Topic 9: Product Differentiation
Introduction

- Firms produce similar but not identical products (differentiated) → in many different ways.
  
  - **Horizontally**
    
    - Goods of *similar quality* targeted at *consumers of different types/* preference/* taste/* location*
      
      - How is variety determined?
      - How does competition influence the equilibrium variety.
    
  - **Vertically**
    
    - Consumers agree that there are *quality differences*.
      
      - They *differ* in *willingness to pay for quality*.

  - What determine the quality of goods?
Introduction …

- **Modeling** horizontal product differentiation:
  
  - **Representative Consumer Model**
    
    - Firms producing differentiated goods **compete equally for all consumers**.
    
    - Demand is continuous $\Rightarrow$ the usual (inverse) demand function $\Rightarrow$ a small change in any one firm’s quantity (or price) $\Rightarrow$ a small change in demand.
  
  - **Spatial/ Location/ Address Model**
    
    - Consumers may **prefer products with certain characteristics** (taste, location, sugar contents, etc) $\Rightarrow$ are **willing to pay premium** for the preferred products.
    
    - Demand maybe **independent** (not close substitutes) or **highly dependent** (close substitutes)
Representative Consumer Model

- Recall that with **homogenous goods** $\rightarrow$ demand:
  \[ P_i = P = D(q_1, q_2, ..., q_N) \]
  \[ P_i = P = D(q_1 + q_2 + ... + q_N) \]

- With 2 firms $P = A - B(q_1 + q_2)$ with $B_1 = B_2$

- With differentiated products: $P_i = A - B_i q_i - B_j q_j$ with $j \neq i$ where $A > 0$ and $|B_i| > |B_j|

- With more than two firms, we can write:
  \[ P_i = A - B_i q_i - B_j \sum_{j=1}^{N} q_j \text{ with } j \neq i \]

  \[ \sum_{j=1}^{N} q_j = \text{ the sum of the quantity of all firms except firm } i. \]
Coke and Pepsi are similar but not identical. As a result, the lower priced product does not win the entire market.

Suppose that econometric estimation gives:

\[
Q_C = 63.42 - 3.98P_C + 2.25P_P \\
MC_C = $4.96
\]

\[
Q_P = 49.52 - 5.48P_P + 1.40P_C \\
MC_P = $3.96
\]

There are at least two methods for solving this for \( P_C \) and \( P_P \). Assume that we have Bertrand competition.
Representative Consumer Model…

**Method 1:** Calculus

Profit of Coke: \( \Pi_C = (P_C - 4.96)(63.42 - 3.98P_C + 2.25P_P) \)

Profit of Pepsi: \( \Pi_P = (P_P - 3.96)(49.52 - 5.48P_P + 1.40P_C) \)

Differentiate with respect to \( P_C \) and \( P_P \) respectively \( \rightarrow \) first order conditions \( \rightarrow \) optimal \( P_C \) and \( P_P \).

**Method 2:** \( MR = MC \)

Reorganize the demand functions

\[
P_C = (15.93 + 0.57P_P) - 0.25Q_C \quad \rightarrow \quad P_C (Q_C, Q_P)
\]

\[
P_P = (9.04 + 0.26P_C) - 0.18Q_P \quad \rightarrow \quad P_P (Q_C, Q_P)
\]

Calculate marginal revenue, equate to marginal cost, solve for \( Q_C \) and \( Q_P \) and substitute in the demand functions.
Both methods give the best response functions:

\[ P_C = 10.44 + 0.2826P_P \]
\[ P_P = 6.49 + 0.1277P_C \]

These can be solved for the equilibrium prices as indicated:

The equilibrium prices are each greater than marginal cost.
Location Model

- Typically, brands (products) compete vigorously with those that consumers view as close substitutes.

- Close substitutes-ness → could either depend on the perception of consumers or physical or product attributes.

- “Location” based model → tries to capture the notion of close substitutes → location can be interpreted as:
  - **Geographic** location → e.g. the location of the outlet (store).
  - **Time** → e.g. departure time, showing time.
  - **Product characteristics** → design and variety → e.g. diet coke vs regular coke, sweetness and crunchiness of cereals.
Location Model...

- Based on Hotelling (1929) → Hotelling’s Linear Street Model.
- Imagine → e.g. a long stretch of beach with ice cream shops (sellers) along it.
- The model discusses the “location” and “pricing behavior” of firms.

**Basic Setup:**

- N-consumers are uniformly distributed along this linear street → thus in any block of the street there are an equal number of consumers.

- Consumers are identical except for location and each of them are considering buying exactly one unit of product as long as the price paid + other costs are lower than the value derived from consuming the product (V).

- As a benchmark, consider for the time being the case of a monopoly seller → operates only 1 store → it is reasonable to expect that it is located in the middle.

- Consumers incur “transportation” costs per unit of distance (e.g. mile) traveled, $t$. 
Location Model...

uniform distribution with density $N$

street line
Hotelling Model...

Suppose that the monopolist sets a price of $p_1$.

All consumers within distance $x_1$ to the left and right of the shop will buy the product.

$p_1 + t \cdot x_1 = V, \text{ so } x_1 = (V - p_1)/t$.
Suppose the firm reduces the price to \( p_2 \)? Then all consumers within distance \( x_2 \) of the shop will buy from the firm.
Hotelling Model…

- Suppose that all consumers are to be served at price $p$.
  - The highest price is that charged to the consumers at the ends of the market.
  - Their transport costs are $t/2$: since they travel $\frac{1}{2}$ mile to the shop.
  - So they pay $p + t/2$ which must be no greater than $V$.
  - So $p = V - t/2$.

- Suppose that marginal costs are $c$ per unit.

- Suppose also that a shop has set-up costs of $F$.

- Then profit is $\Pi = N \left( V - \frac{t}{2} - c \right) - F$.
Hotelling Model…

\[
\begin{align*}
  z &= 0 \\
  x_3 &= \frac{1}{2} \\
  x_2 &< x_1
\end{align*}
\]
What if there are two shops and these two shops are competitors?

Consumers buy from the shop who can offer the lower full price (product price + transportation cost).

Suppose that location of these two shops are fixed at both ends of the street, and they compete only in price.

How large is the demand obtained by each firm and what prices are they going to charge?
Hotelling Model…

Assume that shop 1 sets price $p_1$ and shop 2 sets price $p_2$.

What if shop 1 raises its price to $p'_1$?

$x_m$ marks the location of the marginal buyer—one who is indifferent between buying either firm’s good.

All consumers to the left of $x_m$ buy from shop 1.

$x_m$ moves to the left: some consumers switch to shop 2.

$x_m$ moves to the right: some consumers switch to shop 2.

Some consumers to the right buy from shop 2.
Hotelling Model…

\[ p_1 + tx^m = p_2 + t(1 - x^m) \]
\[ \therefore 2tx^m = p_2 - p_1 + t \]
\[ \therefore x^m(p_1, p_2) = \frac{p_2 - p_1 + t}{2t} \]

There are \( N \) consumers in total
So demand to firm 1 is \( D^1 = \frac{N(p_2 - p_1 + t)}{2t} \)

Price

---

This is the fraction of consumers who buy from firm 1
Hotelling Model...

Profit to firm 1 is $\pi_1 = (p_1 - c)D^1 = N(p_1 - c)(p_2 - p_1 + t)/2t$

$\pi_1 = N(p_2p_1 - p_1^2 + tp_1 + cp_1 - cp_2 - ct)/2t$

Differentiate with respect to $p_1$

$\frac{\partial \pi_1}{\partial p_1} = \frac{N}{2t} (p_2 - 2p_1 + t + c) = 0$

Solve this for $p_1$

$p^*_1 = (p_2 + t + c)/2$

This is the best response function for firm 1

What about firm 2? By symmetry, it has a similar best response function.

$p^*_2 = (p_1 + t + c)/2$

This is the best response function for firm 2
Finding the Bertrand-Nash Eq.:

\[
p^*_1 = \frac{(p_2 + t + c)}{2}
\]

\[
p^*_2 = \frac{(p_1 + t + c)}{2}
\]

\[2p^*_2 = p_1 + t + c\]

\[= \frac{p_2}{2} + \frac{3(t + c)}{2}\]

\[\therefore p^*_2 = t + c\]

\[\therefore p^*_1 = t + c\]

Profit per unit to each firm is \( t \)

Aggregate profit to each firm is \( \frac{Nt}{2} \)
Hotelling Model…

\[ p^*_{1} = t+c \]

\[ p^*_{2} = t+c \]

\[ x^m = \frac{(p_2 - p_1 + t)}{2t} \]

\[ x^m = \frac{1}{2} \]
Strategic Complements and Substitutes

- Best response functions are very different between Cournot and Bertrand
  - they have opposite slopes
  - reflects very different forms of competition
  - firms react differently e.g. to an increase in costs
Strategic Complements and Substitutes...

- Suppose firm 2’s costs increase
- This causes Firm 2’s Cournot best response function to fall
  - at any output for firm 1 firm 2 now wants to produce less
- Firm 1’s output increases and firm 2’s falls
- Firm 2’s Bertrand best response function rises
  - at any price for firm 1 firm 2 now wants to raise its price
- firm 1’s price increases as does firm 2’s
Hotelling Model (continued)

Price

P₁

0

a

xm

a

Shop 1

1 - b

b

P₂

Price

1

x

Shop 2

Price

p₁

p₂
Hotelling Model (continued)

\[ U_x = \begin{cases} 
V - p_1 - t(x^m - a) & \text{if buys from shop 1} \\
V - p_2 - t((1-b) - x^m) & \text{if buys from shop 2} 
\end{cases} \]

\[ V - p_1 - t(x^m - a) = V - p_2 - t((1-b) - x^m) \]

\[ D^1 = N x^m = N \left( \frac{p_2 - p_1}{2t} + \frac{1-b+a}{2} \right) \text{ Demand for Shop 1} \]

\[ D^2 = N (1 - x^m) = N \left( \frac{p_1 - p_2}{2t} + \frac{1+b-a}{2} \right) \text{ Demand for Shop 2} \]
Hotelling Model...

Finding the Bertrand-Nash Eq.:

For simplicity assume \( N=1 \) and \( c=0 \)

\[
\pi_1 = D^1(p_1 - c) = N \left( \frac{p_2 - p_1}{2t} + \frac{1-b+a}{2} \right) (p_1 - c)
\]

\[
\pi_1 = D^1 p_1 = \left( \frac{p_2 - p_1}{2t} + \frac{1-b+a}{2} \right) p_1
\]

\[
\frac{\partial \pi_1}{\partial p_1} = \left( \frac{p_2 - 2p_1}{2t} + \frac{1-b+a}{2} \right) = 0
\]

Similarly for firm 2, the first order condition for max can be derived as,

\[
\pi_2 = D^2 p_2 = \left( \frac{p_1 - p_2}{2t} + \frac{1+b-a}{2} \right) p_2
\]

\[
\frac{\partial \pi_2}{\partial p_2} = \left( \frac{p_1 - 2p_2}{2t} + \frac{1+b-a}{2} \right) = 0
\]
Hotelling Model...

Best response functions can be derived:

\[ p^*_1 = \frac{t(1-b+a)}{2} + \frac{1}{2} p_2 \]
\[ p^*_2 = \frac{t(1+b-a)}{2} + \frac{1}{2} p_1 \]

Bertrand Nash Equilibrium:

\[ p^*_1 = \frac{t(3-b+a)}{3} \]
\[ p^*_2 = \frac{t(3+b-a)}{3} \]
\[ D^1 = x^m = \frac{3-b+a}{6} \]
\[ D^2 = (1-x^m) = \frac{3+b-a}{6} \]
\[ \pi_1 = \frac{t(3-b+a)^2}{18} \]
\[ \pi_2 = \frac{t(3+b-a)^2}{18} \]

Prices and profits increase with the transportation cost (t) \( \rightarrow \) some degree of monopoly power.

Prices and profits increase with the distance between firms (1-(a+b)).
Hotelling Model...

When firms are located at the **extreme ends** \((a=0 \text{ and } b=0)\), prices are **highest** \(\rightarrow\) our previous results.

When firms are located at the same location \((a=1/2 \text{ and } b=1/2)\)

We have the case of Bertrand with homogenous good, and thus \(p_1=p_2=0\).
Hotelling Model…

- Two final points on this analysis
- $t$ is a measure of transport costs
  - it is also a measure of the value consumers place on getting their most preferred variety
  - when $t$ is large competition is softened
    - and profit is increased
  - when $t$ is small competition is tougher
    - and profit is decreased
- Locations have been taken as fixed → what happen when firms also choose locations in addition to prices?
Hotelling Model...

- If firms choose location first and then compete in prices.

- Given the price and location of its opponent, firm 2, would firm 1 want to relocate?
  \[ \pi_1 = \frac{t(3-b+a)^2}{18} \quad \rightarrow \quad \frac{\partial \pi_1}{\partial a} = \frac{t(3-b+a)}{9} > 0 \]
  \[ \pi_2 = \frac{t(3+b-a)^2}{18} \quad \rightarrow \quad \frac{\partial \pi_2}{\partial b} = \frac{t(3+b-a)}{9} > 0 \]

- For any location b, firm 1 could increase its profit by moving closer to firm 2 (towards center) \( \Rightarrow \) similarly firm 2 will have the same intention.

- However, when they get too close to each others they become less differentiated \( \Rightarrow \) moving closer to Bertrand paradox \( \Rightarrow \) profits = 0, so they want to avoid this \( \Rightarrow \) better off to move back.

- Thus, when firms choose both prices and locations \( \Rightarrow \) non-existence of equilibrium \( \Rightarrow \) the drawback of Hotelling’s model.
Hotelling Model...

Demand and profit functions are discontinuous $\Rightarrow$ discontinuity in the best response fu. $\Rightarrow$ no intersection $\Rightarrow$ no pure strategy NE.
Hotelling Model…

When they are located sufficiently far from each other, the problem does not exist.
Salop’s Circle Model

- To avoid the problem of non existence of equilibrium, Salop (1979) developed circle model which introduce 2 major changes to the Hotelling model.
  - Firms are located around a circle instead of a long line.
  - Consideration of an outside (second) good, which is undifferentiated and competitively supplied.

Firms

- Firms are located around a circle (circumference=1) with equal distance (1/N) from each other.
- Fixed cost f, and marginal cost, c.
- Profit: $\pi_i(q_i) = (p_i - c)q_i - f$
Salop’s Circle Model (example: N=6)
Salop’s Circle Model…

- **Consumers**
  - Uniformly located around the circle (e.g. round the clock airline, bus, and train services, etc).
  - A consumer’s location $x^*$ represents the consumer’s most preferred type of product.
  - Each consumer buys one unit
  - Transportation cost per unit of distance $= t$.
  - Given the price, $p$, charged by the adjacent firms (left and right) and $p_1$ charged by firm 1, we can derive the location of the indifferent consumer located at the distance $x \in (0, 1/N)$.

$$V - p_1 - tx = V - p - t\left(\frac{1}{N} - x\right)$$

$$D^1(p_1, p) = 2x = \frac{p - p_1}{t} + \frac{1}{N}$$

Firm 1’s market share (demand)
Salop’s Circle Model...

Therefore:

\[
\pi_1 = (p_1 - c) \left( \frac{p - p_1}{t} + \frac{1}{N} \right) - f
\]

\[
\frac{\partial \pi_1}{\partial p_1} = 0 \quad \rightarrow \quad p_1 = \frac{t}{2N} + \frac{p + c}{2}
\]

By symmetry, we have \( p_1 = p \), and thus,

\[
p = c + \frac{t}{N} \quad \rightarrow \quad (p - c) = \frac{t}{N}
\]

Similar as in the Hotelling model, **price & profit margin increases with transportation cost \( t \) and decrease with \( N \).**

Suppose that entry by new firms is possible (**free-entry**) \( \rightarrow \) entry will take place until profit is fully dissipated.

\[
\pi_i = (p - c) \frac{1}{N} - f = \frac{t}{N^2} - f = 0
\]

\[
N^c = \sqrt{\frac{t}{f}} \quad \text{and} \quad p^c = c + \sqrt{tf}
\]

Firm’s price is above MC, but yet it earns no profit.
Salop’s Circle Model…

- Under free-entry, an increase in fixed cost \((f)\) cause a decrease in the number of firm \((N)\) and an increase in the profit margin \((p-c)\).

- Under free-entry, an increase in transportation cost \((t)\) increases both profit margin \((p-c)\) and the number of firms \((N)\).

- When fixed cost \((f)\) falls to zero \((0)\), the number of firms tends to be very large \((N \rightarrow \infty)\).

\[
N^c = \lim_{f \to 0} \sqrt{\frac{t}{f}} = \infty
\]

- So far, we have been discussing the case in which firms are located sufficiently close to each other and compete for the same consumers → a firm must take into account the price of rivals → competitive region (Salop 1979).

- If there are only few firms such that they don’t compete for the same consumers → each firm is a local monopoly.
Salop’s Circle Model...

Indifferent consumer between **buying** and **not buying**:

\[ V - p_1 - tx = 0 \]

\[ x = \frac{V - p_1}{c} \]

\[ D^1(p_1) = 2x = \frac{2}{c}(V - p_1) \quad \text{monopoly demand} \]
Salop’s Circle Model…

Demand in Salop’s Circle Model

![Diagram showing demand in Salop’s Circle Model with a monopoly region and a competitive region. The price, labeled as $P_m$, and quantity axes are indicated.]
Example (Horizontal Prod. Diff.)
Example (Horizontal Prod. Diff.)
From Our Mini Class Experiment:

Suppose you are a salesman and puts the following display:

- 36-inch Panasonic → $690
- 42-inch Toshiba → $850
- 50-inch Phillips → $1480

### DW I Tutorial Group

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Example (Vertical Prod. Diff.)
Vertical Product Differentiation

- Under **vertical differentiation** → consumers agree that there are **quality differences** among products → and they have **different willingness to pay** for different quality.

- **Setup:**
  - Each consumer buys one unit provided that \( p \leq V \) (there is non-negative surplus).
  - The product (brand) produced by a firm is characterized by a quality index, \( z \in (\underline{z}, \bar{z}) \)
  - There are 2 firms, \( i=1,2, \) produces a good with quality respectively \( z_1 \) and \( z_2 \) with \( z_2 > z_1 \). The unit cost of production is the same for both qualities, \( c \).
  - There is a continuum of consumers with measure \( N \) whose preference for quality \( (\theta) \) is uniformly distributed on the quality interval \( \theta \in (\underline{\theta}, \bar{\theta}) \).
Vertical Product Differentiation…

Highest quality $Z$ \[\bar{\theta}\] highest value (willingness to pay)

Consumer heterogeneity depends on income, taste, etc.

Lowest quality $Z$ \[\theta\] lowest value (willingness to pay)

Consumer taste/preference & the range of quality
Vertical Product Differentiation…

A uniform distribution with density $N$ is shown, with consumer heterogeneity indicated by the range $\theta$ to $\bar{\theta}$. The distribution is represented by a shaded rectangle.
Vertical Product Differentiation…

**Setup:**

- Denote the quality differential between the products of the two firms as $\Delta_z \equiv z_2 - z_1$
- Both firms engage in **price competition**.
- The utility of a consumer from buying a brand,
  
  $$U = \begin{cases} 
  \theta z_i - p & \text{if she buys a brand with quality } z_i \\
  0 & \text{if she does not buy}
  \end{cases}$$

- We are going to assume that the whole market is **“covered”** (consumers will always buy a product).
  $$U = \theta z_i - p \geq 0 \quad \text{or} \quad p \leq \theta z_i$$

- High $\theta$ consumers buy the high quality good $z_2$, and low $\theta$ consumers buy the low quality good $z_1$ (which must be priced lower to attract any consumers).
Vertical Product Differentiation…

**Setup:**

- A consumer with taste (preference) \( \theta \) is indifferent between buying the high quality and the low quality good if:
  \[
  \theta z_2 - p_2 = \theta z_1 - p_1
  \]
  \[
  \bar{\theta} = \frac{(p_2 - p_1)}{(z_2 - z_1)} = \frac{(p_2 - p_1)}{\Delta z}
  \]

- This implies that all consumers with taste in the interval of \( \theta \in (\theta, \bar{\theta}) \) will buy the low quality good from firm 1. While consumers with taste in the interval of \( \theta \in (\bar{\theta}, \bar{\theta}) \) will buy the high quality good from firm 2.

- The **demand functions for both firms** can be derived:
  \[
  D^1 (p_1, p_2) = N \left( \left( \frac{p_2 - p_1}{\Delta z} \right) - \theta \right)
  \]
  \[
  D^2 (p_1, p_2) = N \left( \bar{\theta} - \frac{p_2 - p_1}{\Delta z} \right)
  \]
Vertical Product Differentiation…

- Buy low quality
- Buy high quality

Uniform distribution with density $N$.

Consumer heterogeneity.
Vertical Product Differentiation...

Uniform distribution with density $N$

c consumer heterogeneity

don't buy any

buy low quality

buy high quality

$\theta$

$\theta_1$

$\theta_2$

$\bar{\theta}$
Vertical Product Differentiation...

- Each firm will maximize its profit.

\[ \pi_1 = (p_1 - c) D^1(p_1, p_2) = (p_1 - c) N \left( \frac{(p_2 - p_1)}{\Delta_z} - \theta \right) \]

\[ \pi_2 = (p_2 - c) D^2(p_1, p_2) = (p_2 - c) N \left( \bar{\theta} - \frac{p_2 - p_1}{\Delta_z} \right) \]

\[ \frac{\partial \pi_1}{\partial p_1} = N \left( c + p_2 - 2p_1 - \theta \Delta_z \right) = 0 \]

\[ \frac{\partial \pi_2}{\partial p_2} = N \left( c + p_1 - 2p_2 + \bar{\theta} \Delta_z \right) = 0 \]

\[ p_1 = \frac{c - \theta \Delta_z}{2} + \frac{1}{2} p_2 \]

\[ p_2 = \frac{c + \bar{\theta} \Delta_z}{2} + \frac{1}{2} p_1 \]

\[ D^1 = \left( \frac{\bar{\theta} - 2\theta}{3} \right) N \]

\[ D^2 = \left( \frac{2\bar{\theta} - \theta}{3} \right) N > D^1 \]

\[ \pi_1 = \frac{(\bar{\theta} - 2\theta)^2}{9} \Delta_z N \]

\[ \pi_2 = \frac{(2\bar{\theta} - \theta)^2}{9} \Delta_z N > \pi_1 \]
Vertical Product Differentiation…

- Recall that the condition for consumers to buy any product is:
  \[ U = \theta z_i - p \geq 0 \quad \text{or} \quad p \leq \theta z_i \]

- Thus, to ensure that the market is covered, all consumers will always buy:
  \[ p_1 \leq \theta z_1 \]
  \[ c + \left( \frac{\bar{\theta} - 2\theta}{3} \right)(z_2 - z_1) \leq \theta z_1 \]

- We require that consumers are sufficiently heterogeneous in taste
  \[ \bar{\theta} \geq 2\theta \quad \text{so that} \quad D^1 = \left( \frac{\bar{\theta} - 2\theta}{3} \right) N > 0 \]
  \[ p_1 = c + \left( \frac{\bar{\theta} - 2\theta}{3} \right)(z_2 - z_1) \]
  \[ p_2 = c + \left( \frac{2\bar{\theta} - \theta}{3} \right)(z_2 - z_1) \]

**Summary:**

- Undifferentiated firms \((z_1 = z_2)\) will charge \( p_1 = p_2 = c \) and make no profit.
- Profits are increasing in the quality differential \((z_2 - z_1)\).
- What happen when quality choice is endogenous?
Vertical Product Differentiation…

- Endogenous choice of quality.

  - Suppose now, firms play a **two-stage game**, in which firms first choose quality (one per firm) and then compete in price.

  - Assume for simplicity that the choice of quality is costless. Firms choose $z_i$ from the interval $z_i \in (\underline{z}, \overline{z})$.

  - Since the size of profit depends on $(z_2 - z_1)$, for a given $z_2$ firm 1 wants to choose $z_1$ as lowest as possible ($z_1 = \underline{z}$). For a given $z_1$, firm 2 wants to set $z_2$ is high as possible ($z_2 = \overline{z}$).

  - A similar result is obtained if instead firm 1 is the one which produces high quality.

  - There are **two pure strategy Nash equilibria**, the first one is $(z_1 = \underline{z}, z_2 = \overline{z})$, the second one is $(z_1 = \overline{z}, z_2 = \underline{z})$.

  - In equilibrium, we have **maximal differentiation → relaxing price competition** through product differentiation.
Vertical Product Differentiation...

- Endogenous choice of quality.

  - In a Stackelberg setting, the first mover always wants to enter with high quality, and given this the second mover will choose low quality → this gives us a unique equilibrium.

We have a setting in which choice of quality is costless → and yet, the low quality firm gains from reducing its quality level to the minimum → trade-off: demand reduction because of lower quality vs. softer price competition.