# The Firm and the Market

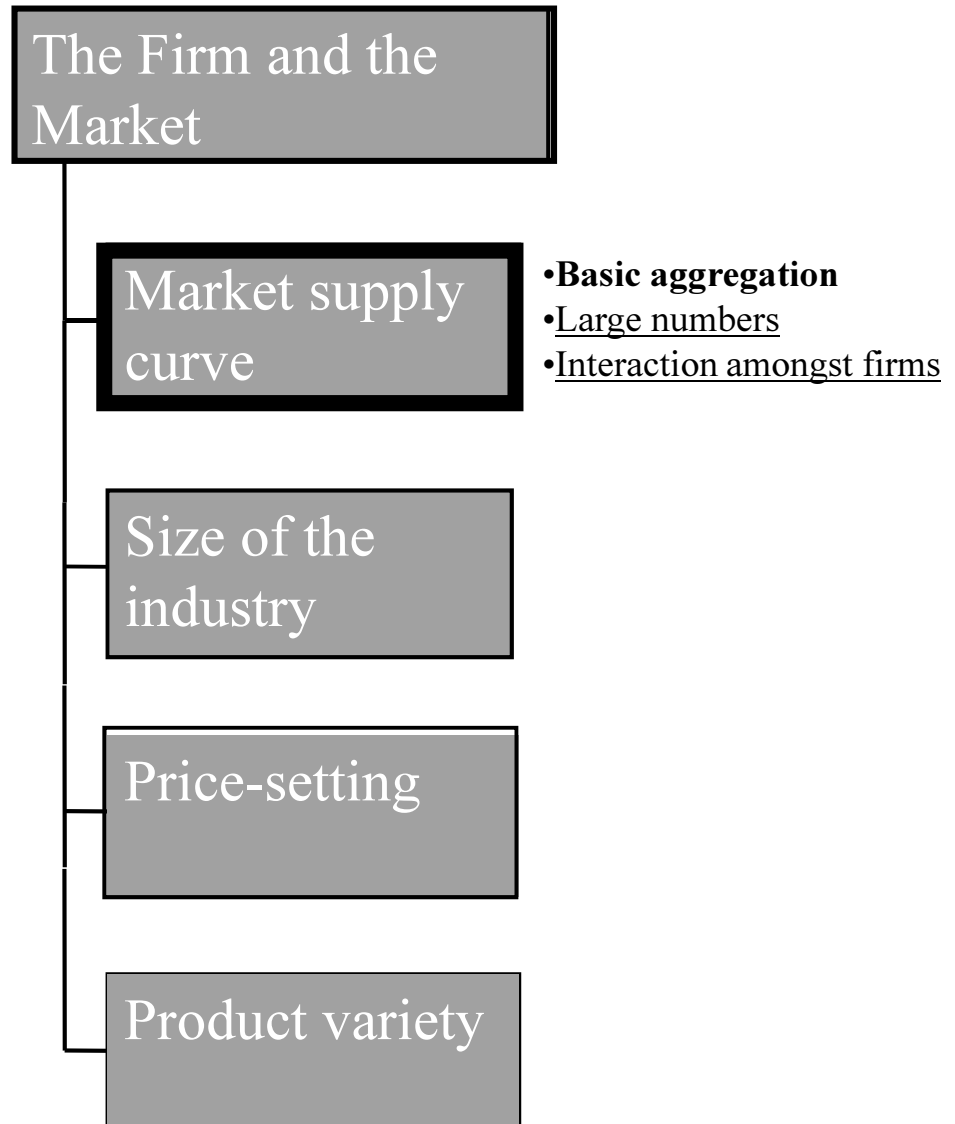## MICROECONOMICS
*Principles and Analysis*

Frank Cowell

October 2005

# Introduction

- In previous presentations we've seen how an optimising agent reacts to the market.
  - Use the comparative statics method
- We could now extend this to other similar problems.
- But first a useful exercise in microeconomics:
  - Relax the special assumptions
- We will do this in two stages:
  - Move from one price-taking firm to many
  - Drop the assumption of price-taking behaviour.

# Overview...

The Firm and the Market

*Issues in aggregating supply curves of price-taking firms*

Market supply curve

- **Basic aggregation**
- Large numbers
- Interaction amongst firms

Size of the industry

Price-setting

Product variety

# Aggregation over firms

- We begin with a very simple model.
- Two firms with similar cost structures.
- But using a very special assumption.
- First we look at the method of getting the market supply curve.
- Then note the shortcomings of our particular example.

# A market with two firms

- *Supply curve firm 1 (from MC).*
- *Supply curve firm 2.*
- *Pick any price*
- *Sum of individual firms' supply*
- *Repeat…*
- *The market supply curve*



low-cost firm

high-cost firm

both firms
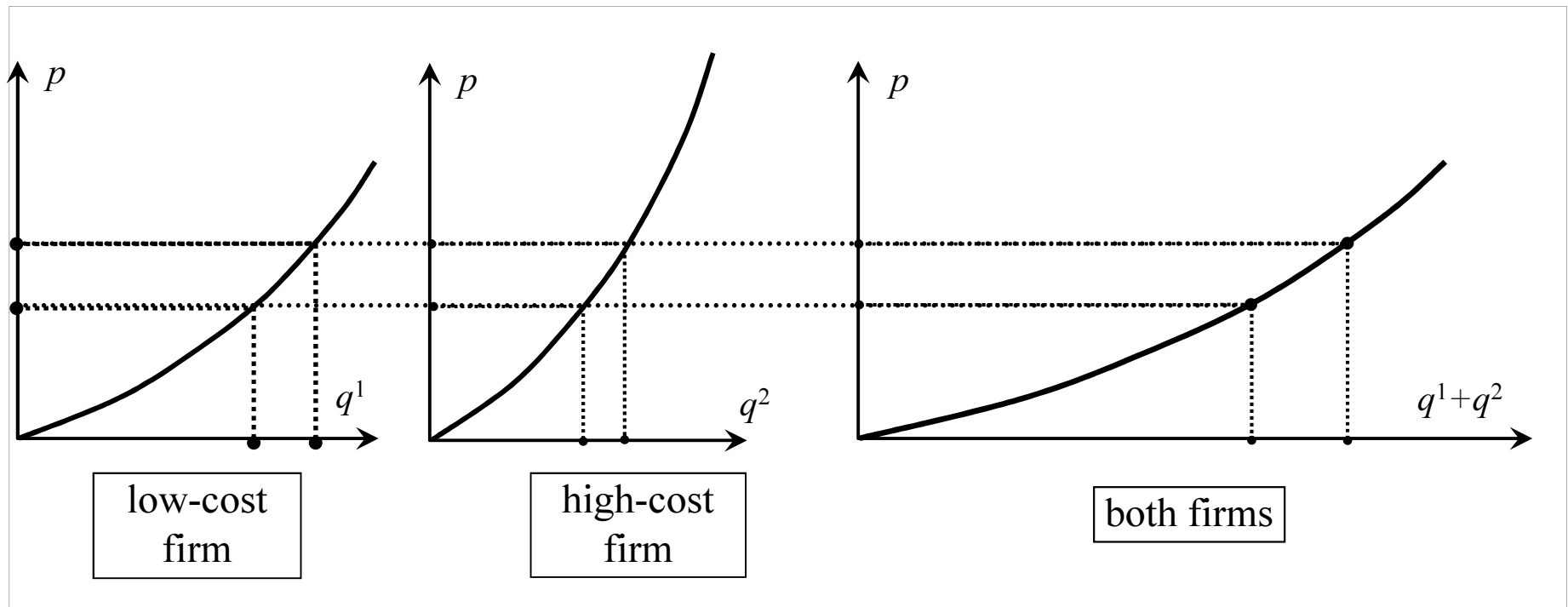
# Simple aggregation

- Individual firm supply curves derived from MC curves
- "Horizontal summation" of supply curves
- Market supply curve is flatter than supply curve for each firm
- But the story is a little strange:
    1. Each firm act as a price taker even though there is just one other firm in the market.
    2. Number of firms is *fixed* (in this case at 2).
    3. Firms' supply curve is different from that in previous presentations
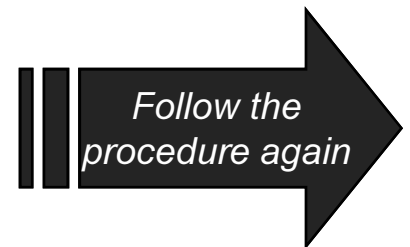
See presentation on duopoly

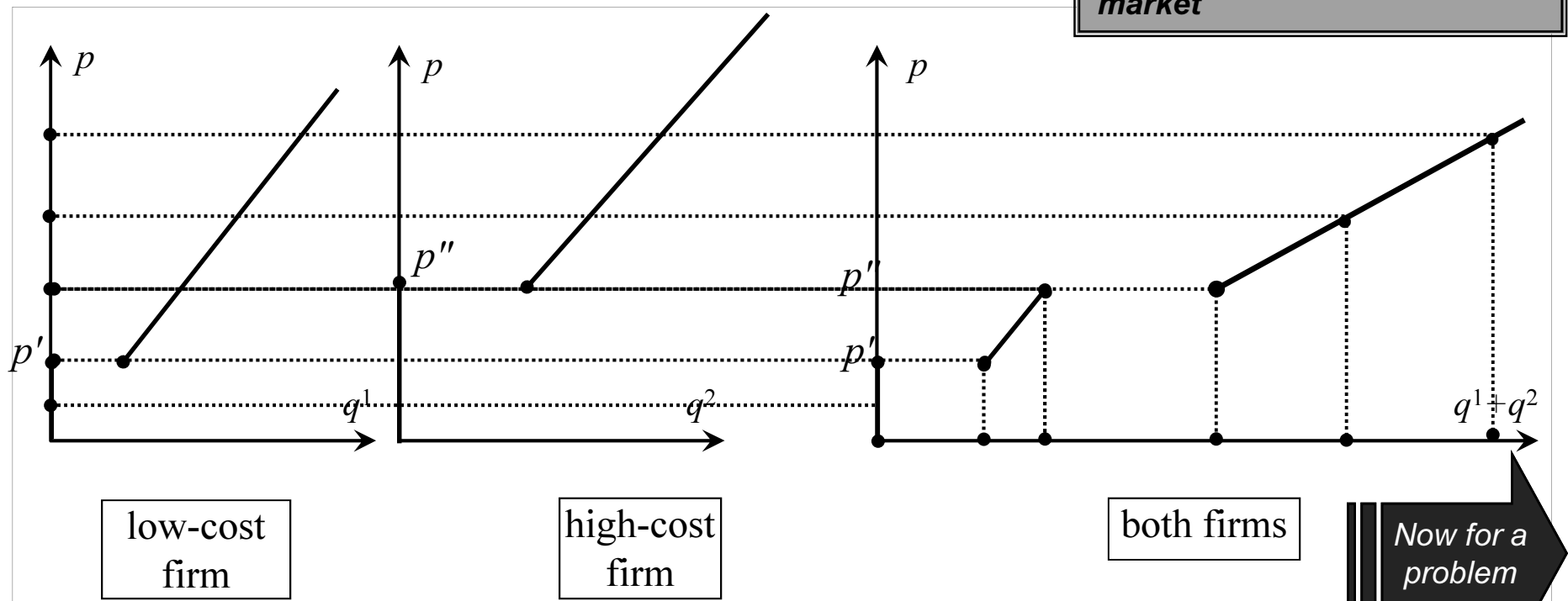Later in this presentation

*Try another example*

# Another simple case

- Two price-taking firms.
- Similar "piecewise linear" MC curves:
  - Each firm has a fixed cost.
  - Marginal cost rises at the same constant rate.
  - Firm 1 is the low-cost firm.
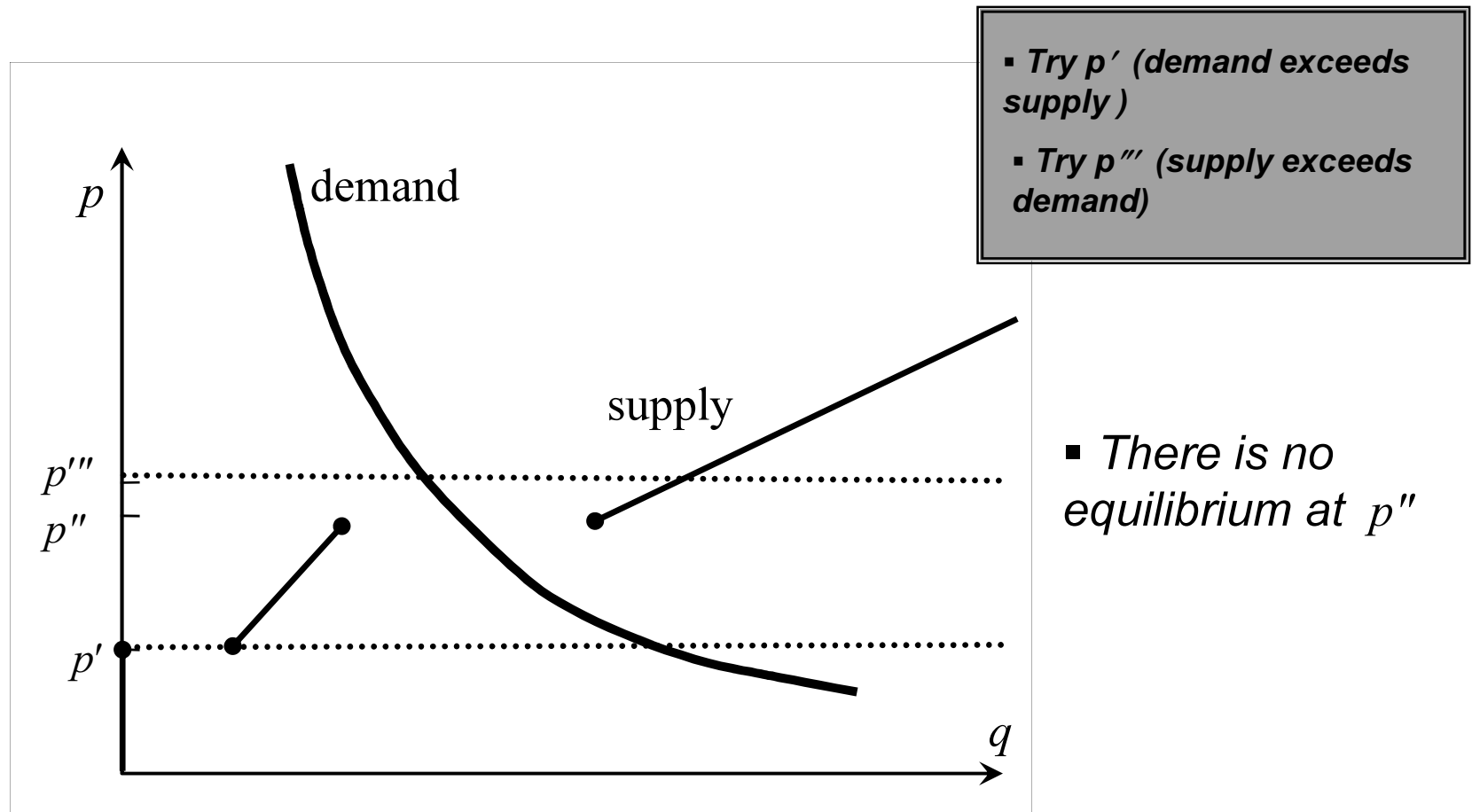- Analyse the supply of these firms over three price ranges.

*Follow the procedure again*

# Market supply curve (2)

- **Below p' neither firm is in the market**
- **Between p' and p'' only firm 1 is in the market**
- **Above p'' both firms are in the market**

$p$

$p'$

$p''$

$p'$

$q^1$

$q^2$

$p''$

$p'$

$q^1+q^2$

low-cost firm

high-cost firm

both firms

*Now for a problem*

# Where is the market equilibrium?



- **Try p′ (demand exceeds supply )**
- **Try p‴ (supply exceeds demand)**
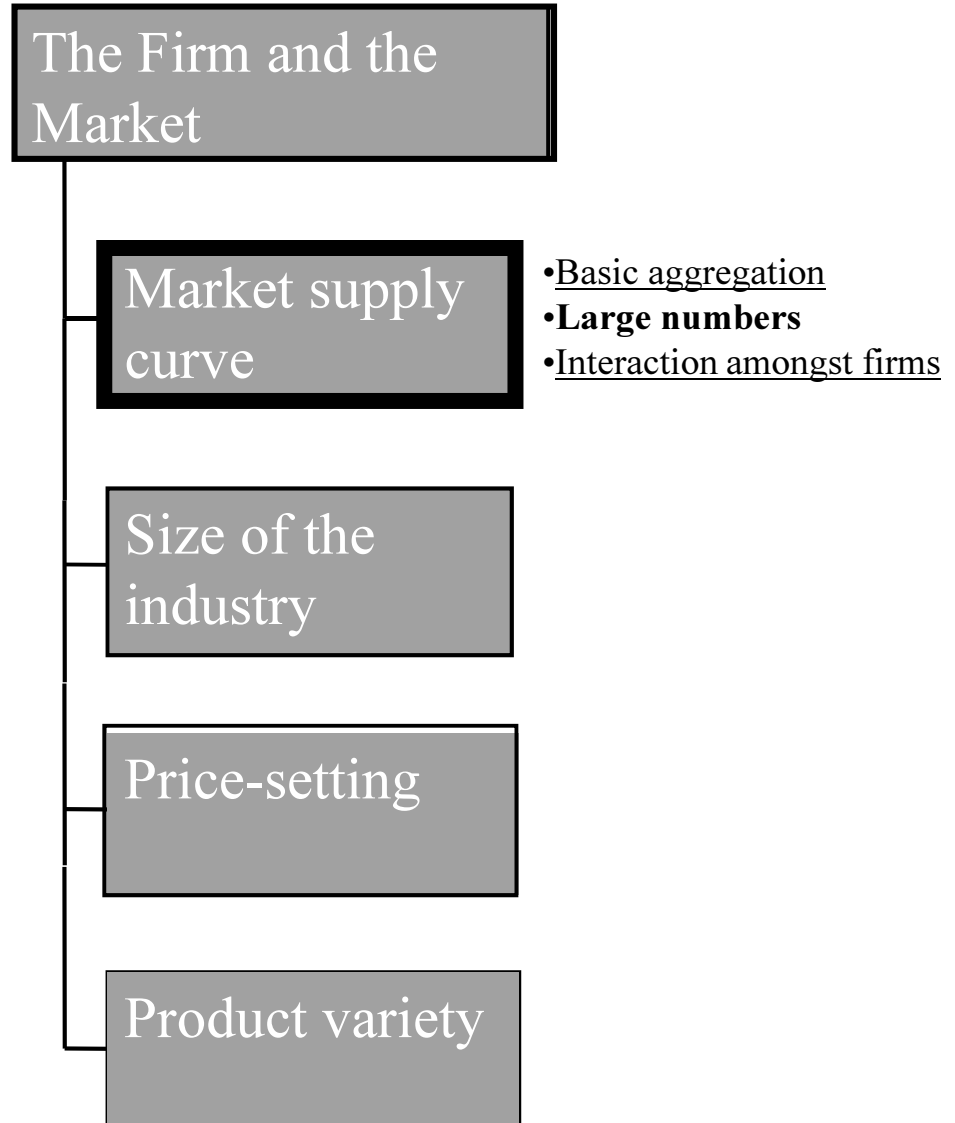
- *There is no equilibrium at $p''$*

# Lesson 1

- Nonconcave production function can lead to discontinuity in supply function.

- Discontinuity in supply functions may mean that there is no equilibrium.

# Overview...

*A simplified continuity argument*

| | |
|---|---|
| **The Firm and the Market** | |
| **Market supply curve** | •<u>Basic aggregation</u><br>•**Large numbers**<br>•<u>Interaction amongst firms</u> |
| **Size of the industry** | |
| **Price-setting** | |
| **Product variety** | |

# A further experiment

- The problem of nonexistent equilibrium arose from discontinuity in supply.

- But is discontinuity likely to be a serious problem?

- Let's go through another example.
  - Similar cost function to previous case
  - This time – *identical* firms
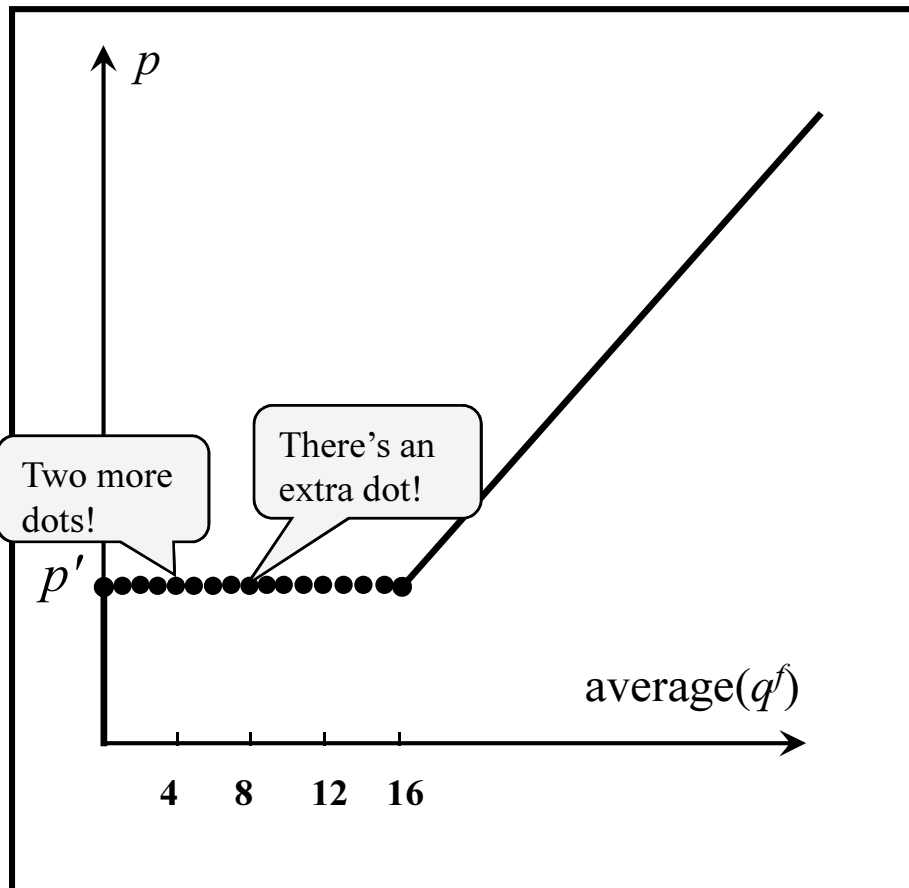  - (Not essential – but it's easier to follow)

# Take two identical firms...
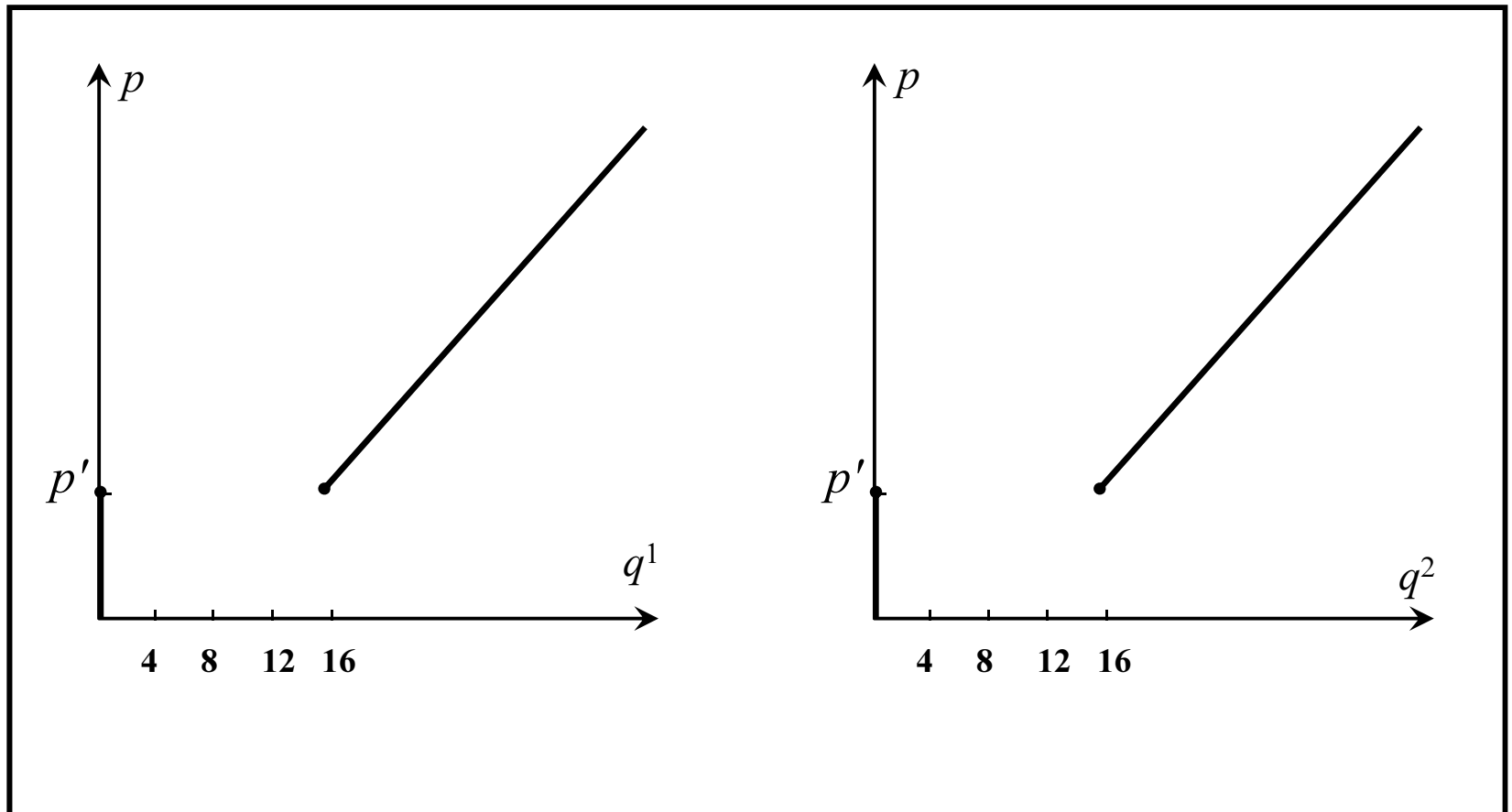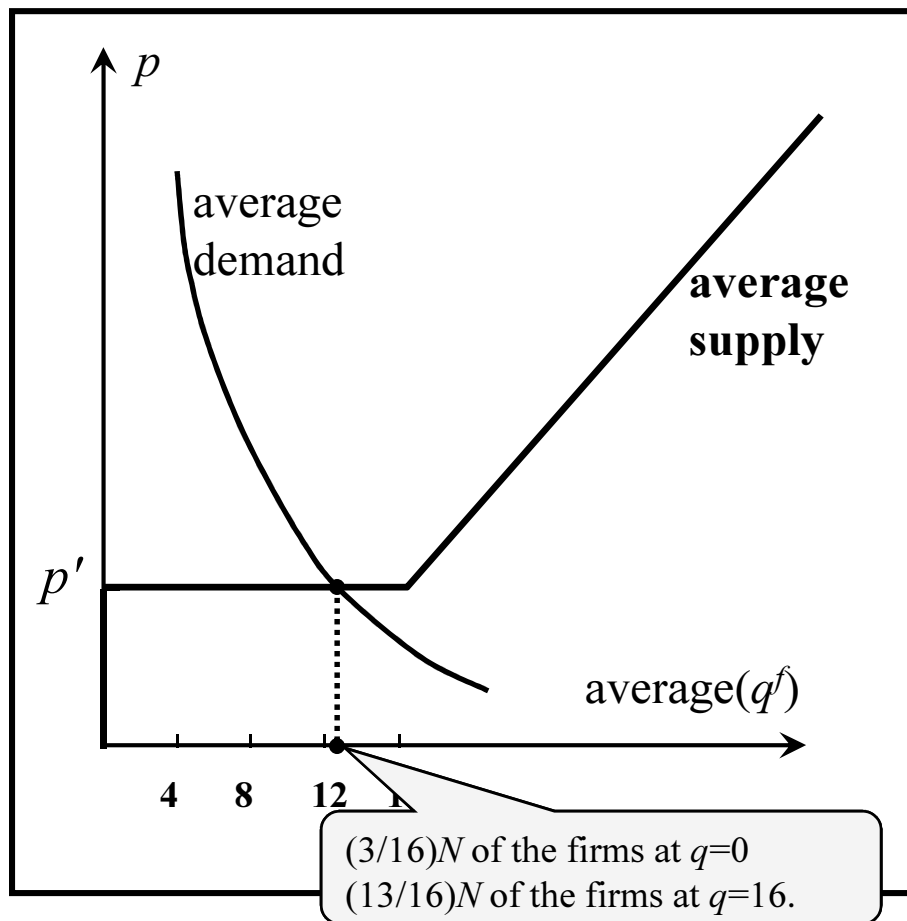
# Sum to get aggregate supply
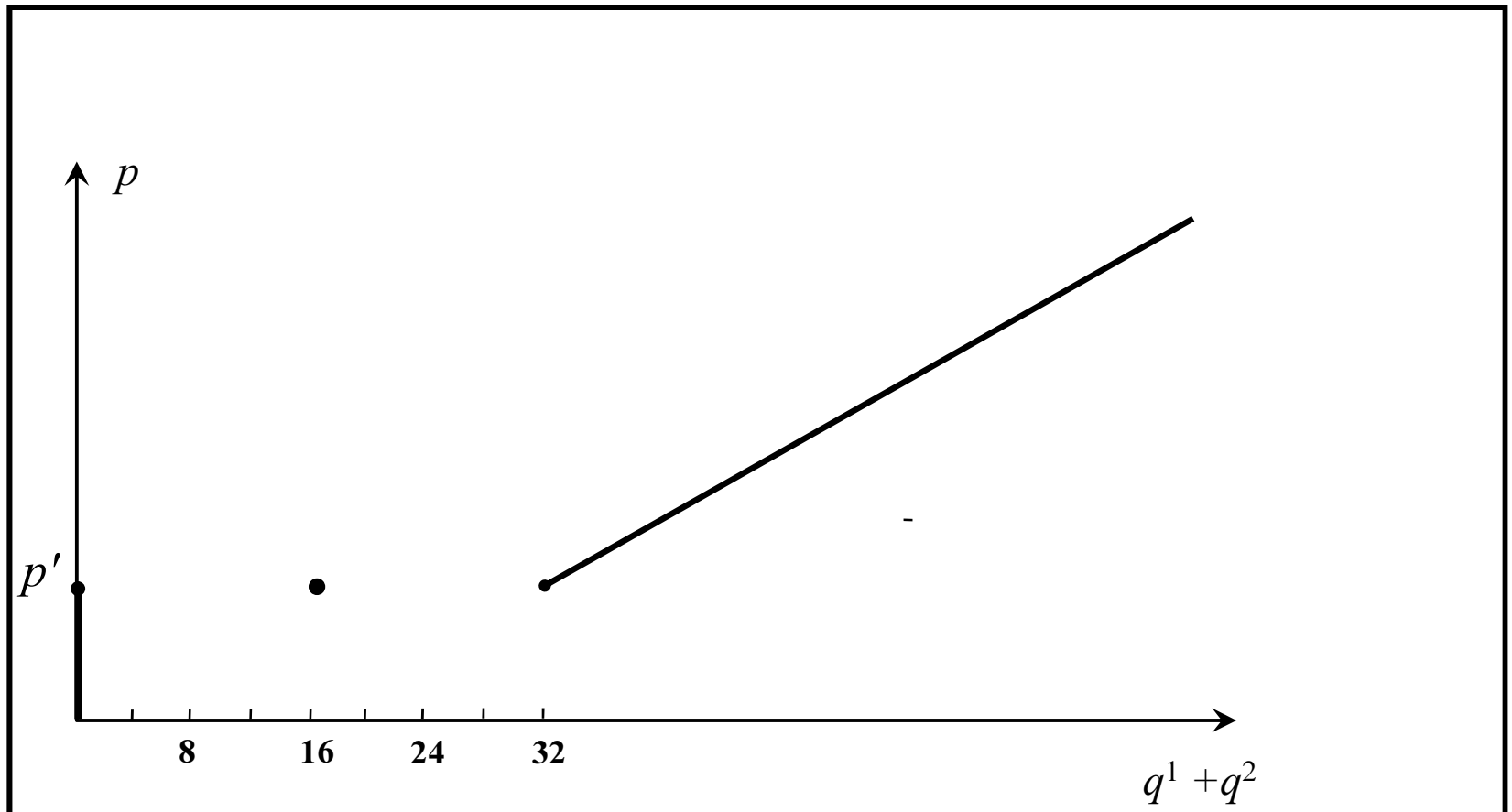
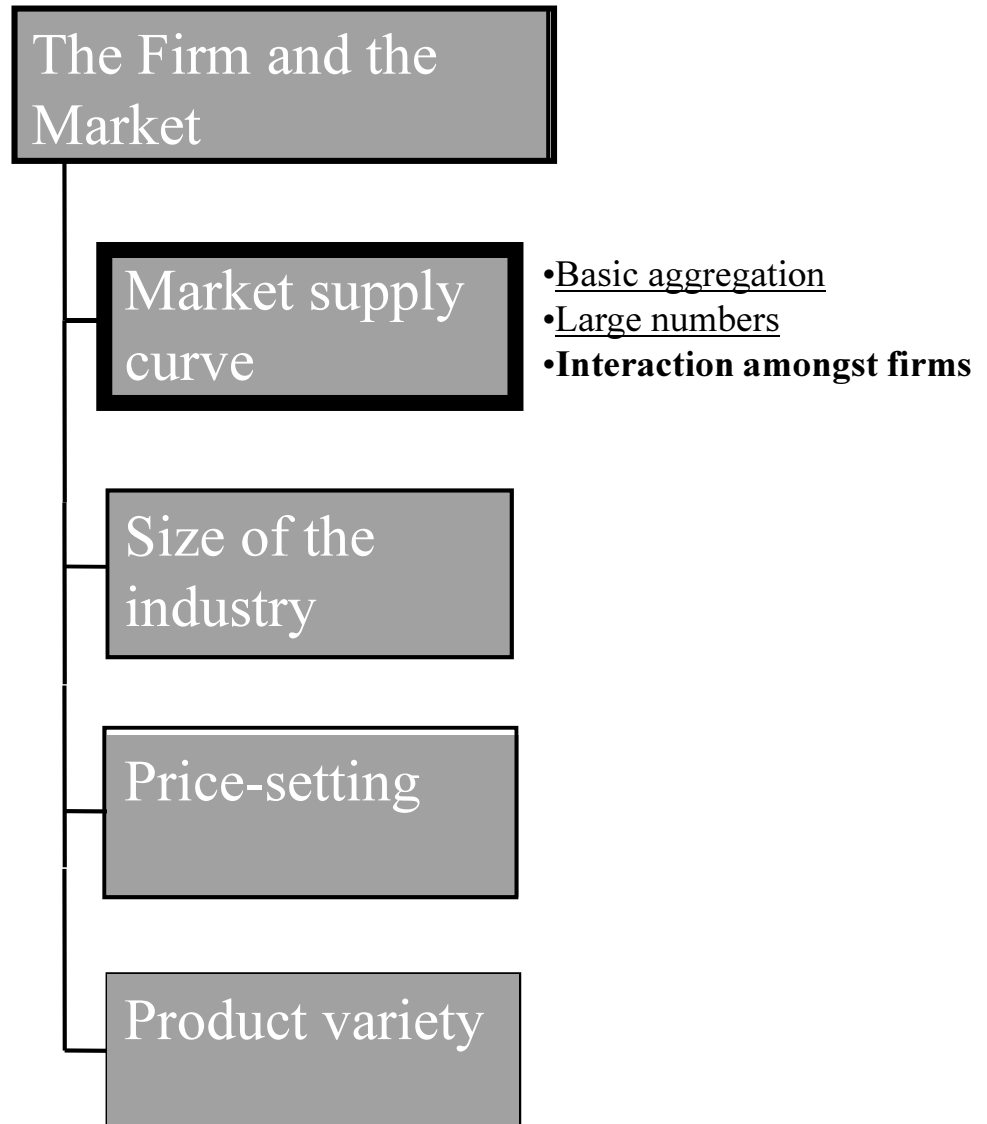# Numbers and average supply

# The limiting case



- **In the limit draw a continuous "averaged" supply curve**

- **A solution to the non-existence problem?**

- **A well-defined equilibrium**

- **Firms' outputs in equilibrium**

average demand

**average supply**

$p$

$p'$

average$(q^f)$

4   8   12

$(3/16)N$ of the firms at $q=0$
$(13/16)N$ of the firms at $q=16$.

# Lesson 2

- A further insight into nonconcavity of production function (nonconvexity of production possibilities).
- Yes, nonconvexities can lead to problems:
  - Discontinuity of response function.
  - Nonexistence of equilibrium.
- But if there are large numbers of firms then then we may have a solution.
- The *average* behaviour may appear to be conventional.

# Overview...

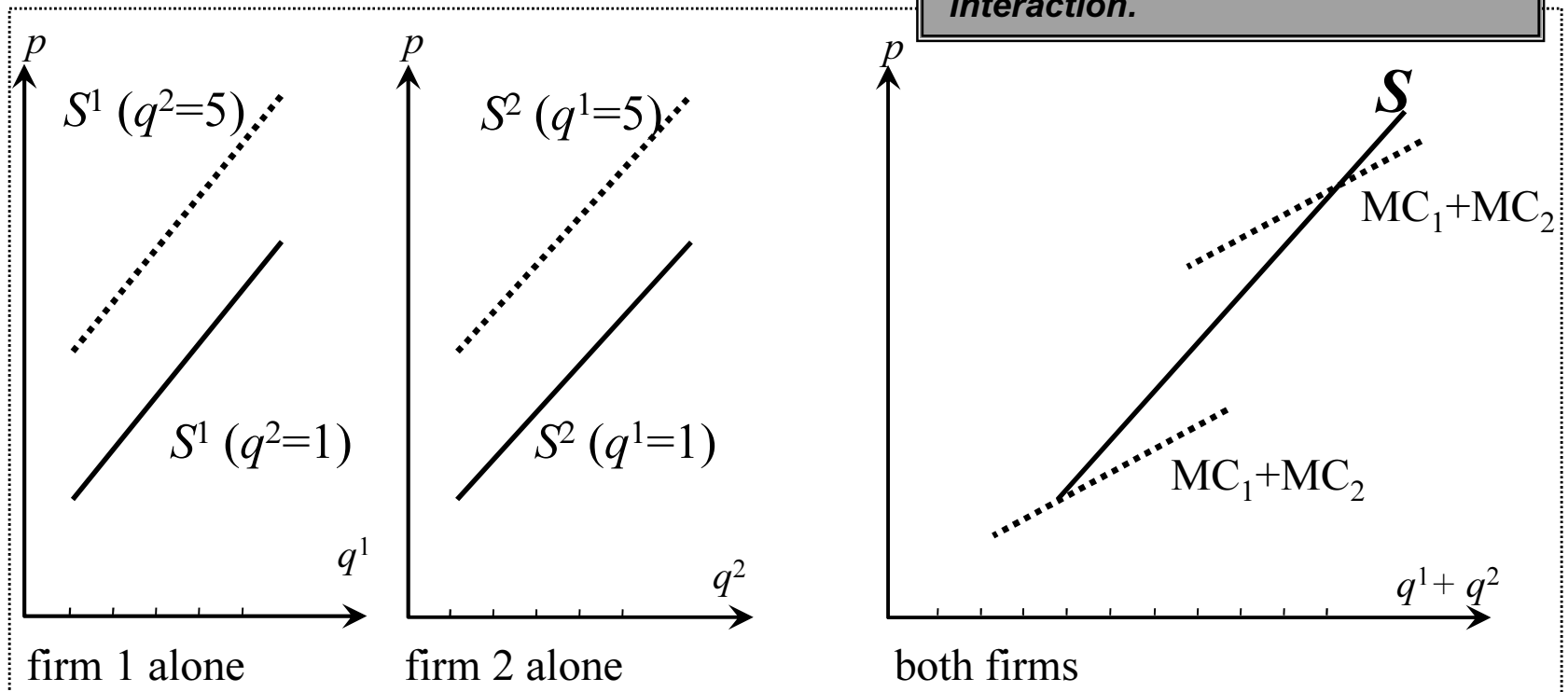*Introducing "externalities"*

| The Firm and the Market |
| --- |

| Market supply curve |
| --- |

- Basic aggregation
- Large numbers
- **Interaction amongst firms**

| Size of the industry |
| --- |

| Price-setting |
| --- |

| Product variety |
| --- |

# Interaction amongst firms

- Consider two main types of interaction
- Negative externalities
  - Pollution
  - Congestion
  - …
- Positive externalities
  - Training
  - Networking
  - Infrastructure
- Other interactions?
  - For example, effects of one firm on input prices of other firms
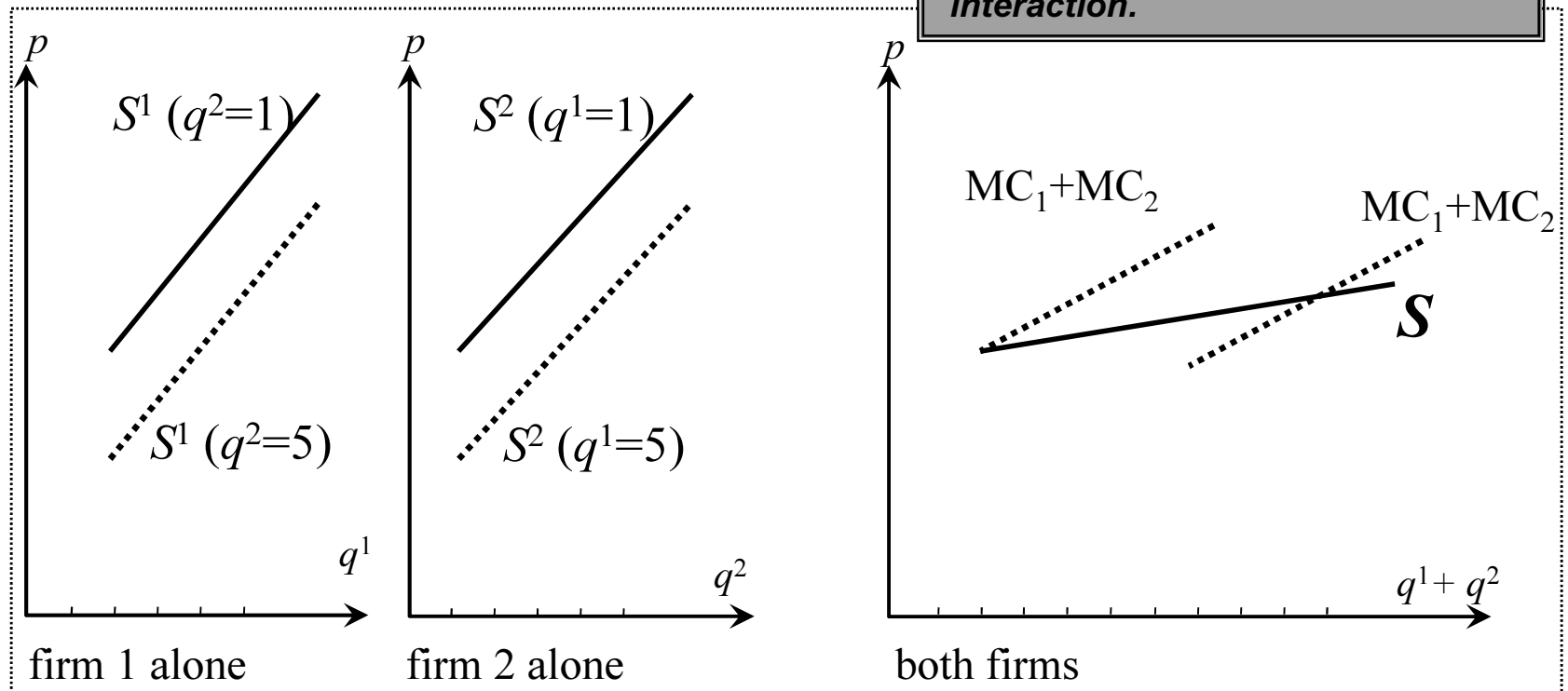  - Normal multimarket equilibrium
  - Not relevant here

# Industry supply: negative externality

> ▪ *Each firm's S-curve (MC) shifted by the other's output*
> ▪ *The result of simple $\Sigma MC$ at each output level*
> ▪ *Industry supply allowing for interaction.*



**firm 1 alone** — axes: $p$ vs $q^1$; curves $S^1 (q^2=5)$, $S^1 (q^2=1)$

**firm 2 alone** — axes: $p$ vs $q^2$; curves $S^2 (q^1=5)$, $S^2 (q^1=1)$

**both firms** — axes: $p$ vs $q^1 + q^2$; curves $S$, $MC_1+MC_2$, $MC_1+MC_2$

# Industry supply: positive externality

$p$

$S^1 (q^2=1)$

$S^1 (q^2=5)$

$q^1$

firm 1 alone

$p$

$S^2 (q^1=1)$

$S^2 (q^1=5)$

$q^2$

firm 2 alone

$p$

$MC_1+MC_2$

$MC_1+MC_2$

$S$

$q^1+ q^2$

both firms

# Positive externality: extreme case
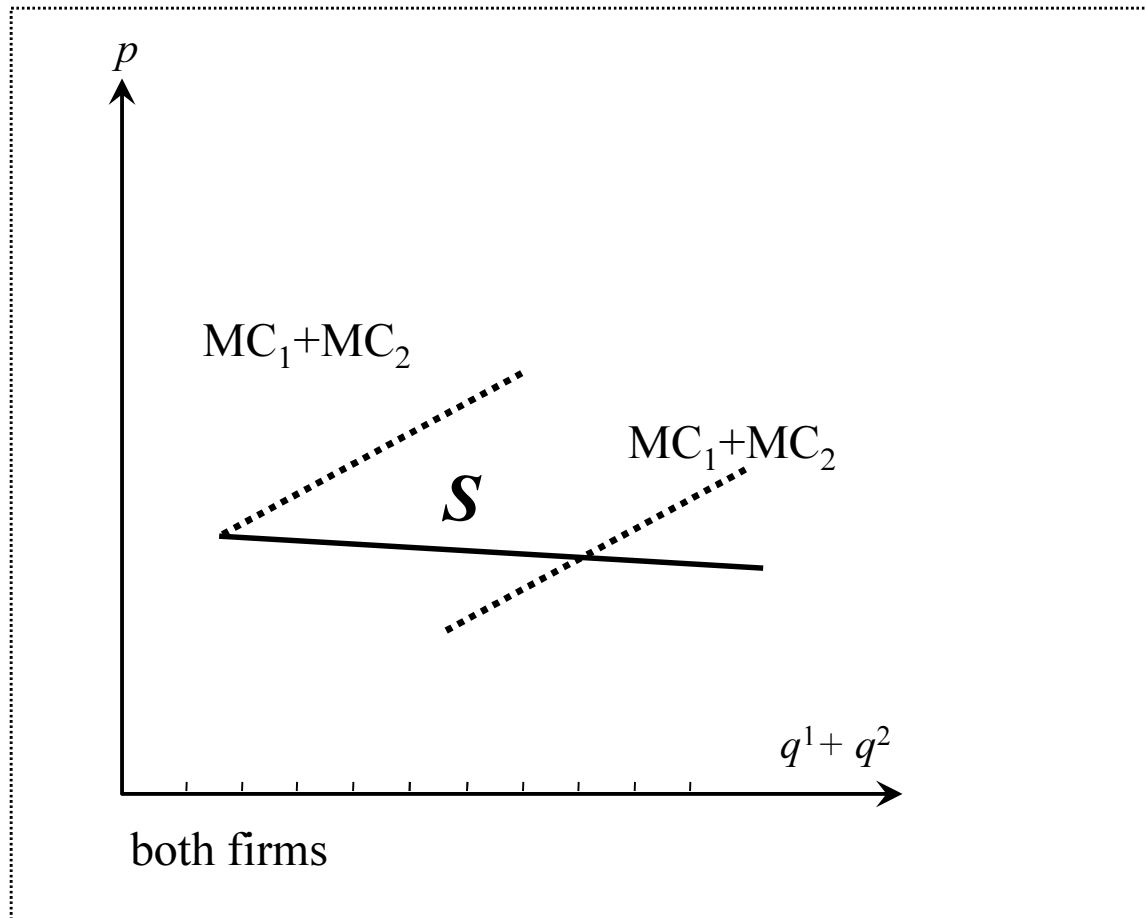
# Externality and supply: summary

- Externalities affect properties of response function.
- Negative externality:
  - Supply less responsive than the "sum-of-the-MC" rule indicates.
- Positive externality:
  - Supply more responsive than the "sum-of-the-MC" rule indicates.
- Could have forward-falling supply curve.

# Overview...

*Determining the equilibrium number of firms*

The Firm and the Market

Market supply curve

Size of the industry

Price-setting

Product variety
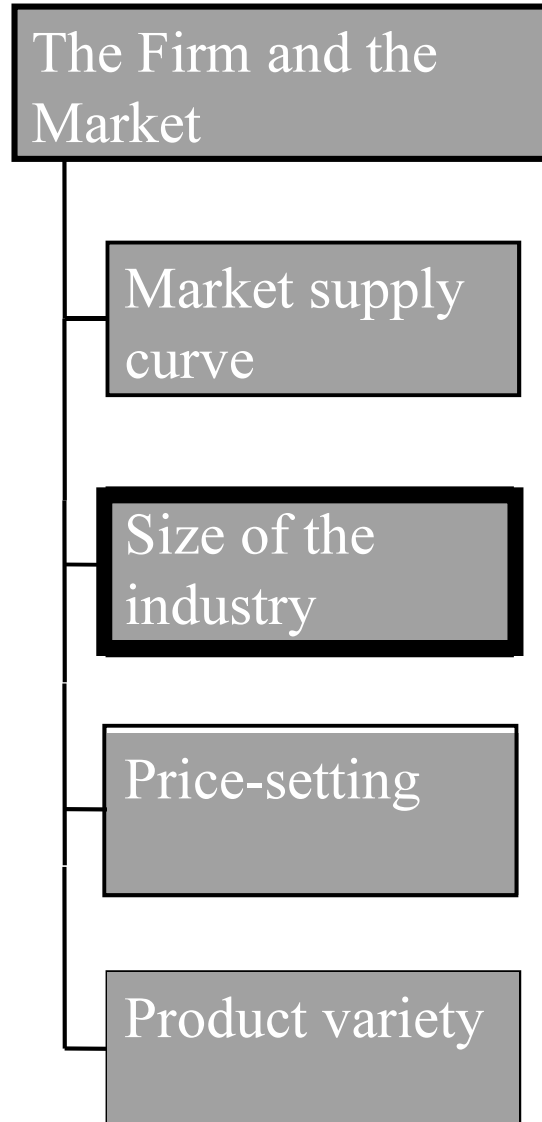
# The issue

- Previous argument has taken given number of firms.
- This is unsatisfactory:
  - How is the number to be fixed?
  - Should be determined within the model
  - …by economic behaviour of firms
  - …by conditions in the market.
- Look at the "entry mechanism."
  - Base this on previous model
  - Must be consistent with equilibrium behaviour
- So, begin with equilibrium conditions for a single firm…

# Analysing firms' equilibrium

- ■ price = marginal cost
  - ◆ determines output of any one firm.
- ■ price ≥ average cost
  - ◆ determines number of firms.

- ■ An entry mechanism:
  - ◆ If the $p - C/q$ gap is large enough then this may permit another firm to enter.
  - ◆ Applying this rule iteratively enables us to determine the size of the industry.

# Outline of the process

- (0) Assume that firm 1 makes a positive profit
- (1) Is $pq - C \leq$ set-up costs of a new firm?
  - ◆ ...if YES then stop. We've got the eqm # of firms
  - ◆ ...otherwise continue:
- (2) Number of firms goes up by 1
- (3) Industry output goes up
- (4) Price falls ($D$-curve) and individual firms adjust output (individual firm's $S$-curve)
- (5) Back to step 1

# Firm equilibrium with entry

price

marginal cost

average cost

$p$

$q^N$

output of firm
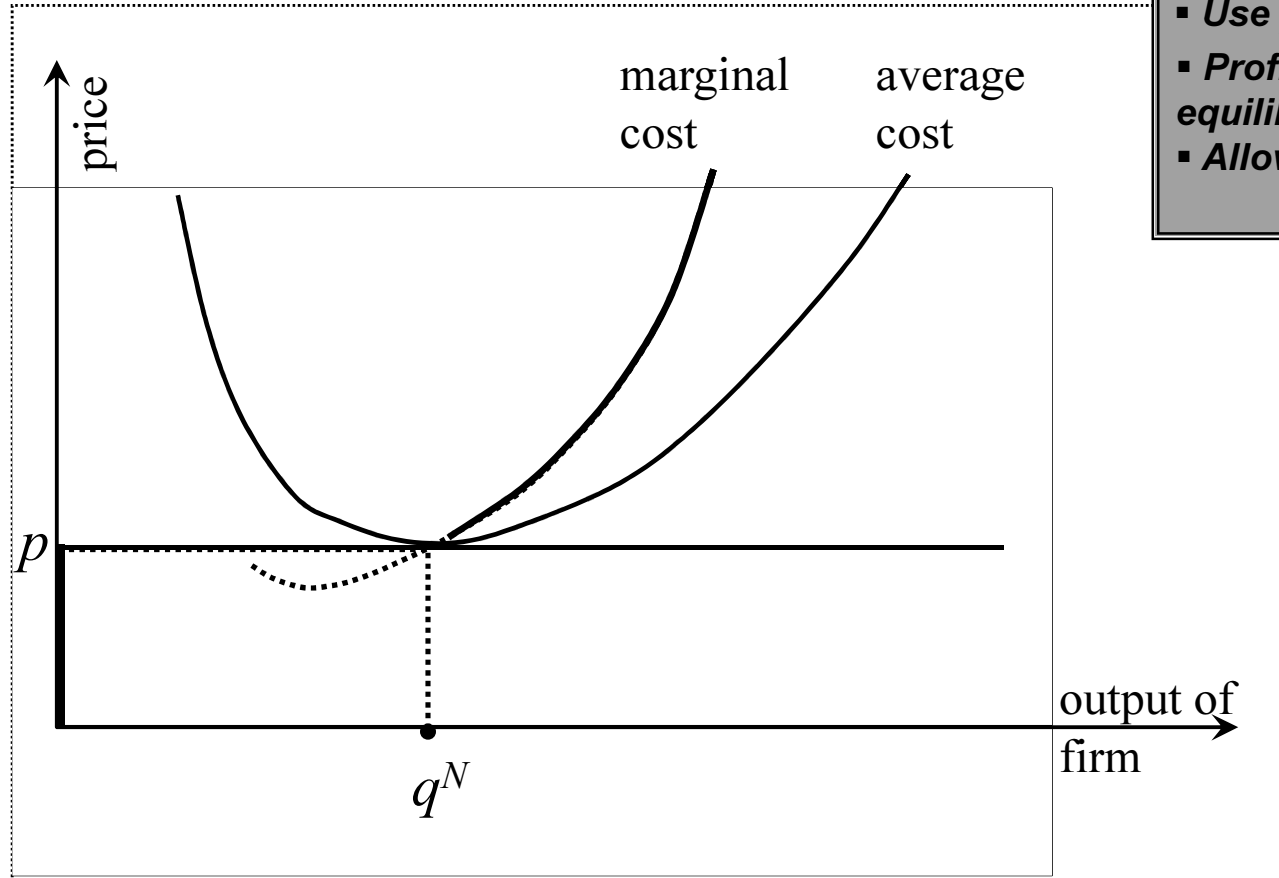
- *Draw AC and MC*
- *Get supply curve from MC*
- *Use price to find output*
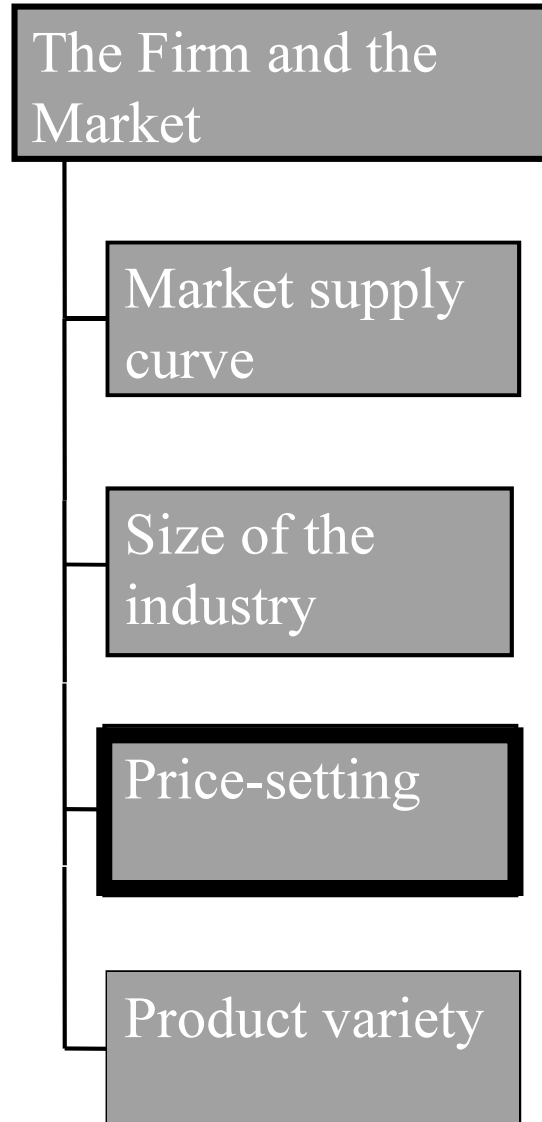- *Profits in temporary equilibrium*
- *Allow new firms to enter*

- *In the limit entry ensures profits are competed away.*

- $p = C/q$

- $n_f = N$

# Overview...

*The economic analysis of monopoly*

The Firm and the Market

Market supply curve

Size of the industry

**Price-setting**

Product variety

# The issues

- We've taken for granted a firm's environment.
- What basis for the given price assumption?
- What if we relax it for a single firm?
- Get the classic model of *monopoly*:
  - ◆ An elementary story of market power
  - ◆ A bit strange – what ensures there is only one firm?
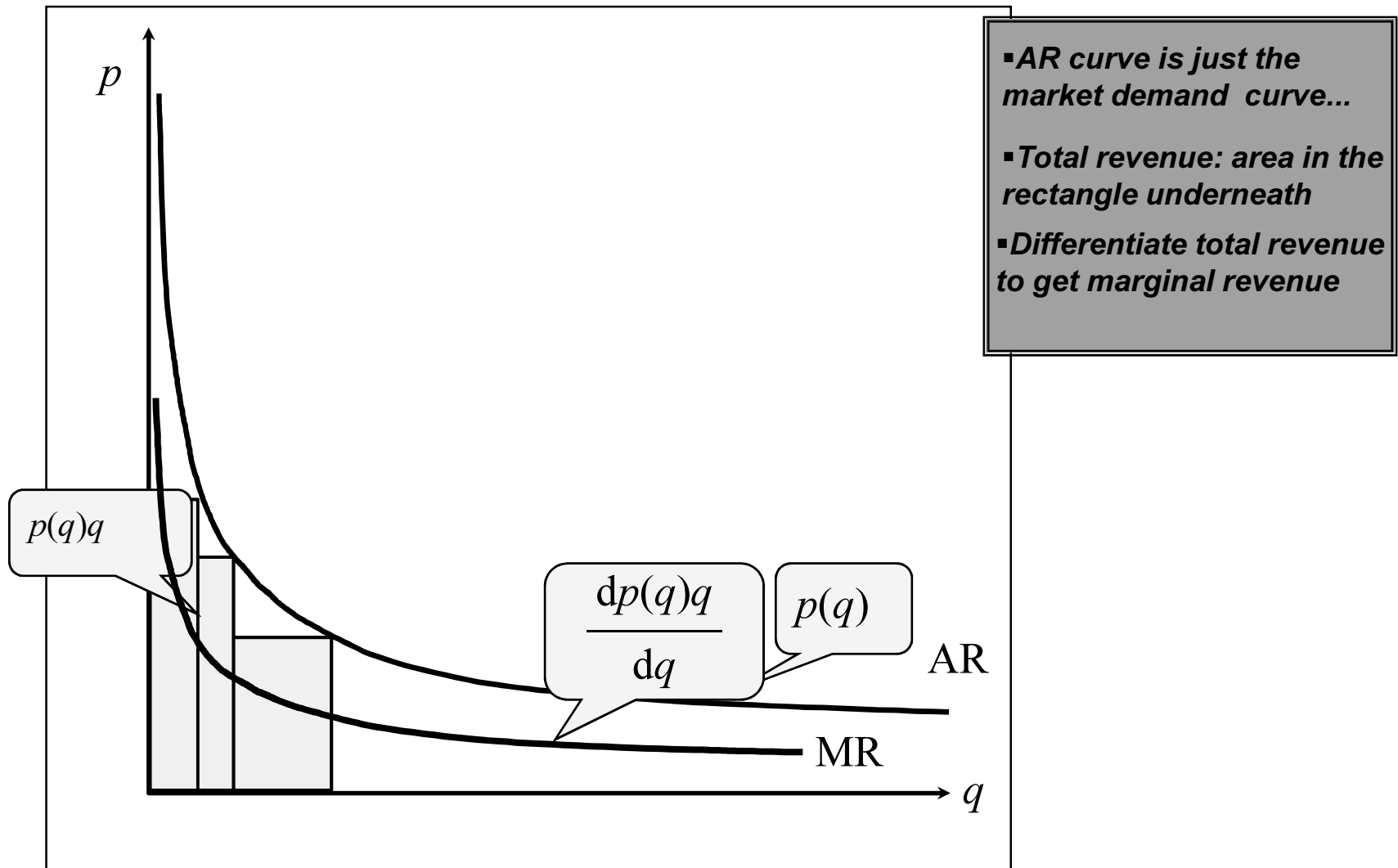  - ◆ The basis for many other models of the firm.

# A simple price-setting firm

- Compare with the price-taking firm.
- Output price is no longer exogenous.
- We assume a determinate demand curve.
- No other firm's actions are relevant.
- Profit maximisation is still the objective.

# Monopoly – model structure

- We are given the *inverse demand function*:
  - ◆ $p = p(q)$
  - ◆ Gives the price that rules if the monopolist delivers $q$ to the market.
  - ◆ For obvious reasons, consider it as the *average revenue curve* (AR).

- Total revenue is:
  - ◆ $p(q)q$.

- Differentiate to get monopolist's *marginal revenue* (MR):
  - ◆ $p(q)+p_q(q)q$
  - ◆ $p_q(\bullet)$ means $dp(\bullet)/dq$

- Clearly, if $p_q(q)$ is negative (demand curve is downward sloping), then MR < AR.

# Average and marginal revenue



- AR curve is just the market demand curve...

- Total revenue: area in the rectangle underneath
- Differentiate total revenue to get marginal revenue

$p$

$p(q)q$

$$\frac{\mathrm{d}p(q)q}{\mathrm{d}q}$$

$p(q)$

AR

MR

$q$

# Monopoly – optimisation problem

- Introduce the firm's cost function $C(q)$.
  - Same basic properties as for the competitive firm.
- From $C$ we derive marginal and average cost:
  - MC: $C_q(q)$.
  - AC: $C(q) / q$.
- Given $C(q)$ and total revenue $p(q)q$ profits are:
  - $\Pi(q) = p(q)q - C(q)$.
- The shape of $\Pi$ is important:
  - We assume it to be differentiable
  - Whether it is concave depends on both $C(\bullet)$ *and* $p(\bullet)$.
  - Of course $\Pi(0) = 0$.
- Firm maximises $\Pi(q)$ subject to $q \geq 0$.

# Monopoly – solving the problem

- Problem is "max $\Pi(q)$ s.t. $q \geq 0$," where:
  - $\Pi(q) = p(q)q - C(q)$.
- First- and second-order conditions for *interior* maximum:
  - $\Pi_q(q) = 0$.
  - $\Pi_{qq}(q) < 0$.
- Evaluating the FOC:
  - $p(q) + p_q(q)q - C_q(q) = 0$.
- Rearrange this:
  - $p(q) + p_q(q)q = C_q(q)$
  - "Marginal Revenue = Marginal Cost"
- This condition gives the solution.
  - From above get optimal output $q^*$.
  - Put $q^*$ in $p(\bullet)$ to get monopolist's price:
  - $p^* = p(q^*)$.
- Check this diagrammatically…

# Monopolist's optimum
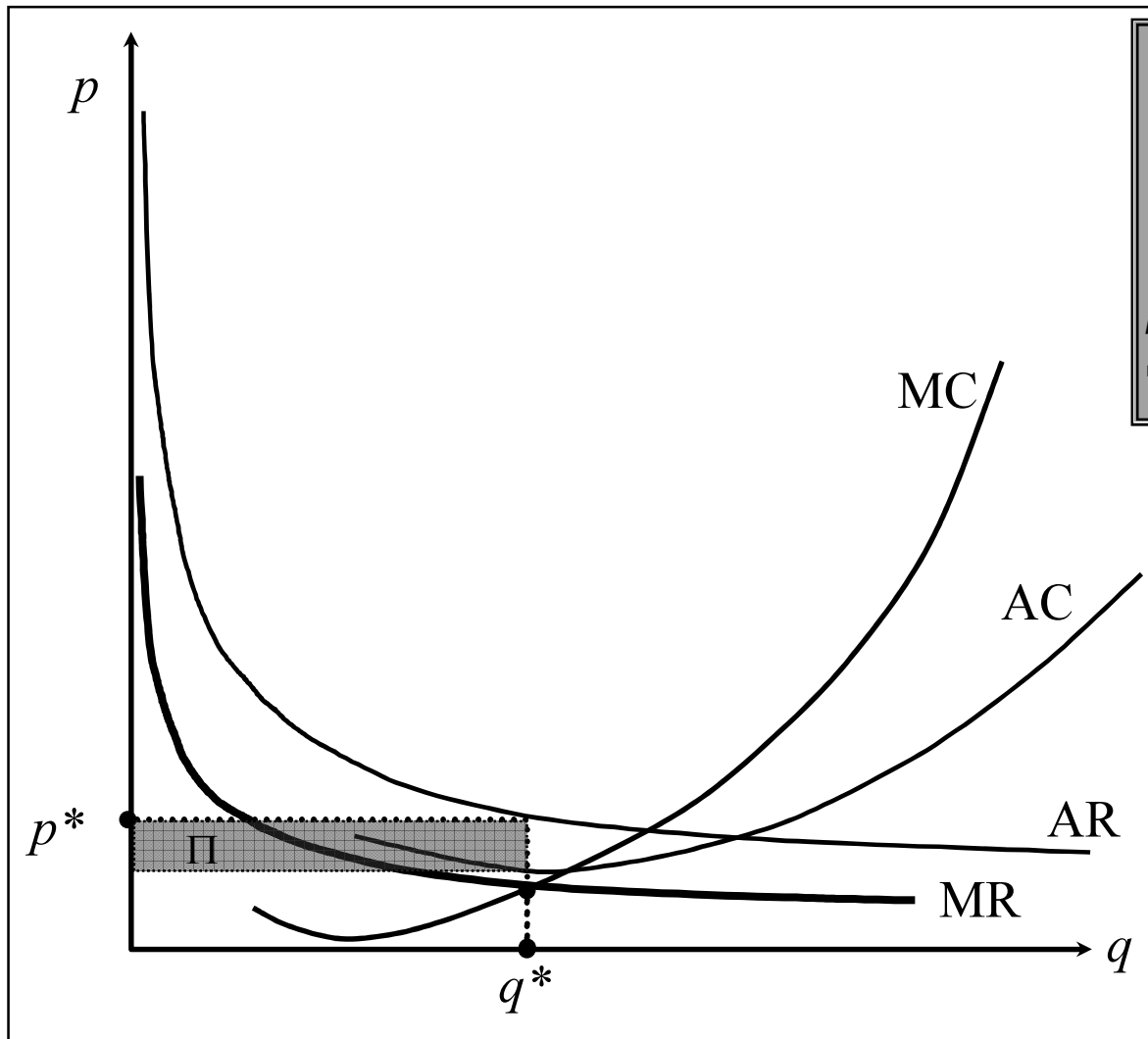


- AR and MR
- Marginal and average cost
- Optimum where MC=MR
- Monopolist's optimum price.
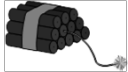- Monopolist's profit

# Monopoly – pricing rule

- Introduce the *elasticity of demand* $\eta$:
    - $\eta := \mathrm{d}(\log q) / \mathrm{d}(\log p)$
    - $= p(q) / qp_q(q)$
    - $\eta < 0$

- First-order condition for an interior maximum
    - $p(q) + p_q(q)q = C_q(q)$
- …can be rewritten as
    - $p(q) \ [1+1/\eta] = C_q(q)$
- This gives the monopolist's pricing rule:
    - $p(q) = \dfrac{C_q(q)}{1 + 1/\eta}$

# Monopoly – the role of demand

- Suppose demand were changed to
  - ◆ $a + bp(q)$
  - ◆ $a$ and $b$ are constants.

- Marginal revenue and demand elasticity are now:
  - ◆ $MR(q) = bp_q(q)\, q + [a + bp(q)]$
  - ◆ $\eta = [a/b + p(q)] / qp_q(q)$

- Rotate the demand curve around $(p^*, q^*)$.
  - ◆ $db > 0$ and $da = -p(q^*)\, db < 0$.
  - ◆ Price at $q^*$ remains the same.
  - ◆ Marginal revenue at $q^*$ increases – $dMR(q^*) > 0$.
  - ◆ Abs value of elasticity at $q^*$ decreases – $d|\eta| < 0$.
  - ◆ But what happens to optimal output?

- Differentiate FOC in the neighbourhood of $q^*$:
  - ◆ $dMR(q^*)db + \Pi_{qq}\, dq^* = 0$

- So $dq^* > 0$ if $db > 0$.

# Monopoly – analysing the optimum

- Take the basic pricing rule
  - $p(q) = \dfrac{C_q(q)}{1 + 1/\eta}$

- Use the definition of demand elasticity
  - $p(q) \geq C_q(q)$
  - $p(q) > C_q(q)$ if $|\eta| < \infty$.
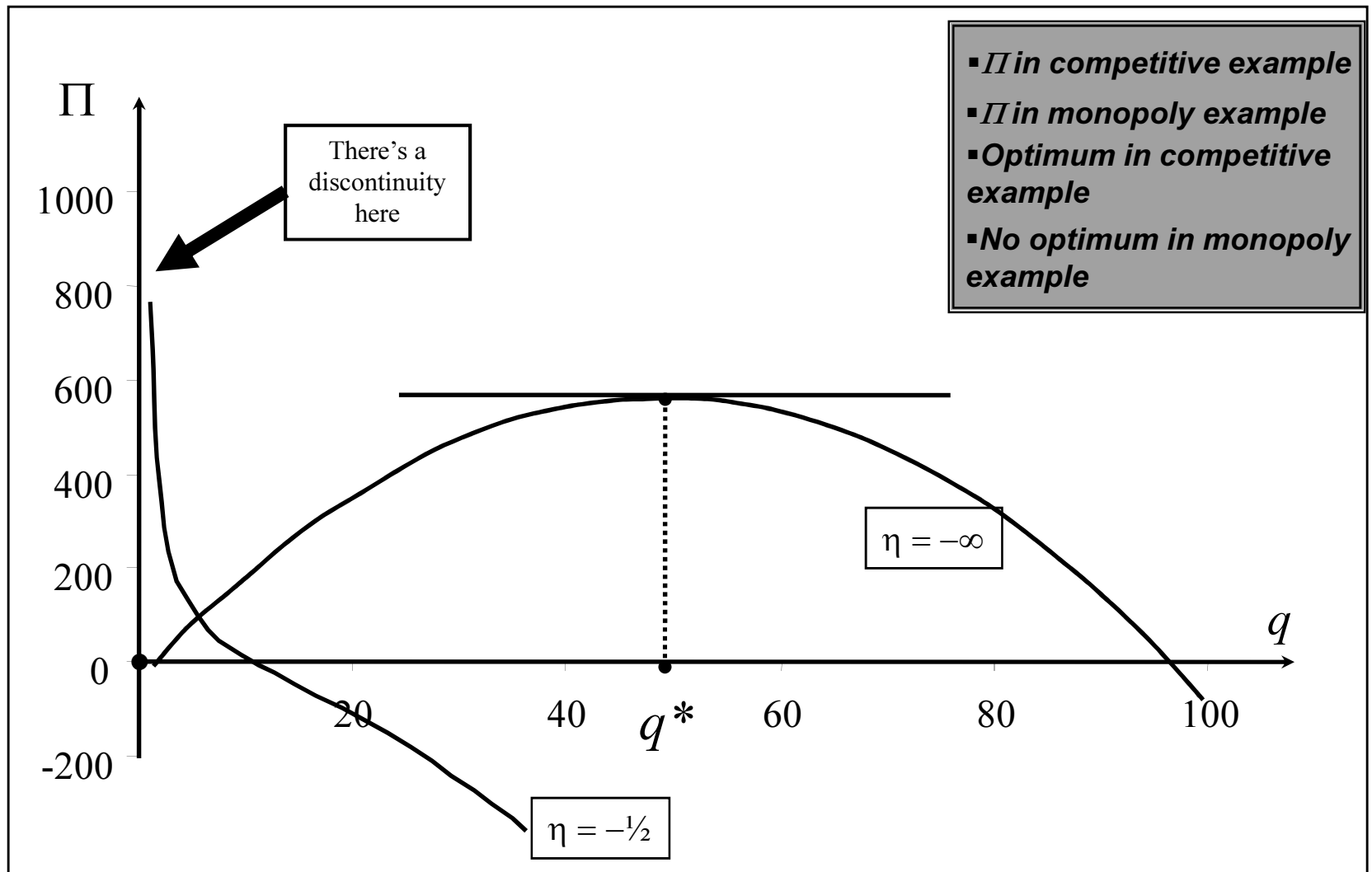  - "price > marginal cost"
- Clearly as $|\eta|$ decreases:
  - output decreases.
  - gap between price and marginal cost increases.
- What happens if $|\eta| \leq 1$ $(\eta \geq -1)$?

# What is going on?

- To understand why there may be no solution consider two examples.

- A firm in a competitive market: $\eta = -\infty$
  - $p(q) = \bar{p}$

- A monopoly with inelastic demand: $\eta = -\frac{1}{2}$
  - $p(q) = aq^{-2}$

- Same quadratic cost structure for both:
  - $C(q) = c_0 + c_1 q + c_2 q^2$

- Examine the behaviour of $\Pi(q)$ .
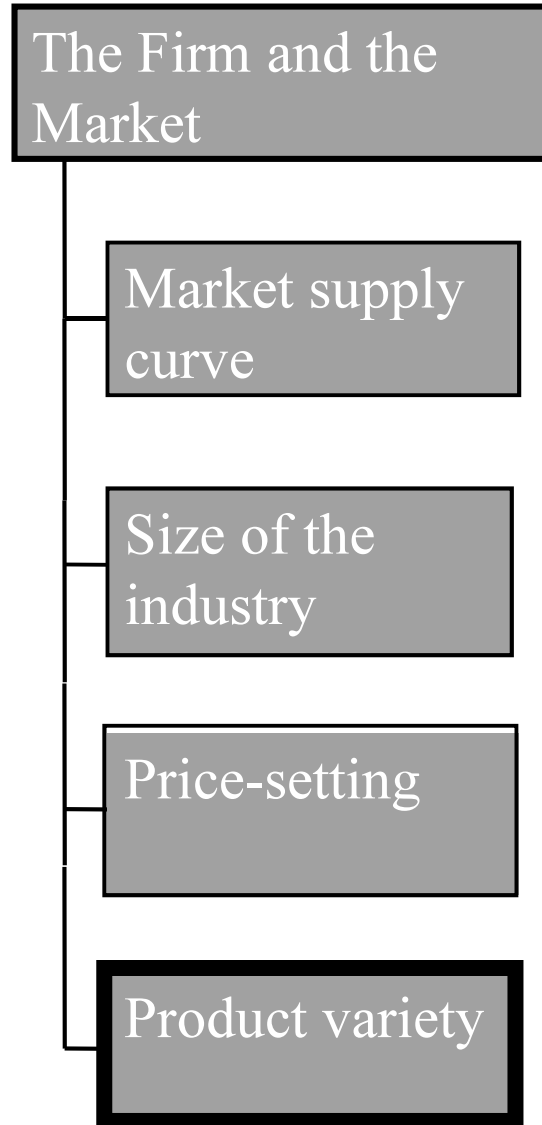
# Profit in the two examples

# The result of simple market power

- **There's no supply curve:**
  - For competitive firm market price is sufficient to determine output.
  - Here output depends on *shape* of market demand curve.
- **Price is artificially high:**
  - Price is above marginal cost
  - Price/MC gap is larger if demand is inelastic
- **There may be no solution:**
  - What if demand is very inelastic?

# Overview...

*Modelling "monopolistic competition"*

The Firm and the Market

Market supply curve

Size of the industry

Price-setting

Product variety

# Market power and product diversity

- Each firm has a downward-sloping demand curve:
  - Like the case of monopoly.
- Firms' products may differ one from another.
- New firms can enter with new products.
- Diversity may depend on size of market.
- Introduces the concept of "monopolistic competition."
- Follow the method competitive firm:
  - Start with the analysis of a single firm.
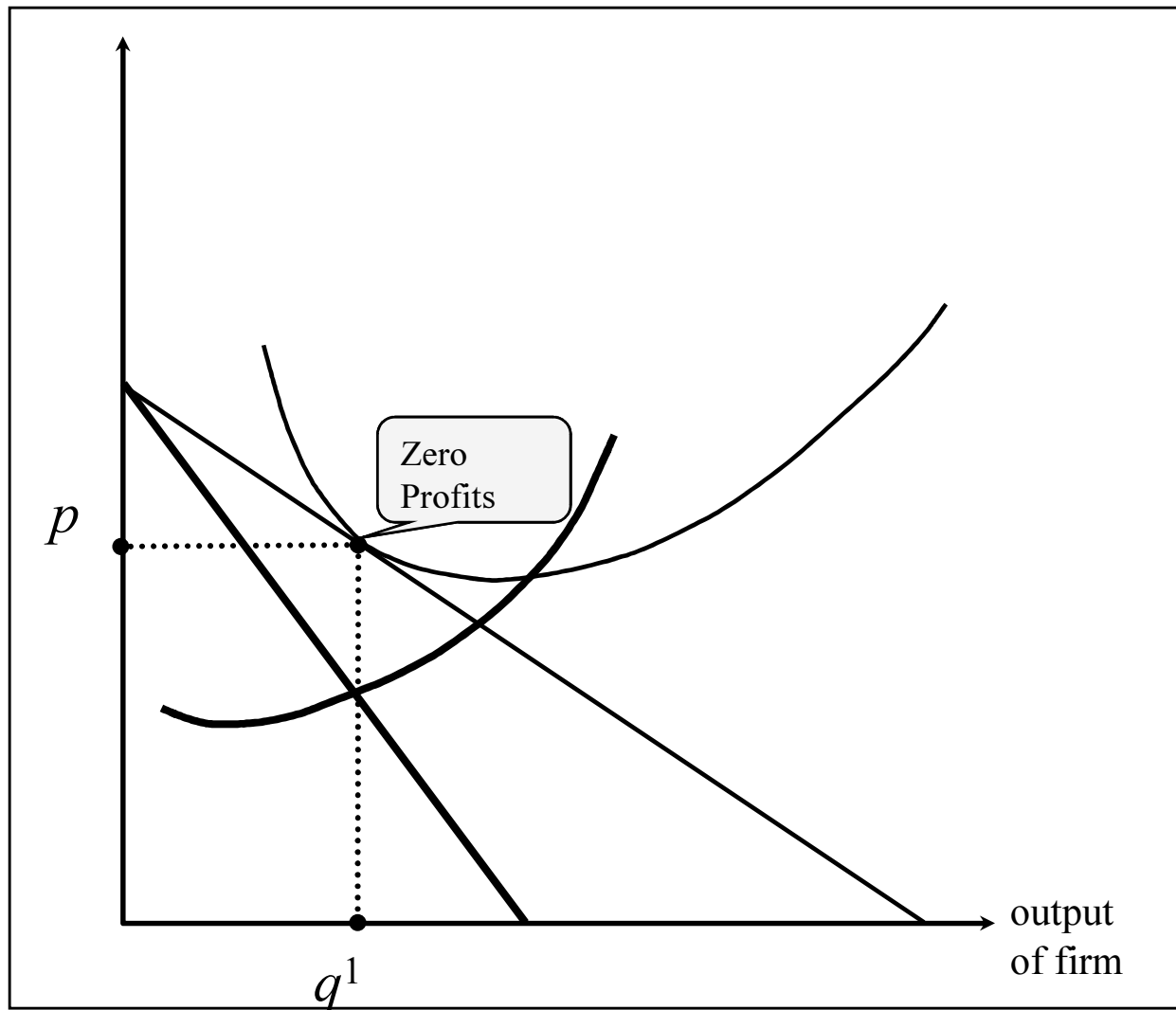  - Entry of new firms competes away profits.

# Monopolistic competition: 1
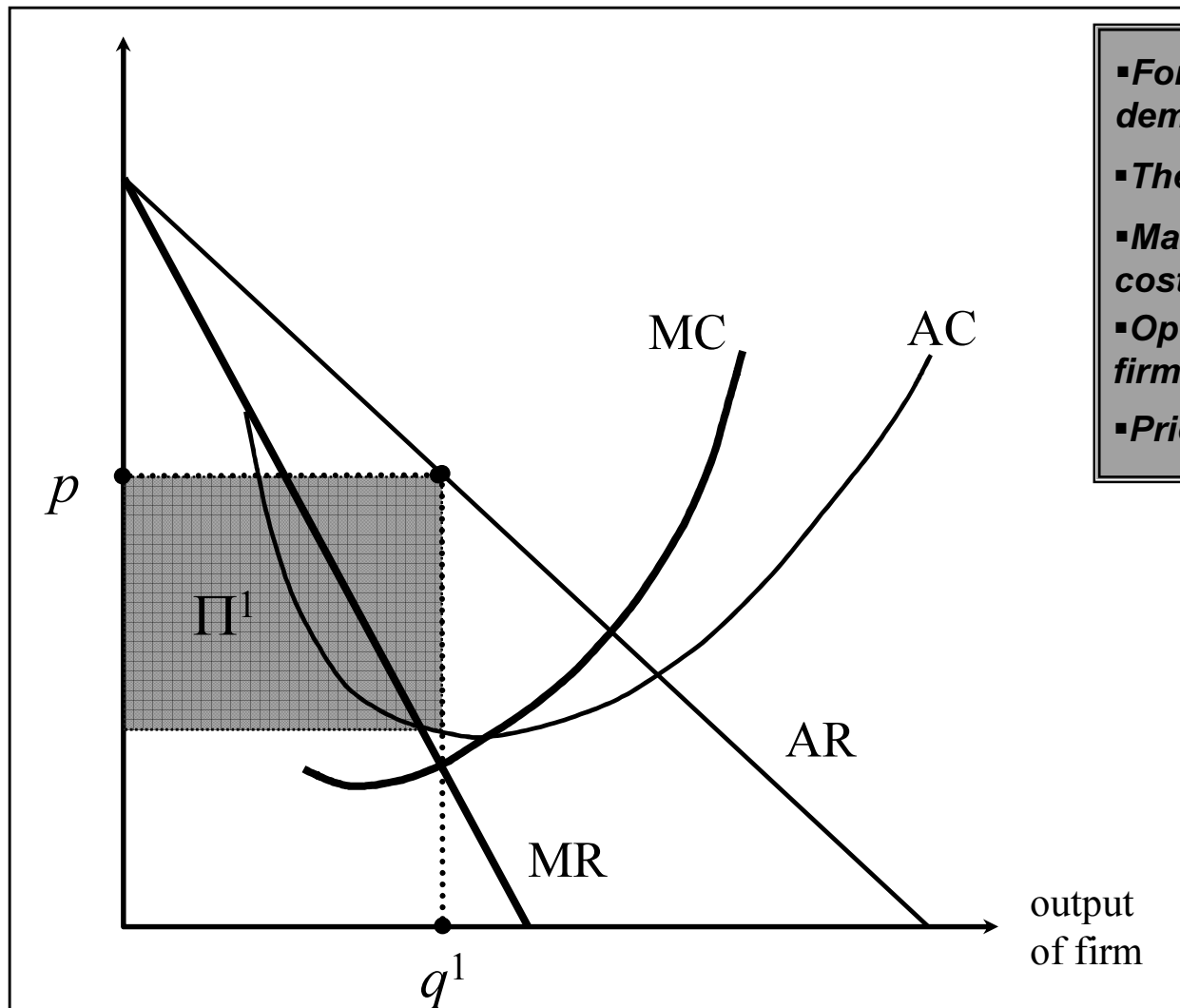


- *For simplicity take linear demand curve (AR)*
- *The derived MR curve*
- *Marginal and average costs*
- *Optimal output for single firm*
- *Price and profits*

MC  AC

$p$

$\Pi^1$

AR

MR

output of firm

$q^1$

- *outcome is effectively the same as for monopoly.*

# Monopolistic competition: 2



Zero
Profits

$p$

$q^1$

output
of firm

# Review

- Individual supply curves are discontinuous: a problem for market equilibrium?

- A large-numbers argument may help.

- The size of the industry can be determined by a simple "entry" model

- With monopoly equilibrium conditions depend on demand elasticity

- Monopoly + entry model yield monopolistic competition.

# What next?

- We could move on to more complex issues of industrial organisation.
- Or apply the insights from the firm to the <u>consumer</u>.