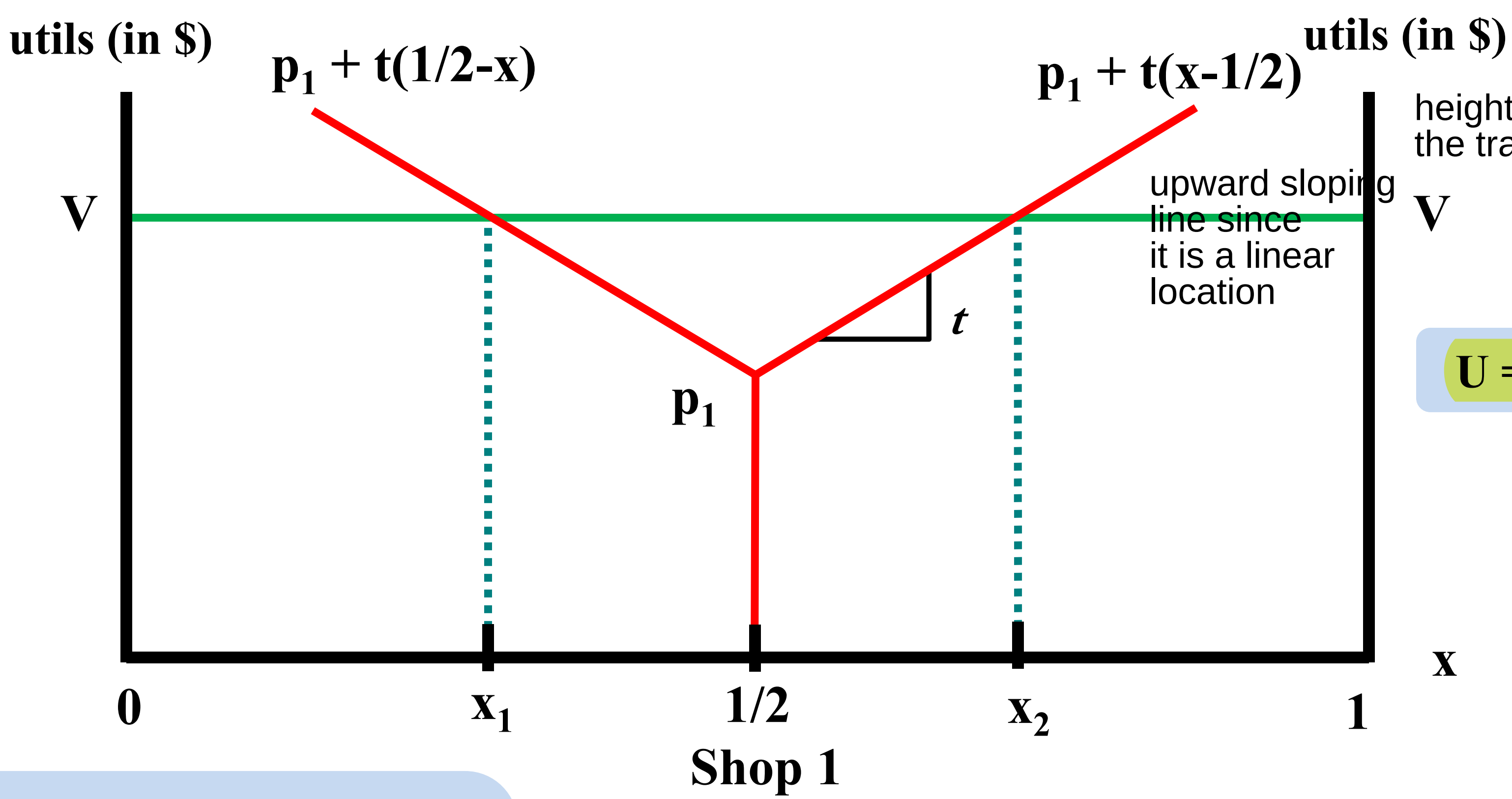


Hotelling Model

- We'll interpret the line as a street and consider a monopolist who sells a service (e.g., a health club or spa) at its shops along the street
- **Basic Setup**
  - N consumers are uniformly (evenly) distributed along a street of length 1
    - $\mathbf{0 \leq x \leq 1}$ denotes a location, **d** is distance
    - Consumers consider **buying one unit** of the service. The gross value of the service to the consumer is **V**
  - consumers incur "**transportation" costs (t)** per unit of distance traveled to buy the service (utility loss from not consuming their preferred product)
  - utility: $\mathbf{U = V - p - td}$ ➔ consumer buys if $\mathbf{U \geq 0}$
- The monopolist chooses the price and where to offer the service (where to locate the shops on the street)
- Consider first the case of a **single shop** ➔ it is reasonable to expect the firm to locate the shop in the middle of the line (**x = 0.5**)

Hotelling Model

Suppose that the monopolist sets a price of $p_1 < V$. Who buys the service?



height is the price paid and the transportation costs

U = V–(p+td)

Everyone between x_1 and x_2 has $U \geq 0$ and therefore buy

$$V = p_1 + t(x_2 - 1/2) \rightarrow x_2 = \frac{1}{2} + \frac{V - p_1}{t}$$

$$V = p_1 + t(1/2 - x_1) \rightarrow x_1 = \frac{1}{2} - \frac{V - p_1}{t}$$

two marginal consumers

Hotelling Model

- Total demand is

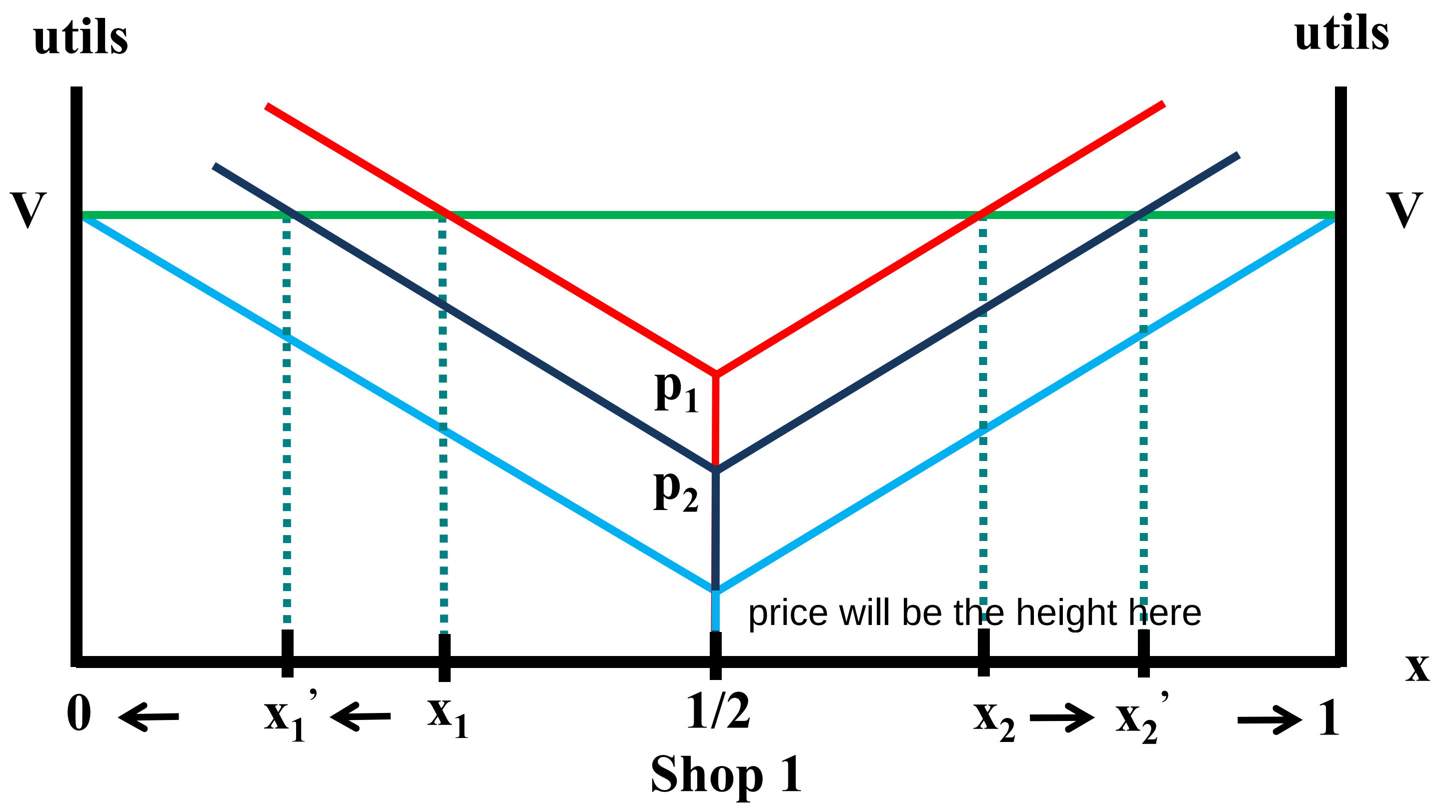
$$Q(p_1,1)=N(x_2-x_1)=N\left(\frac{1}{2}+\frac{V-p_1}{t}-\left(\frac{1}{2}-\frac{V-p_1}{t}\right)\right)=2N\left(\frac{V-p_1}{t}\right)$$

- When V - t > c, the firm will sell to the whole market
  - In this case we say that the market is covered
  - We will assume throughout that this is the case
- The highest price possible is the price such that the two persons who live furthest away are just willing to buy
  - these persons are ½ distance away from the shop
  - transport costs are t/2
  - price is then: **V – p – t/2 = 0 ➔ p = V – t / 2**

Hotelling Model

Suppose the firm reduces the price to p_2

If the firm decreases price enough, everyone buys.



a shop wouldn't want to set up shop at 0 or 1 since majority of the consumer will have to pay alot of transportation cost, can extract higher price if less transportation costs are incurred

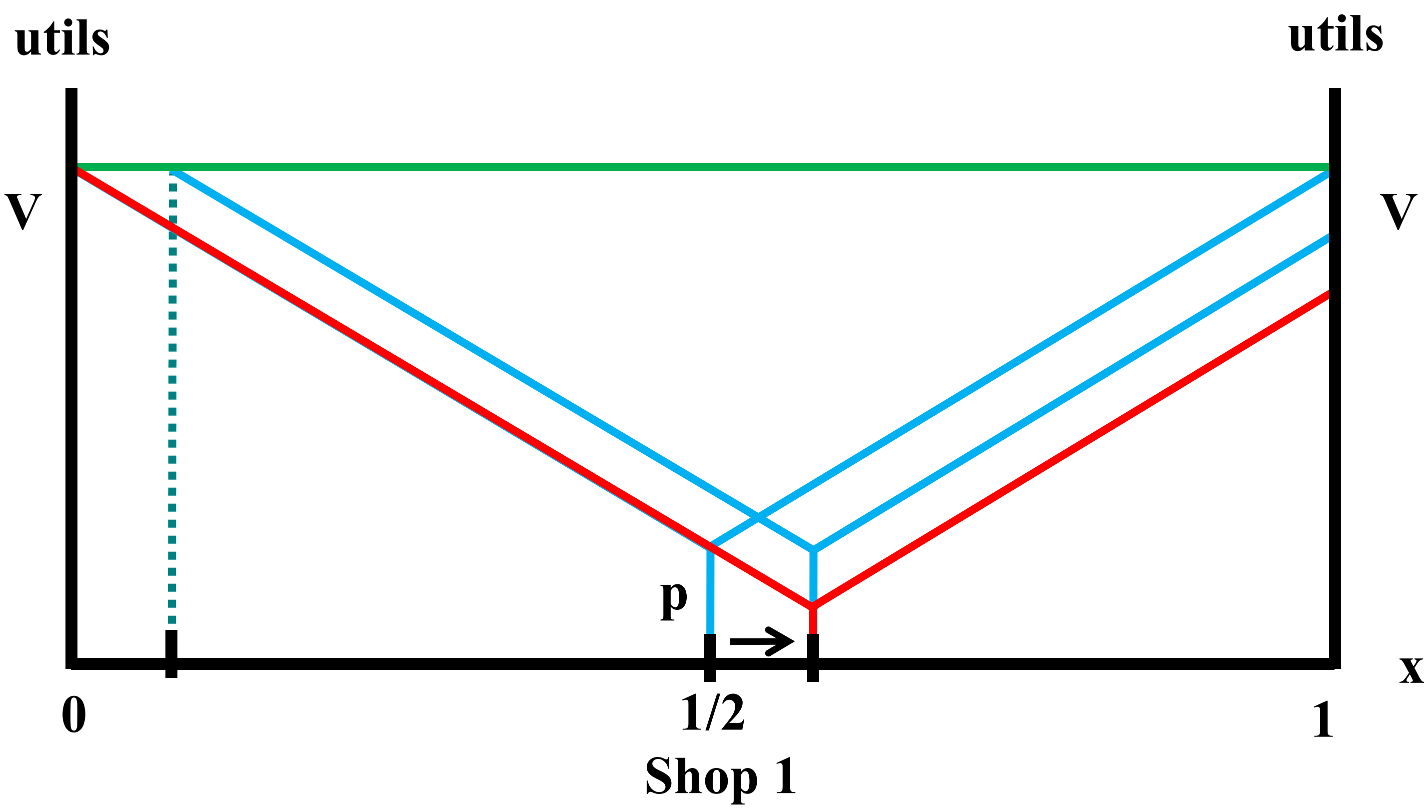
Hotelling Model

Why does the firm set up in the middle?

Suppose the firm moves from x = ½

It would have to drop price to cover the market

But sales are the same…profit must be lower than at x = ½.



Hotelling Model

- What is the firm's profit?
- Let marginal cost be **c** and set-up costs per shop be **F**
- Profit is then

$$\pi(1) = N\left(V - \frac{t}{2} - c\right) - F$$

- What if the firm had **two shops**?
- Since each shop has the same costs the monopolist will choose the same price for each shop
- The optimal location is for one shop to be located at ¼ and one at ¾
- What is the maximum price that the monopolist can set and cover the market?

Hotelling Model

With two shops, ¼ is the maximum distance a person has to travel

Hotelling Model

- The person ¼ distance away from a shop has transport costs t /4
- Price is then: **V – p – t/4 = 0 ➔ p = V – t / 4**
- Profit is:

$$\pi(2) = N\left(V - \frac{t}{4} - c\right) - 2F$$

price is higher but there is an additional cost of fixed fee F

- What if the firm had **three shops**?
- The optimal locations are 1/6, ½, and 5/6 and price is **p = V – t / 6**
- Profit is:

$$\pi(3) = N\left(V - \frac{t}{6} - c\right) - 3F$$

Hotelling Model

- There is a general pattern emerging
- If the monopolist has *n* shops, it locates the *i*th shop at $\frac{2i-1}{2n}$
- E.g., if n = 3, then the first shop is located at (2*1 – 1)/(2*3) = 1/6
- Price is **p = V – t / 2n**
- Profit is:

$$\pi(n) = N\left(V - \frac{t}{2n} - c\right) - nF$$

high fixed costs will lead to shops opening less

- The effect of a new shop on profit is: $\frac{d\pi(n)}{dn} = \frac{Nt}{2n^2} - F$

Hotelling Model

p = V – t / 2n

$$\frac{d\pi(n)}{dn} = \frac{Nt}{2n^2} - F$$

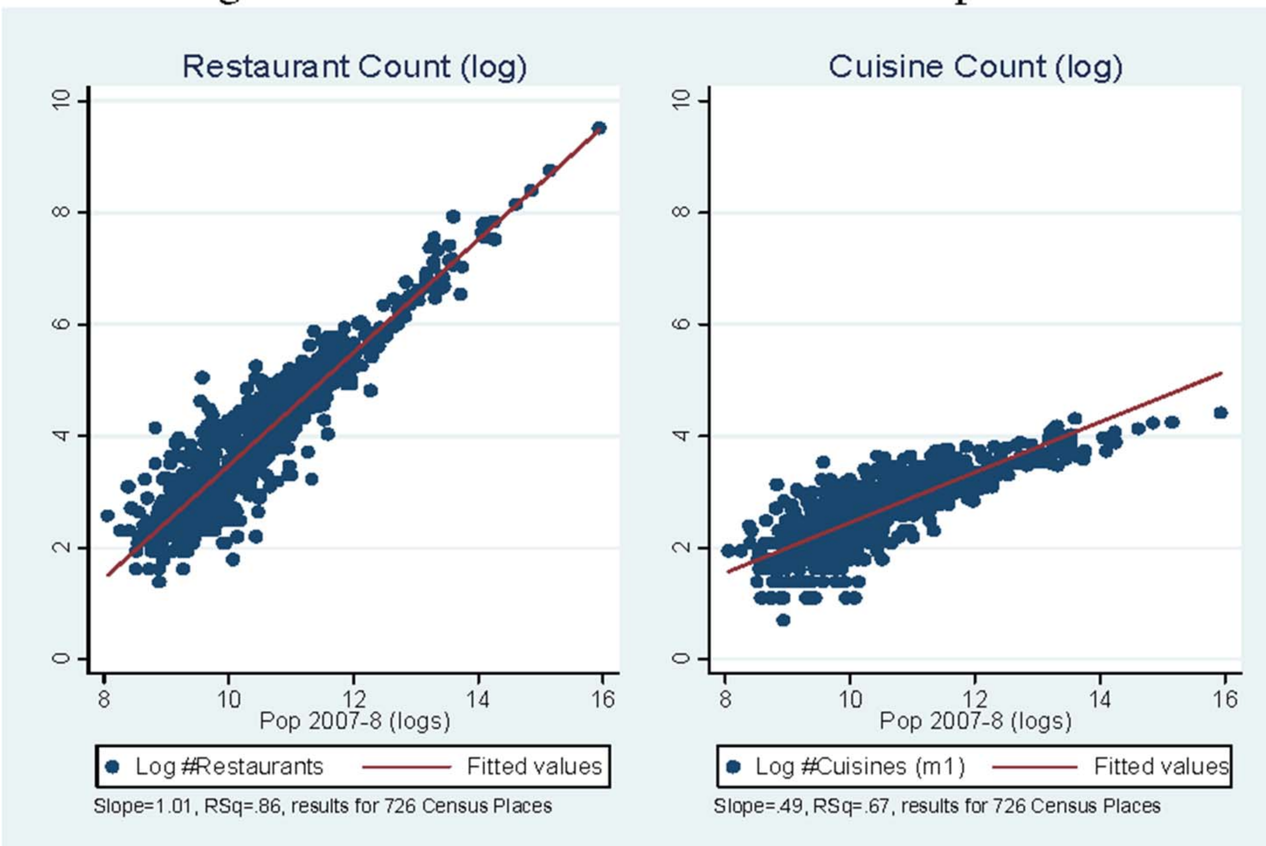
- Notice that as the number of shops (products) increases, the higher the price the monopolist charges
  - o with more shops the closer a shop will be to each customer's location
- But introducing new shops is costly so there is a tradeoff
- Also notice that that there will be more product variety (more shops):
  - o in bigger markets
  - o when set up costs are small
  - o when transportation cost is high
    - when transportation cost is high, it means that people really value their ideal product so it's better to introduce more products to cater to the different customers

Product Variety

- The monopolist has an incentive to introduce a lot of products in order to extract higher prices
  - Solve $$\frac{d\pi(n)}{dn} = \frac{Nt}{2n^2} - F = 0$$
  - The monopolist will introduce $n^* = \sqrt{\frac{tN}{2F}}$ products

Ex. City Size and Product Variety (Schiff)

Figure 1: Restaurants and Cuisines vs Population



Product Variety

- Are too many products introduced? That is, is the profit-maximizing number of products the same as the socially optimal number?

- The socially optimal number of products maximizes total welfare, W:

  - $W = NV - cN - T(n) - nF$

- The total gross benefit that the customers receive is NV and the total variable cost of producing the product is cN

  - these do not depend on n and thus can be ignored

marginal benefit of the additional food is decreasing

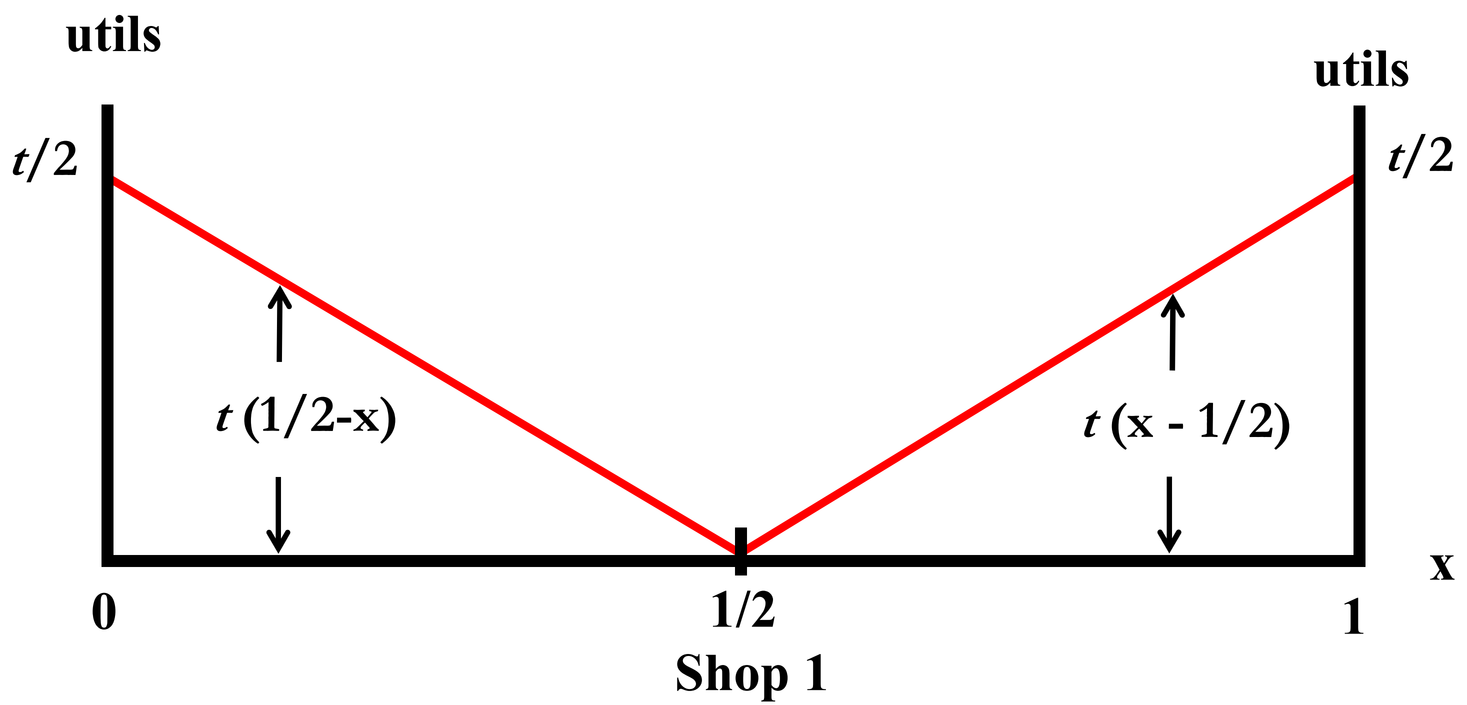
Product Variety

- The factors that affect total welfare and depend on the number of products are total transportation costs, $T(n)$, and the setup costs, nF
  - Maximizing W is equivalent to minimizing the costs $T(n) + nF$
- The social planner, just like the monopolist, will space the shops evenly
- This makes computing $T(n)$ relatively straightforward
- We start again with one shop

Total transportation costs with 1 shop

- The figure shows the transportation cost of a consumer at x
- $T(1)$ is the area under the lines times the number of consumers:

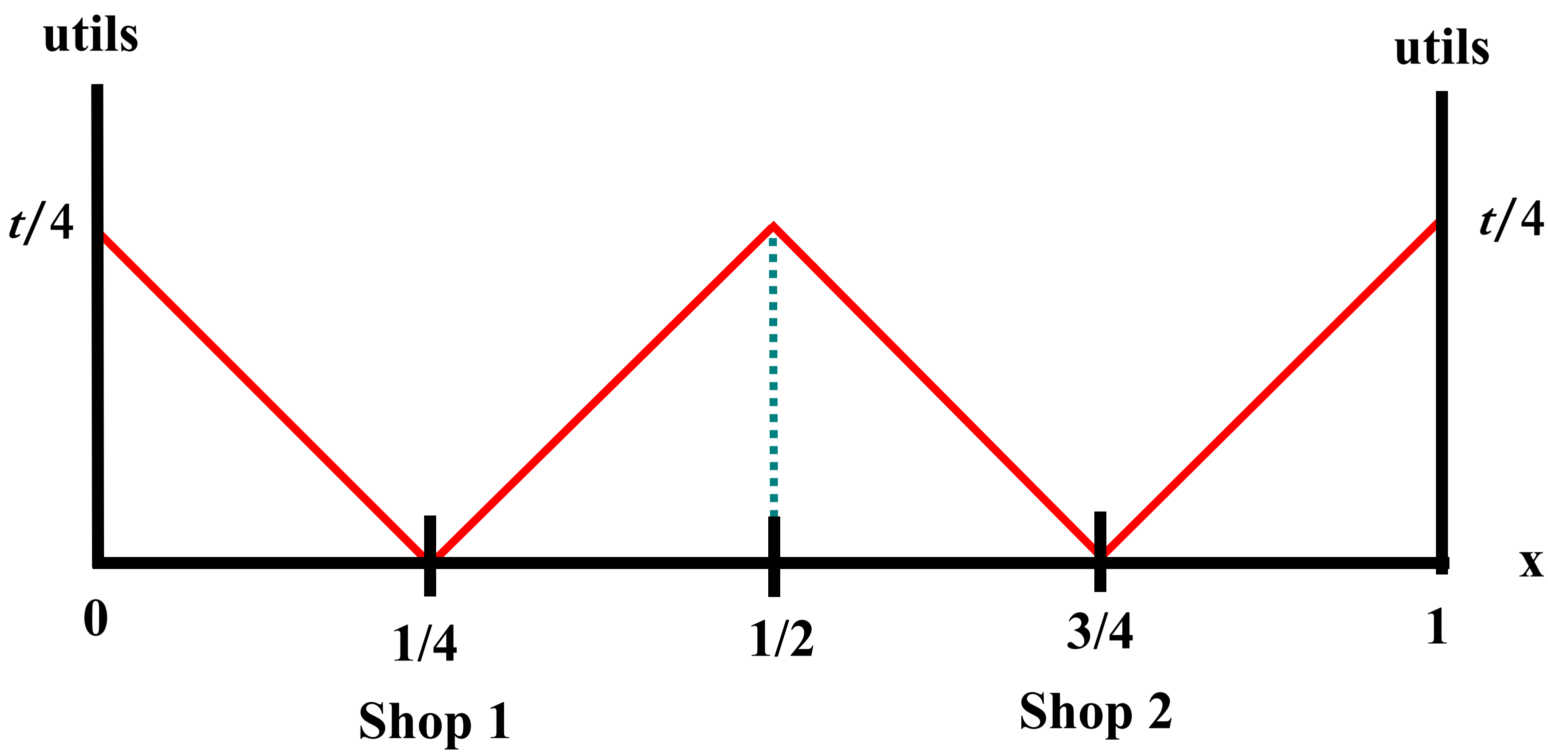
$$T(1) = N \cdot 2 \cdot \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{t}{2} = \frac{tN}{4}$$



Total transportation costs with 2 shops

- With two shops: $T(2) = N \cdot 4 \cdot \frac{1}{2} \cdot \frac{1}{4} \cdot \frac{t}{4} = \frac{tN}{8}$

area under the lines



Transportation costs with *n* shops

- With *n* shops: $T(n) = \dfrac{tN}{4n}$
- Thus, the total cost of *n* products is: $\dfrac{tN}{4n} + nF$
- The welfare maximizing number of products: $n^W = \sqrt{\dfrac{tN}{4F}}$
- We can compare this to the monopoly's choice: $n^* = \sqrt{\dfrac{tN}{2F}}$
  - ➢ **The market produces too much variety**
- The firm values the higher price/extra revenue from an additional shop/product but from a social standpoint this is just a transfer from the consumer to the firm and does not affect total welfare
  - ➢ **The firm overvalues new products**

Vertical differentiation

- Vertical differentiation means that the ranking of products is the same for all consumers
  - if two different products were sold at the same price, everyone would buy the same product
- Even though consumers rank the products similarly, their willingness to pay for the products differs
  - some consumers will pay more for a high quality product than other consumers due to, for example, differing incomes
- We will use this framework to understand what product quality a monopolist chooses and whether it is socially optimal

Vertical differentiation

- To keep the analysis simple we will assume that the firm offers only one product
- The choice variables for the firm are quantity and quality
- The demand curve depends on the quality, z: $P = P(Q, z)$
  - Each consumer buys at most one unit of the good
    - The demand curve is a ranking of the consumers' WTP for a product of quality z
  - an increase in quality increases WTP, rotating the demand curve out
  - but increases in quality are costly so the firm faces a tradeoff

Vertical differentiation

- Suppose demand and costs are given by:

$$P = z(50 - Q) \quad \text{and} \quad C(Q, z) = 5z^2$$

- Profit is then:

$$\pi(Q, z) = z(50 - Q)Q - 5z^2$$

- First-order conditions:

$$\frac{\partial \pi(Q, z)}{\partial Q} = 0 \Rightarrow z(50 - 2Q) = 0 \Rightarrow Q^* = 25$$

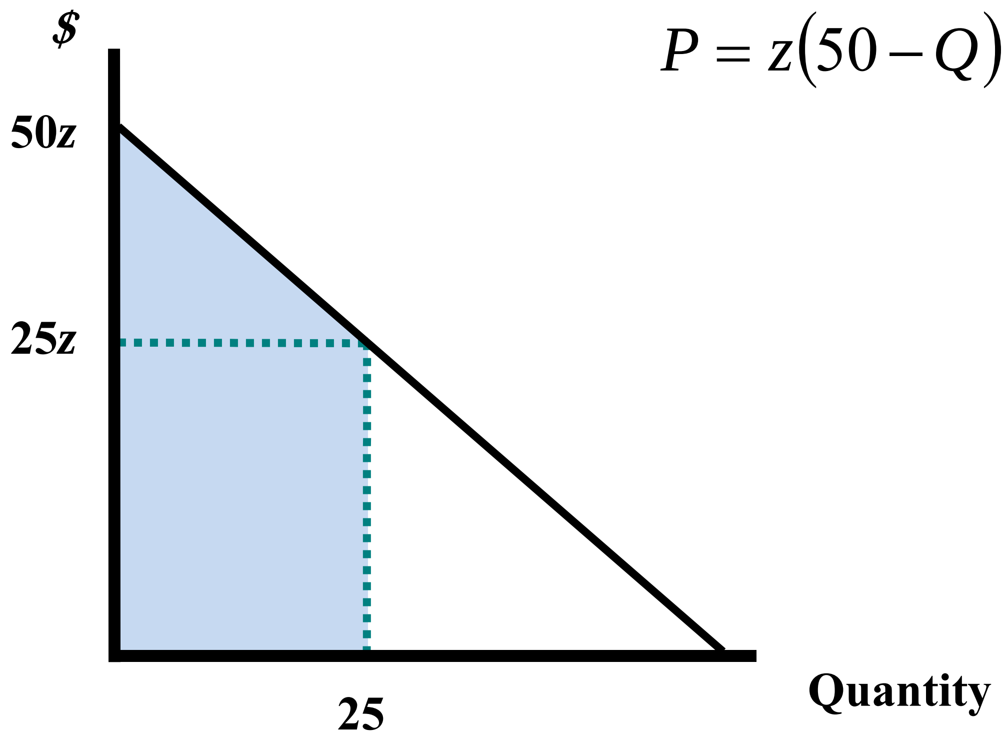
$$\frac{\partial \pi(Q, z)}{\partial z} = 0 \Rightarrow (50 - Q)Q - 10z = 0 \Rightarrow z^* = 62.5$$

Vertical differentiation

- How does the monopolist's choice compare to the socially efficient outcome?
- The social planner would choose a higher level of quantity than the monopolist
  - *mc* of producing an additional unit for a given quality is zero
- This will affect the optimal choice of quality
- We wish to abstract from this effect so we assume that the social planner chooses the same quantity as the monopolist
- The social planner chooses z to maximize total welfare, which is the total benefit of 25 units of a product of quality z minus the cost of developing the product

Vertical differentiation

- Total benefit is the area under the demand curve up to Q = 25: 1875z/2



$$P = z(50 - Q)$$

Vertical differentiation

- Total welfare is then: $$W = \frac{1875}{2}z - 5z^2$$

- Maximize W to find the socially optimal choice of quality: $z^w = 93.75$
  - the monopolist chooses too little quality

- Underprovision of quality, however, is not a general result

- In some cases, the monopolist chooses too little quality, in other cases it chooses too much quality

Vertical differentiation

- A social planner cares about the increase in consumer surplus resulting from an increase in quality
  - An increase in quality affects all consumers of the good, providing them with greater surplus
- In contrast, the monopolist is only interested in the higher price it can get from the marginal consumer being willing to pay more for greater quality
- In other words, the social planner cares about the effect of quality across all consumers who buy the product (these are called *inframarginal* consumers) while the monopolist cares about the effect of quality on the *marginal* consumer

Vertical differentiation

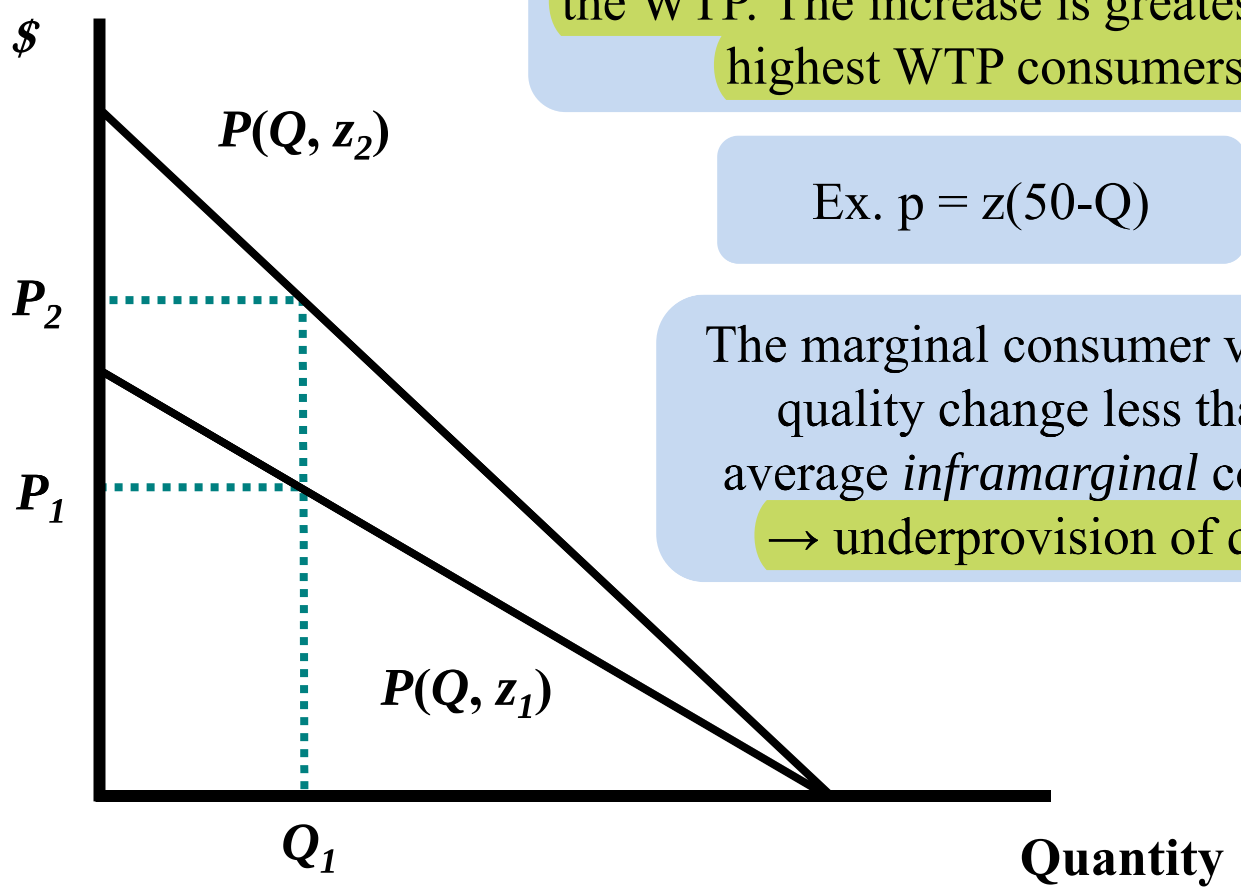
- For a given quantity, if the impact of quality on the willingness to pay of the average *inframarginal* consumer is greater than the impact on the *marginal* consumer, then a monopolist will undersupply quality
- This is likely to hold if consumers who value the product highly also tend to have a higher valuation for quality improvements
- For example, consumers who value the speed of computers are also likely to put a higher valuation on any improvement in the speed than a consumer who is only just willing to buy a computer at the current price

Case 1: underprovision of quality

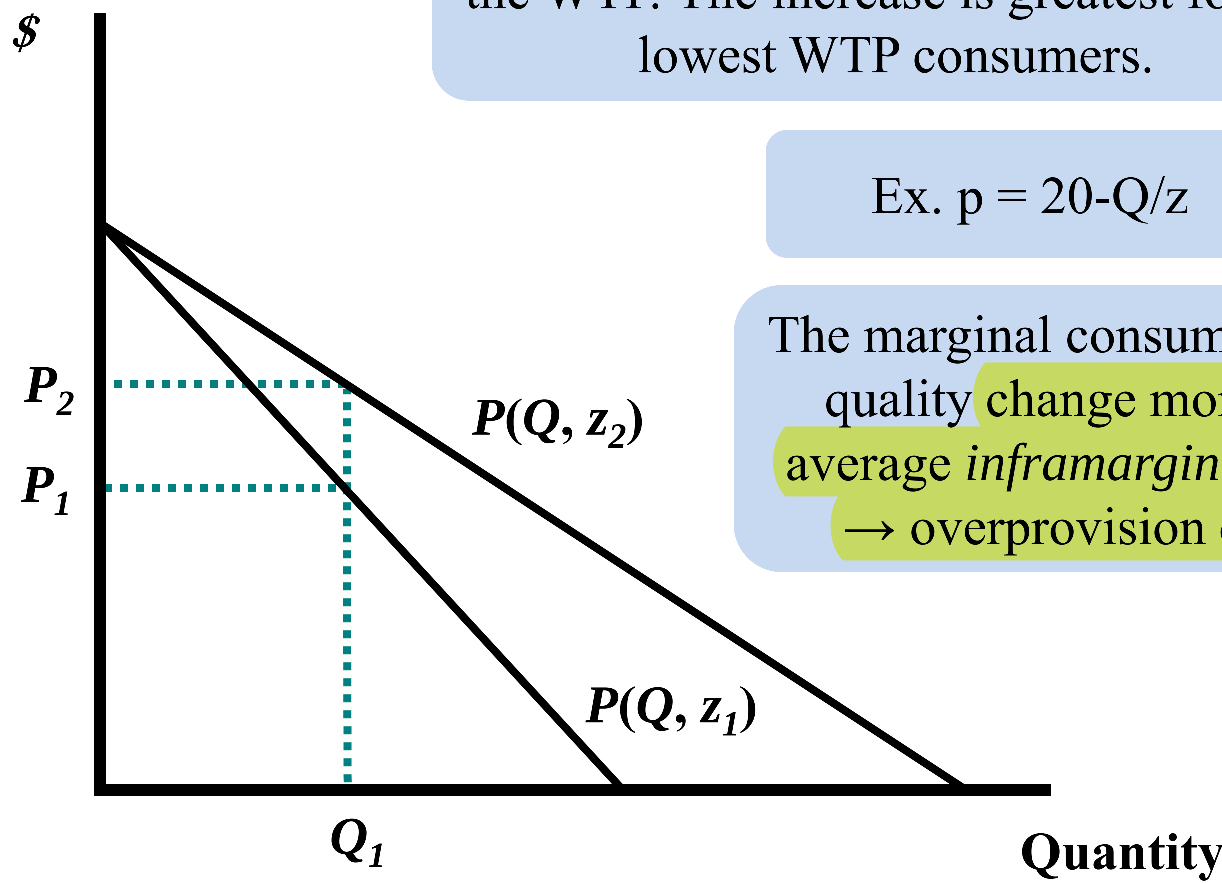
Case 1. An increase in quality increases the WTP. The increase is greatest for the highest WTP consumers.

Ex. p = z(50-Q)

The marginal consumer values the quality change less than the average *inframarginal* consumer → underprovision of quality



Case 2: overprovision of quality



Case 2. An increase in quality increases the WTP. The increase is greatest for the lowest WTP consumers.

Ex. p = 20-Q/z

The marginal consumer values the quality change more than the average *inframarginal* consumer → overprovision of quality