MGT 621 – MICROECONOMICS

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5. Market Power

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École Polytechnique Fédérale de Lausanne
College of Management of Technology

AGENDA

What is Market Power?

Monopoly

Monopsony

Price Discrimination

Key Concepts to Remember

MARKET POWER

Definition. **Market power** is the ability of a firm to *increase its output prices above the competitive level*, and/or to *reduce its input prices below the competitive level*.

- **Monopoly**
    - Single seller of a product
- **Oligopoly**
    - Small number of sellers of a product

Sellers' Market

- **Monopsony**
    - Single buyer of a product
- **Oligopsony**
    - Small number of buyers of a product

Buyers' Market

ANALYSIS OF MARKET POWER
Initial Focus on Single Firm

We first examine the case where one single firm has market power, in a monopoly or a monopsony. Other market participants' actions are aggregated to a market demand (for monopoly) or a market supply (for monopsony).

- When more than one firm holds market power, it is necessary to model the interactions between those firms explicitly. For this, one needs the tools of *Game Theory*

Since actions of all non-market-power-holding entities (the 'other' side of the market) are aggregated into a demand curve (or a supply curve), this is often referred to as partial equilibrium analysis.

In general equilibrium analysis, the optimizing behavior of all market participants is explicitly taken into account (they could be price takers or not).

We first focus on partial equilibrium analysis of monopoly and monopsony.

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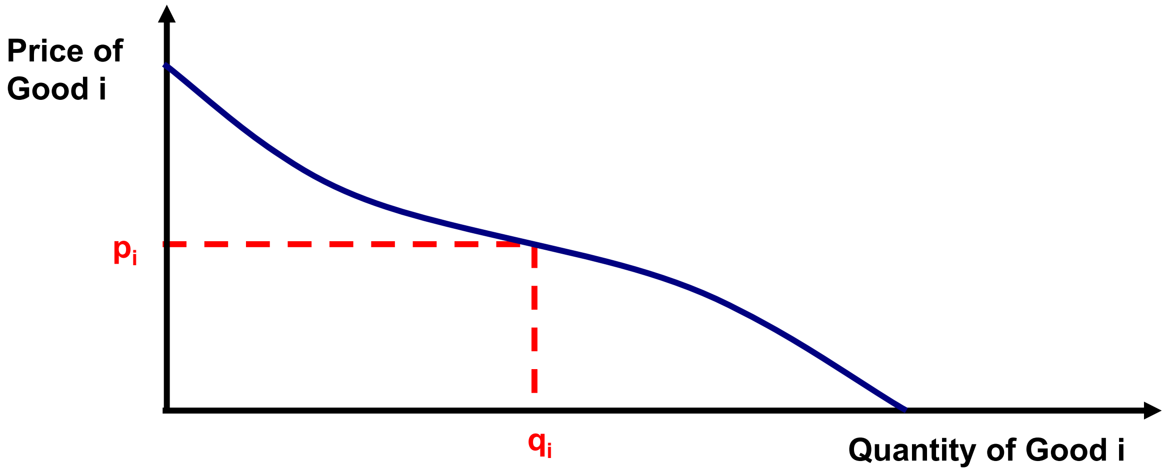
DEMAND CURVE

The quantity of commodity i a monopolist can sell, its “demand” $D_i(p)$, is a decreasing function of the price p_i. Equivalently, the price at which the firm can sell the product, referred to as its “inverse demand” $p_i(q_i, q_{-i}; p_{-i})$, is a decreasing function of the quantity q_i.



$q_i = D_i(p_i, p_{-i})$ ⟵ **Demand Curve**

$p_i = p_i(q_i, q_{-i}; p_{-i})$ ⟵ **Inverse Demand Curve**

OPTIMAL CHOICE OF MONOPOLY OUTPUT

Assume that a monopolist produces a quantity q of a single output and that the market price at that output is given by the *downward-sloping* inverse market demand p(q). The monopolist's cost function C(q) is *increasing and convex*.

Monopolist's profit:

$$\Pi(q) = \underbrace{R(q)}_{\textbf{Revenue}} - \underbrace{C(q)}_{\textbf{Cost}} = p(q)q - C(q)$$

First-order necessary optimality condition:

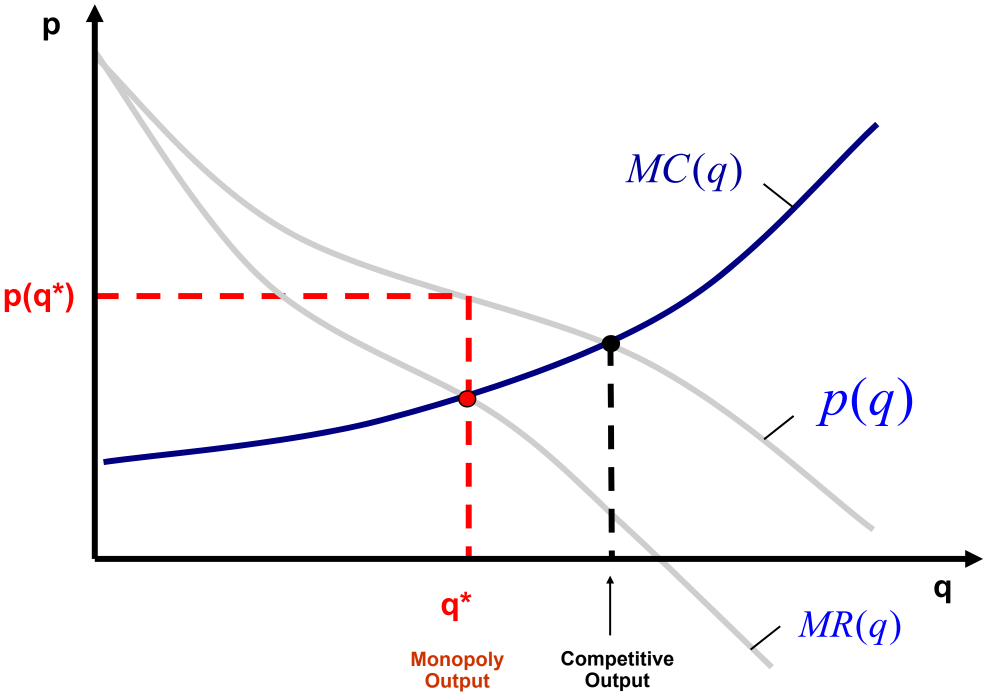
$$\frac{d\Pi(q)}{dq} = \frac{dR(q)}{dq} - \frac{dC(q)}{dq} = 0 \quad \Leftrightarrow \quad \frac{dR(q)}{dq} = \frac{dC(q)}{dq}$$

Hence,

$$\boxed{p(q) > p(q) + q\underbrace{\frac{dp(q)}{dq}}_{<0} = \frac{dC(q)}{dq}}$$

In other words, the market price in a monopoly exceeds marginal cost!

OPTIMAL MONOPOLY OUTPUT (Cont'd)



MONOPOLY PRICING
Inverse Elasticity Rule

Consider the monopolist's choice of a profit-maximizing price p, given its (downward-sloping) demand function D(p).

The (own-price) demand elasticity is $\varepsilon(p) = -\frac{p}{D(p)}\frac{dD(p)}{dp}$

Maximizing the monopolist's profit $\Pi(p) = pD(p) - C(D(p))$

yields the first-order necessary optimality condition

$$D(p) + p\frac{dD(p)}{dp} = \frac{dC(D(p))}{dq}\frac{dD(p)}{dp}$$

or

$$1 = \left(-\frac{D'(p)}{D(p)}\right)\left(p - MC(D(p))\right) = \varepsilon(p)\frac{p - MC(D(p))}{p}$$

Hence, we obtain the "inverse elasticity rule" for monopoly pricing:

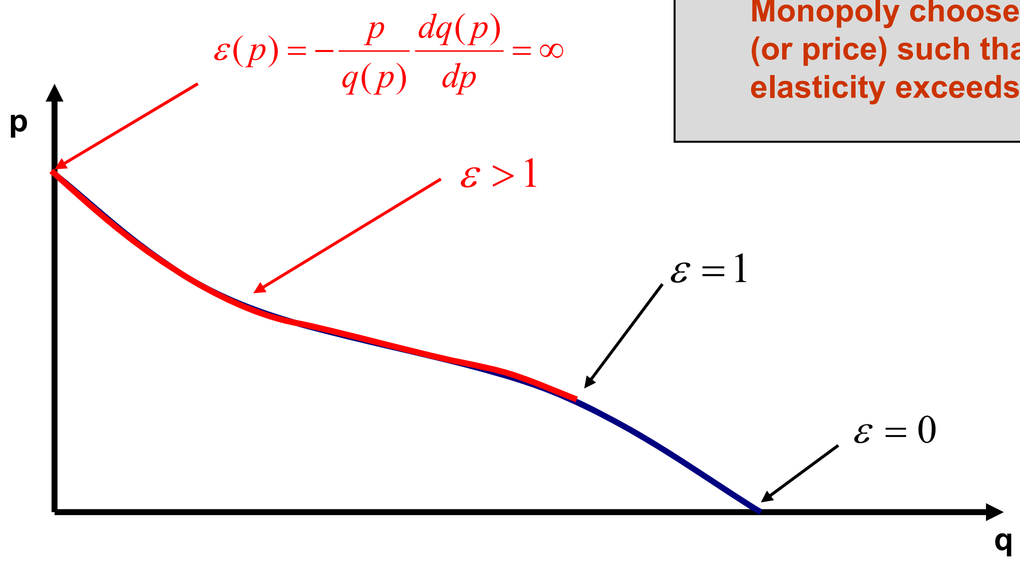
$$1 \geq \underbrace{\frac{p - MC(D(p))}{p}}_{\text{Relative Markup}} = \underbrace{\frac{1}{\varepsilon(p)}}_{\text{Inverse Demand Elasticity (Lerner Index)}}$$

RELATIVE MONOPOLY MARKUPS

Demand Elasticity	Lerner Index: Markup as Percent of Price	Markup in Percent of Marginal Cost
50	2%	2%
20	5%	5%
10	10%	11%
2	50%	100%
1.5	67%	200%
1.1	91%	1,000%
1.01	99%	10,000%
1	100%	Infinity

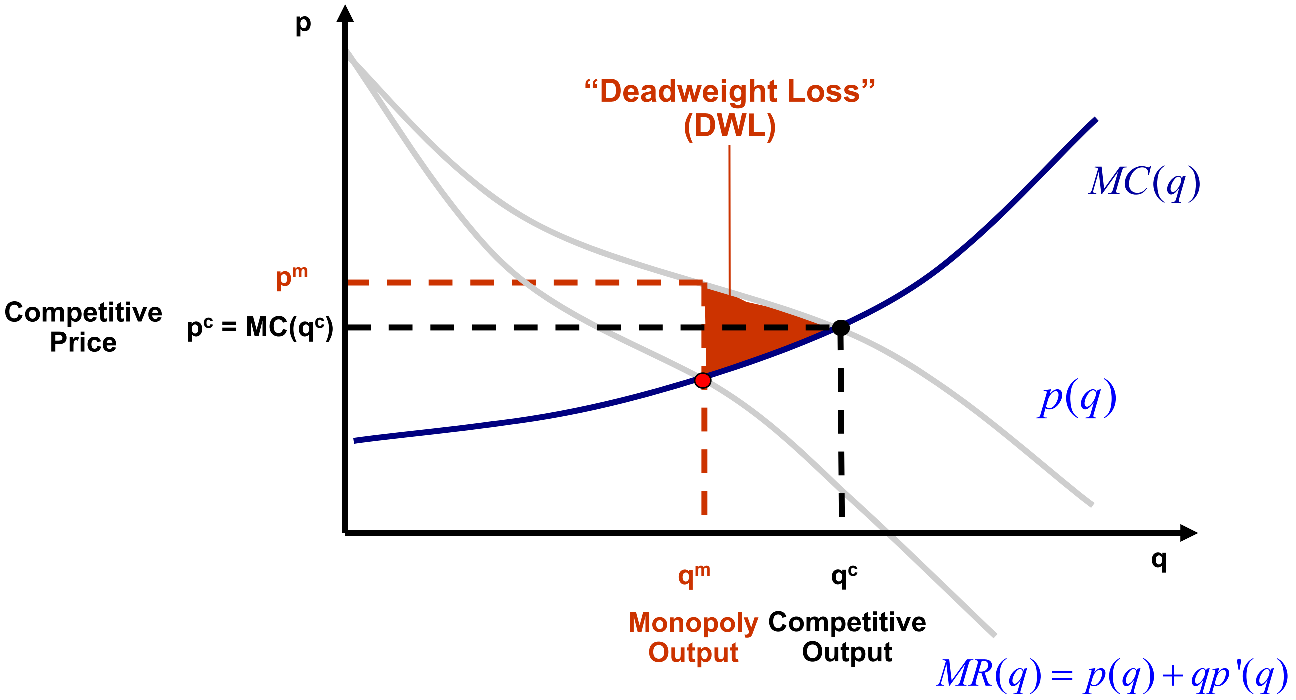
DEMAND ELASTICITY CHANGES ALONG DEMAND FUNCTION

… typically from 0 to infinity



Monopoly chooses production (or price) such that demand elasticity exceeds 1

INEFFICIENCY CREATED BY MONOPOLY



$$\mathrm{DWL} = \int_{q^m}^{q^c} (p(q) - MC(q))dq = \int_{q^m}^{q^c} p(q)dq - \left(C(q^c) - C(q^m)\right)$$

WHAT CAN A REGULATOR DO?

Price Caps

When trying to reduce the deadweight loss created by a monopolist, the typical difficulty a regulator faces, is that the marginal cost MC(q) as a function of output belongs to the monopolist's private information.

Hence, when imposing a price-cap p^{reg} the regulator has no way of knowing if the regulated price is corresponds to the efficient market price

Two exceptions:

- **When $p^{reg} > p^{m}$, then the observed market price is below the price cap**
- **When $p^{reg} < p^{c}$, then one may be able to observe excess demand**

In general, in order to set an efficient market price (improving the performance of the market by reducing deadweight loss) a regulator needs to find ways to elicit the monopolist's private information about its cost structure.

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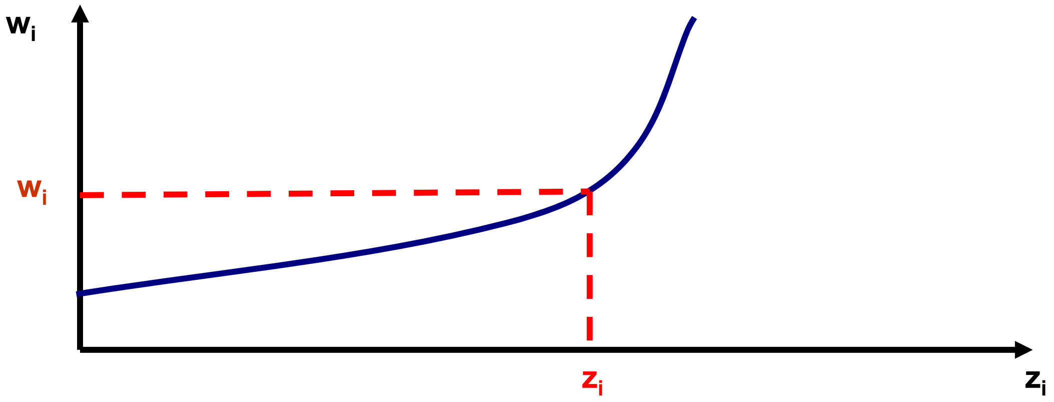
SUPPLY CURVE

The quantity z_i of commodity i a monopsonist can buy, its "supply" $S_i(w_i, w_{-i}; z_{-i})$, is an increasing function of the price w_i. Equivalently, the price at which the firm can buy the product, referred to as its "inverse supply" $w_i(z_i, z_{-i}; w_{-i})$, is a decreasing function of the quantity z_i.



$$z_i = S_i(w_i, w_{-i}; z_{-i}) \longleftarrow$$ **Supply Curve**

$$w_i = w_i(z_i, z_{-i}; w_{-i}) \longleftarrow$$ **Inverse Supply Curve**

OPTIMAL MONOPSONY INPUT

Without loss of generality, consider input 1, and assume that the firm has one output q which is produced as a function of the input vector, i.e., q(z) is the firm's production function.

Profit:

$$\Pi(z) = pq(z) - \sum_{i \neq 1} w_i z_i - w_1(z_1) z_1$$

FOCs:

$$\frac{\partial \Pi(z)}{\partial z_i} = p\frac{\partial q(z)}{\partial z_i} - w_i = 0 \quad \text{for } i \neq 1$$

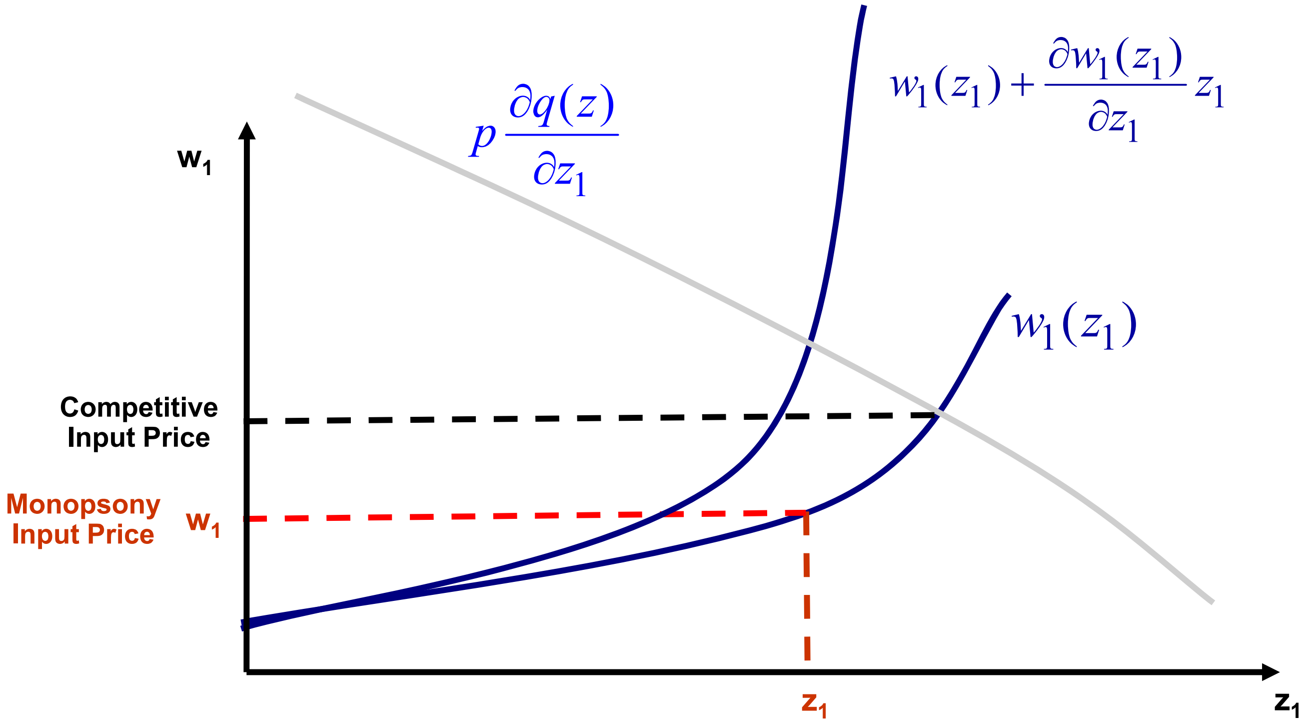
$$\frac{\partial \Pi(z)}{\partial z_1} = p\frac{\partial q(z)}{\partial z_1} - w_1(z_1) - \frac{\partial w_1(z_1)}{\partial z_1} z_1 = 0$$

$$p\frac{\partial q(z)}{\partial z_i} = w_i \quad \text{for } i \neq 1$$

$$p\frac{\partial q(z)}{\partial z_1} = w_1(z_1) + \frac{\partial w_1(z_1)}{\partial z_1} z_1 > w_1(z_1)$$

MONOPSONIST'S INPUT CHOICE

Consider input 1.



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Key Concepts to Remember

WHAT IS PRICE DISCRIMINATION?

Definition. **Price discrimination** exists if *different units of the same good are sold at different prices to one or more consumers*.

One commonly distinguishes three different degrees of price discrimination.

- **First-Degree** Price Discrimination: the seller charges a *price for each unit corresponding to the maximum willingness to pay* over all available consumers of that unit. This is also referred to as **perfect price discrimination** as it maximizes the seller's revenues.
- **Second-Degree** Price Discrimination: the seller charges *different amounts for different numbers of units* bought by the *same* consumer. This is also referred to as **nonlinear pricing**.
- **Third-Degree** Price Discrimination: the seller charges *different prices to different consumer groups* based on observable differences between the groups.

FIRST-DEGREE PRICE DISCRIMINATION

If the maximum willingness to pay for each unit is available, then the seller can order these values so that the willingness to pay for additional units is nonincreasing. This yields a **nonincreasing inverse demand curve p(q)** as a function of the seller's output q.

The seller can choose the optimal output by maximizing

$$\Pi(q) = \int_0^q p(\hat{q})d\hat{q} - C(q)$$

with respect to q. The first-order necessary optimality condition is

$$p(q) = MC(q)$$

In other words, the *seller should increase output until the maximum willingness to pay for the next unit exactly equals her marginal cost of producing that unit.*

Note that with perfect price discrimination, the **monopolist's deadweight loss vanishes**, and so does the consumers' surplus.

SECOND-DEGREE PRICE DISCRIMINATION

- **Second-degree price discrimination (or “nonlinear pricing,” or “screening”) is a mechanism-design problem. It is more difficult than first-degree or third-degree price discrimination, but it is also more realistic.**
- **It operates under the assumption that the seller knows that consumers have heterogeneous preferences but is unable to directly distinguish the different consumers. Information about a given consumer’s preferences (his utility function) is assumed to be only privately available to that consumer.**
- **In order to incentivize a consumer to reveal his utility function (or his “type”) the seller needs to offer several options for the consumer to choose from. Through his choice the consumer “reveals” his preference, and the seller may thereby be able to charge different consumers (or groups of consumers) different prices.**
- **The solution to the problem will naturally depend on the seller’s model of the consumer heterogeneity.**

EXAMPLE: SELLING A REFRIGERATOR

Screening Model

Instead of quantities (which can vary continuously) we take a very simple shot at this generally difficult problem and examine a special case where the seller has two refrigerators (of qualities q_1=1 and q_2 = 2) to sell to consumers who are heterogeneous but indistinguishable to the seller.

Question. How much should the seller charge for the two refrigerators?

What needs to be considered?

1.Buyer’s private information:

- **The seller does not know how much the buyer is willing to pay for the refrigerator**
- **She assumes that the buyer values a refrigerator of quality q at $u = \theta q$, where θ is unknown to her**
- **She assumes that the buyer might be of two types $\theta \in \{\theta_L, \theta_H\}$: with probability μ it is $\theta_H = 2$ and with probability 1-μ it is $\theta_L = 1$**

2. The buyer’s voluntary participation in the mechanism

- **The seller cannot force the buyer to pay more than his WTP u**
- **The seller has to leave the choice of the refrigerator up to the buyer**

SELLING A REFRIGERATOR (Cont'd)

Designing a mechanism amounts for the seller to choosing the best possible prices p_1 and p_2 for the two products (of qualities q_1 and q_2 respectively).

Seller's maximizes expected revenues and assuming that the high-type buys the product

Buyer's participation ("individual rationality"):

- **Type** $\theta_L = 1$ **: participates if and only if** $p_1 \le \theta_L q_1 \iff p_1 \le 1$
- **Type** $\theta_H = 2$ **: participates if and only if** $p_2 \le \theta_H q_2 \iff p_2 \le 4$

Buyer's choice ("incentive compatibility"):

- **Type** $\theta_L = 1$ **: chooses q_1 over q_2 if and only if**
  $\theta_L q_2 - p_2 \le \theta_L q_1 - p_1 \iff 2 - p_2 \le 1 - p_1 \iff 1 \le p_2 - p_1$
- **Type** $\theta_H = 2$ **: chooses q_2 over q_1 if and only if**
  $\theta_H q_1 - p_1 \le \theta_H q_2 - p_2 \iff 2 - p_1 \le 4 - p_2 \iff p_2 - p_1 \le 2$

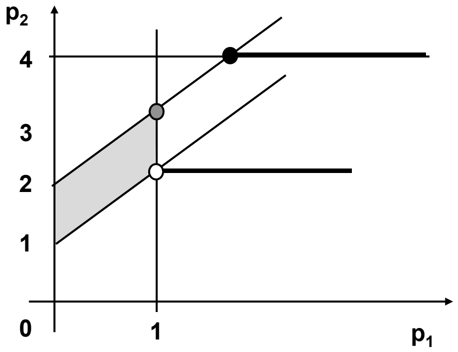
SELLING A REFRIGERATOR (Cont'd)

Hence, the seller solves the following revenue-maximization problem:

$$\max_{p_1, p_2} \{\mu p_1 + (1-\mu) p_2\}$$

subject to $p_1 \le 1, p_2 \le 4$ **(individual rationality)**

and $1 \le p_2 - p_1 \le 2$ **(incentive compatibility)**



$p_1^* \ge 2, p_2^* = 4$ **(only θ_H participates; sell only product 2)**

optimal for $\mu \le 1/2$

$p_1^* = 1, p_2^* = 3$ **(full participation; sell both products)**

optimal for $\mu = 1/2$

(*) $p_1^* > 1, p_2^* = 2$ **(full participation; sell only product 2)**

optimal for $\mu \ge 1/2$

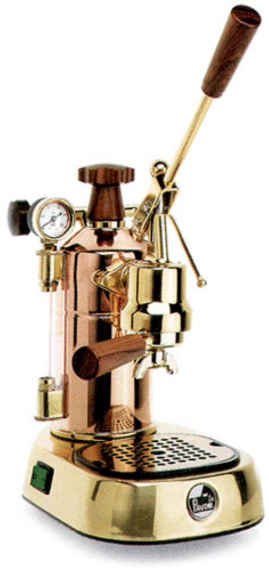
Remark. Solution (*) is typically "overlooked" in the more general case, as it does not satisfy the incentive-compatibility constraint for the low type but at the same time encourages full participation. We neglect it in the discussion that follows.

CONCLUSIONS ABOUT THE SCREENING MODEL
Second-Degree Price Discrimination

Key Conclusions from the example: (generalizes to other nonlinear pricing models)

1. **In the presence of asymmetric information, high consumer types typically obtain a positive surplus ("information rent")**
2. **Low-type consumers exert a positive externality on high-type consumers**
3. **As low-type consumers become less frequent, it becomes optimal for the seller to exclude them from the market ("shut-down solution")**
4. **When designing a good mechanism, the seller needs to take into account the consumers' individual rationality and incentive compatibility constraints**
5. **As long as the seller can commit to her mechanism she can, without any loss in generality, restrict her attention to "truthful" mechanisms in which all participating agents report their types truthfully ("revelation principle")**

A MORE GENERAL EXAMPLE



Question. At what qualities and what prices should a company offer a "vertically differentiated" product, such as an espresso maker?

For simplicity, we restrict attention to a firm which offers at most two products.

THERE ARE MANY OTHER EXAMPLES
Memory Sticks

CONSIDER A SIMPLE SCREENING MODEL

Model Features

- **Two Types ("high" θ_H and "low" θ_L, with $\theta_H > \theta_L > 0$)**
- **Utility increasing in instrument and in type, quasi-linear in wealth**
- **Outside option valued at zero**

- **Risk-neutral seller, maximizes expected profit**
- **Prior beliefs of principal (corresponding to the probability μ of a consumer being a high type) given**
- **Instrument (i.e., product quality) costly to provide, C(q) $\geq$ 0**

What is missing? – SORTING CONDITION …

$$\boxed{\hat{q} \geq q \quad \Rightarrow \quad u(\hat{q}, \theta_H) - u(q, \theta_H) \geq u(\hat{q}, \theta_L) - u(q, \theta_L)}$$

u exhibits "increasing differences" (or is "supermodular")

The sorting condition enables the seller to separate high types from low types.

SELLER'S PROBLEM

The seller chooses the qualities and prices of the products such as to maximize her expected profits, i.e., she solves the constrained optimization problem

$$\max_{p_L, p_H, q_L, q_H \geq 0} \left\{ (1-\mu)\left(p_L - C(q_L)\right) + \mu\left(p_H - C(q_H)\right) \right\}$$

subject to

$$u(q_L, \theta_L) - p_L \geq 0 \qquad \textbf{(IR-L)}$$
$$u(q_H, \theta_H) - p_H \geq 0 \qquad \textbf{(IR-H)}$$

Individual Rationality

$$u(q_L, \theta_L) - p_L \geq u(q_H, \theta_L) - p_H \qquad \textbf{(IC-L)}$$
$$u(q_H, \theta_H) - p_H \geq u(q_L, \theta_H) - p_L \qquad \textbf{(IC-H)}$$

Incentive Compatibility

THE SELLER'S PROBLEM CAN BE SIMPLIFIED

Two constraints are binding.

1. <u>(IR-L) is binding at optimum</u>

Proof. Assume not. Then $u(q_L, \theta_L) - p_L > 0$ **, so that**

$$u(q_H, \theta_H) - p_H \underset{\substack{\uparrow \\ \textbf{(IC-H)}}}{\geq} u(q_L, \theta_H) - p_L \underset{\substack{\uparrow \\ \partial u / \partial \theta > 0}}{\geq} u(q_L, \theta_L) - p_L > 0$$

But this means that p_L **cannot be optimal, a contradiction.** **QED**

2. <u>(IC-H) is binding at optimum</u>

Proof. Assume not. Then

$$\textbf{(*)} \qquad u(q_H, \theta_H) - p_H \underset{\substack{\uparrow \\ \textbf{(IC-H)}}}{>} u(q_L, \theta_H) - p_L \underset{\substack{\uparrow \\ \partial u / \partial \theta > 0}}{\geq} u(q_L, \theta_L) - p_L = 0$$

But this means that the seller could increase p_H **, a contradiction. QED**

THE SELLER'S PROBLEM CAN BE SIMPLIFIED (Cont'd)

Two constraints are redundant.

3. (IC-L) can be neglected

Proof. Since (IC-H) is binding, it is $u(q_H,\theta_H)-p_H=u(q_L,\theta_H)-p_L$

Hence, $$p_H-p_L=u(q_H,\theta_H)-u(q_L,\theta_H)\underset{\substack{\uparrow\\ \textbf{(SC)}}}{\geq}u(q_H,\theta_L)-u(q_L,\theta_L)$$

Therefore $u(q_L,\theta_L)-p_L\geq u(q_H,\theta_L)-p_H$ **QED**

4. (IR-H) can be neglected

The proof follows directly from (*) in the proof of claim 2.

THE SIMPLIFIED PROBLEM

The seller's nonlinear pricing problem is equivalent to

$$\max_{p_L,p_H,q_L,q_H\geq 0}\left\{(1-\mu)\left(p_L-C(q_L)\right)+\mu\left(p_H-C(q_H)\right)\right\}$$

subject to

$$u(q_L,\theta_L)-p_L=0 \qquad \textbf{(IR-L)}$$

$$u(q_H,\theta_H)-p_H=u(q_L,\theta_H)-p_L \qquad \textbf{(IC-H)}$$

The constraints (IR-L) and (IC-H) can be directly substituted into the objective function.

THE SIMPLIFIED PROBLEM

The seller's nonlinear pricing problem is equivalent to

$$\max_{q_L,q_H\geq 0}\left\{(1-\mu)\big(u(q_L,\theta_L)-C(q_L)\big)+\mu\big((u(q_H,\theta_H)-u(q_L,\theta_H)+u(q_L,\theta_L))-C(q_H)\big)\right\}$$

Hence, the seller's optimal quality levels obtain as follows (for $\mu > 0$):

$$q_L^* \in \arg\max_{q_L\geq 0}\left\{\big(u(q_L,\theta_L)-C(q_L)\big)-\frac{\mu}{1-\mu}\big(u(q_L,\theta_H)-u(q_L,\theta_L)\big)\right\}$$

(Distorted Quality Level)

$$q_H^* \in \arg\max_{q_H\geq 0}\left\{u(q_H,\theta_H)-C(q_H)\right\}$$

(Efficient Quality Level)

From (IR-L) and (IC-H) we then get

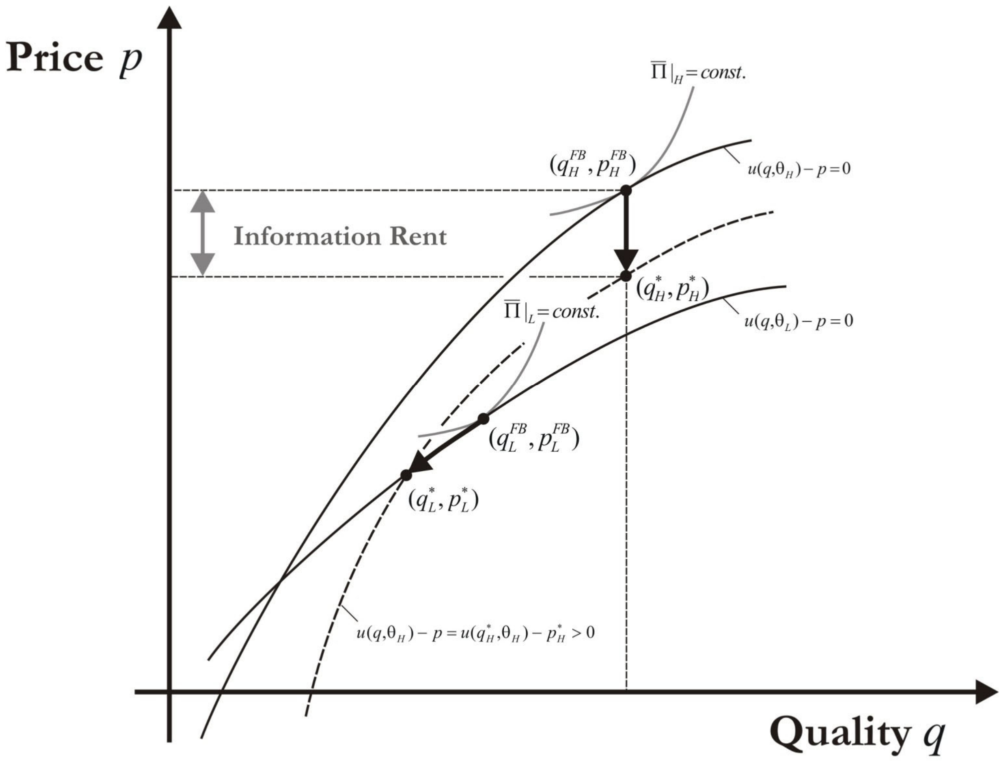
$$p_L^* = u(q_L^*,\theta_L)$$

(Efficient Price Level)

$$p_H^* = u(q_H^*,\theta_H)-\underbrace{\big(u(q_L^*,\theta_H)-u(q_L^*,\theta_L)\big)}_{\text{Information Rent }(\geq 0)}$$

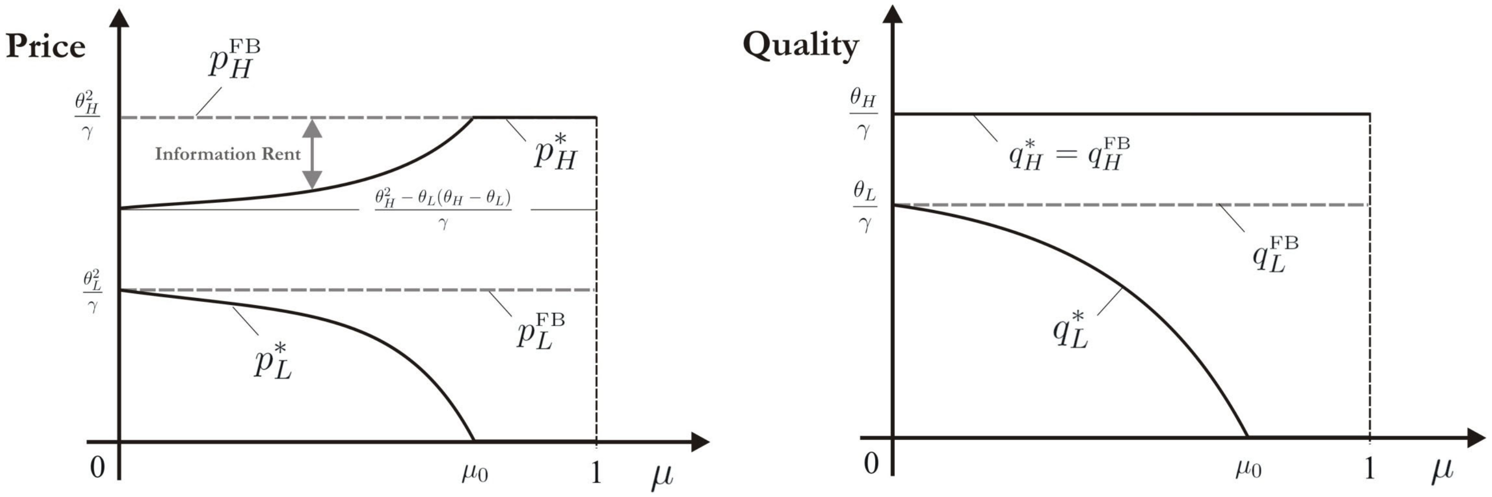
(Distorted Price Level)

FIRST-BEST AND SECOND-BEST SOLUTIONS IN THE SCREENING MODEL



PRICE AND QUALITY IN THE TWO-TYPE SCREENING MODEL

Example: $u(q,\theta)=\theta q$ $C(q)=\gamma q^2/2,\ \gamma>0$



THIRD-DEGREE PRICE DISCRIMINATION

For simplicity, let us assume that there are two different consumer groups, 1 and 2, that the seller can distinguish and which can legally be charged different prices for the same product. Let the inverse demand curve of consumer group $i\in\{1,2\}$ be given by $p_i(q_i)$, where q_i is the amount consumed by that group.

Given a standard (increasing, convex) cost function C(q), the monopolist then solves the profit-maximization problem

$$\max_{q_1,q_2\geq 0}\left\{p_1(q_1)q_1+p_2(q_2)q_2-C(q_1+q_2)\right\}$$

which for $q_1,q_2>0$ leads to the first-order necessary optimality conditions

$$p_1(q_1)+q_1p_1{}'(q_1)=C'(q_1+q_2)$$
$$p_2(q_2)+q_2p_2{}'(q_2)=C'(q_1+q_2)$$

Hence, at an optimum, the marginal revenues from the two consumer groups are equal to each other and equal to the marginal cost at the combined output.

THIRD-DEGREE PRICE DISCRIMINATION (Cont'd)

More generally, the two consumer groups may not be fully separable. Each group's demand may be influenced by the amount sold to the other group. Then the inverse demand curve of consumer group $i \in \{1,2\}$ is given by $p_i(q_1,q_2)$, where q_i is the amount consumed by that group.

Given an increasing, jointly convex cost function $C(q_1,q_2)$, the monopolist then solves the profit-maximization problem

$$\max_{q_1,q_2 \geq 0} \{p_1(q_1,q_2)q_1 + p_2(q_1,q_2)q_2 - C(q_1,q_2)\}$$

which for $q_1, q_2 > 0$ leads to the first-order necessary optimality conditions

$$p_1(q_1,q_2) + q_1 \frac{\partial p_1(q_1,q_2)}{\partial q_1} + q_2 \frac{\partial p_2(q_1,q_2)}{\partial q_1} = \frac{\partial C(q_1,q_2)}{\partial q_1}$$

$$p_2(q_1,q_2) + q_1 \frac{\partial p_1(q_1,q_2)}{\partial q_2} + q_2 \frac{\partial p_2(q_1,q_2)}{\partial q_2} = \frac{\partial C(q_1,q_2)}{\partial q_2}$$

At an optimum, the marginal revenue from each of the two consumer groups is equal to the marginal cost of increasing the output for that group (sometimes equal to the marginal cost of increasing output for the other group, e.g., when the cost depends only on $q_1 + q_2$).

AGENDA

What is Market Power?

Monopoly

Monopsony

Price Discrimination

Key Concepts to Remember

KEY CONCEPTS TO REMEMBER

- **Market Power**
- **Monopoly/Monopsony**
- **(Own-)Price Elasticity**
- **Inverse Elasticity Pricing Rule**
- **Lerner Index**
- **Deadweight Loss**
- **Price Caps**
- **Price Discrimination (first/second/third degree)**