Section 5
The Cost of Production II

Reference:
- N. Gregory Mankiw and Mark P. Taylor (2023), "*Microeconomics*", Cengage Learning, Chapter 5
- Pindyck, R.S. und D.L. Rubinfeld (2012), *"Microeconomics"*, 8th Edition, Prentice Hall, Chapter 7 and 15

The slides of this section are mainly based on the 6th edition of the book by Mankiw and Taylor (2023). In some slides we reproduce figures, sentences and definitions given in the book.

Introductory Video: Economies of Scale in the Local Transport Sector

https://www.youtube.com/watch?v=H77as7pLdV4

Five-year overview of key figures

→ Key figures (XLS)

		2019
Result		
Operating income	CHF million	7,164
Generated in competition	% of operating income	85.4
Generated abroad and cross-border	% of operating income	14.8
Operating profit	CHF million	450
Generated in competition	% of operating profit	75.1
Generated abroad and cross-border	% of operating profit	14.9
Group profit	CHF million	255
Equity	CHF million	6,834

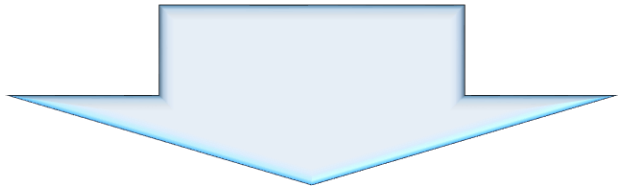
A positive profit implies that all economic cost has been covered?

https://geschaeftsbericht.post.ch/19/ar/en/key-figures/

A. Costs, Revenues, Economic and Accounting Profit and return on equity

Costs, Revenues, Economic and Accounting Profit

- Generally, the economic goal of a firm is to maximize economic profit.
- **Total Revenue**: the amount of money that a firm receives for the sale of its output.
- **Total Cost**: the market value of all inputs a firm uses in production.



- **Economic Profit** is the firm's total revenue minus its total cost.

Profit = Total Revenue – Total Cost

Cost of production

- A firm's **cost of production** also includes all the opportunity costs of making its output of goods and services.
- **Opportunity cost**: choosing one thing in a world of scarcity means giving up something else. The opportunity cost is

➢ the benefit or value of the most valuable good forgone.

➢ what you must forgo in order to get something.

- Examples

  ↳ Mark buys a pizza and with that same amount of money he could have bought a drink and an hamburger. The opportunity cost is the value of the drink and hamburger.

  ↳ If you decide not to go to work, the opportunity cost is the lost wages

Explicit and Implicit Costs

- A firm's cost of production includes **explicit costs** and **implicit costs**

  - **Explicit costs** are input costs that require a direct outlay of money by the firm.

  - **Implicit costs** are input costs that do *not* require directly an outlay of money by the firm.

Example of an implicit cost: the opportunity cost of capital

The opportunity cost of capital is an important cost to include in any analysis of firm performance.

Example:

- Bill uses 100'000$ of his savings to start a firm. (This money was in a saving account paying 5% interest.)
- Since Bill could have earned 5'000$ per year on his saving, we must include this opportunity cost (**implicit cost**) in our analysis.
- Note that an accountant would not count this 5000$ as part of the firm's costs.
- If Bill had instead borrowed from a bank 100'000$ with an interest rate of 5% ➔ **explicit cost**
- Accountant would now count 5000$ in interest paid for the bank loan.

Economic Profit and Accounting Profit

- The distinction between explicit and implicit costs highlights an important difference between how economists and accountants analyse a business!
- The Economist‘s view:

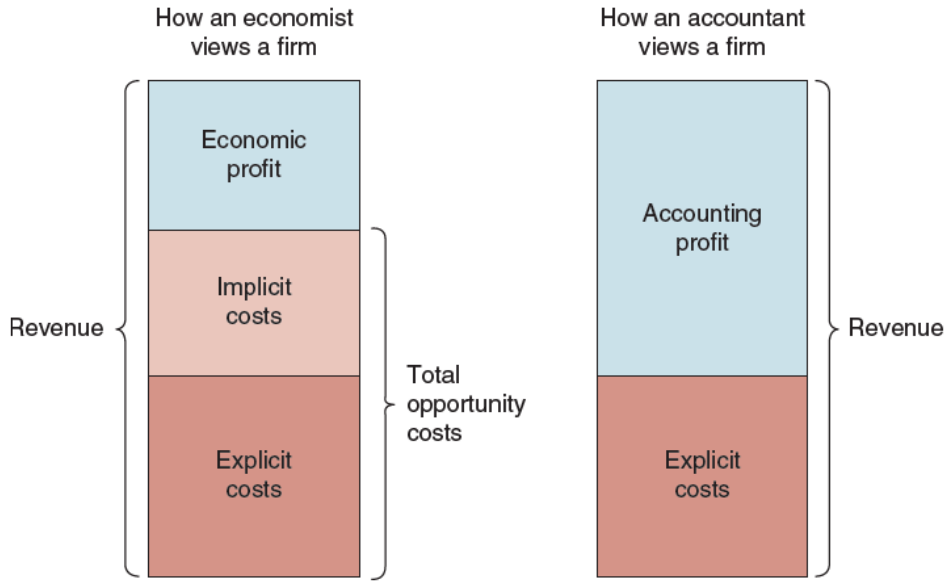
Economic Profit = Total Revenue – Total Cost

Total Cost = Explicit Cost + Implicit Cost

- The Accountant‘s view:

Accounting Profit = Total Revenue – Explicit Cost

Economic Profit and Accounting Profit



Source: Mankiw & Taylor (2023), "Microeconomics"

- **Economists** are interested in studying how firms make production and pricing decisions.
- **Accountants** are interested in keeping track of the money that flows into and out of the firm.

Implicit environmental costs from a society point of view

- From an **economic and society** point of view:

  the cost of production includes **explicit costs** and **implicit costs** that also include all **external/social costs** (ex: health cost due to pollution)

- Example implicit and explicit cost of elderly care services

Accounting Profit: Income Statement and Balance Sheet

- **The income statement** measures the flows into and out of the firm.

- **The balance sheet** measures the stocks of assets and liabilities at the end of the accounting year.

Example: Income Statement of a coal power plant (company with equity and debt capital; equity capital =10'000'000 $)

	Year 2020
Energy sales	30'000'000
Total revenues	**30000000**
Coal	18'000'000
Material	2'000'000
Salaries	4'000'000
Depreciation	3'000'000
Interest on debt capital	1'700'000
Total expenditures	**28'700'000**
Net operating income	**1'300'000**
Tax	-300'000
Net accounting profit (income) after taxes	**1'000'000**

- **How much is the Economic profit assuming that the only missing implicit cost is the opportunity cost of capital?**

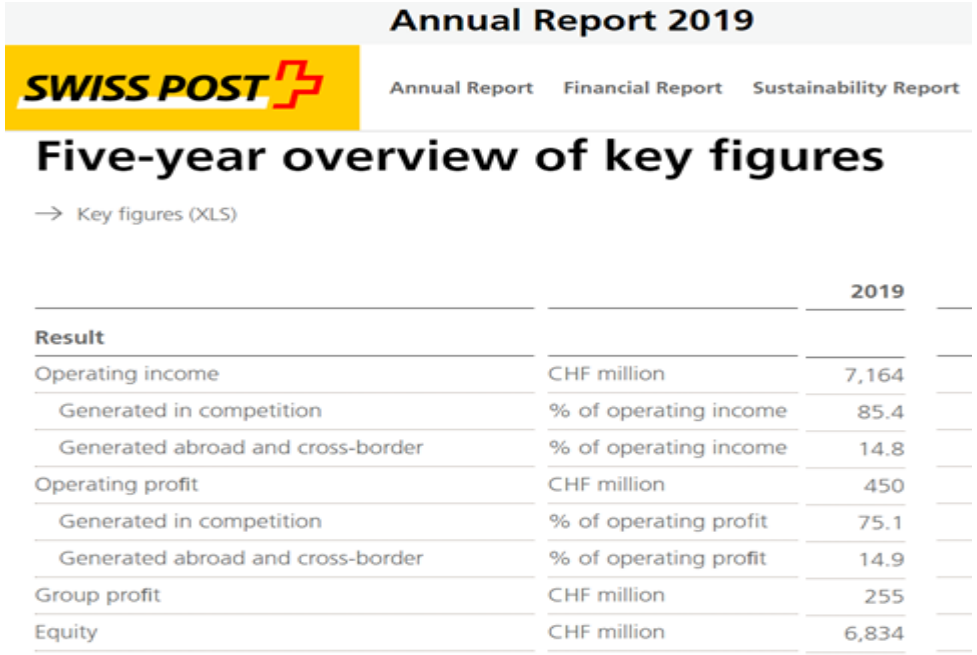
- First compute the opportunity cost of equity capital
- Then add the opportunity cost of equity capital to the cost
- Alternative: compute the return on equity capital for the firm and compare it with the opportunity costs of equity capital

↳ return on equity capital= profit/equity capital =10%
↳ Opportunity cost = 5% (assumption)

↳ Higher or lower than opportunity cost of capital?
↳ If higher ➔ economic profit
↳ If lower➔ economic loss

cepe
Centre for Energy Policy and Economics
Swiss Federal Institutes of Technology

Example accounting profit



Annual Report 2019

SWISS POST

Annual Report | Financial Report | Sustainability Report

Five-year overview of key figures

→ Key figures (XLS)

		2019
Result		
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https://geschaeftsbericht.post.ch/19/ar/en/key-figures/

Return on equity =255/6834 = 3.7%

Other Differences Between Economic Costs and Accounting Costs

- **Depreciation** is not based on the actual life of a machine. It is mainly regulated by law.

- **Sunk Costs** are part of accounting costs.

  – Sunk Costs are expenditures that have been made and cannot be recovered.
  – Sunk Costs will not be considered for future decisions.
  – Ex: marketing

- **Social and environmental costs due to negative externalities (air pollution, noise,…)**

Sunk Costs: Example (Gwartney, Stroup, and Sobel, 2000)

- A company pays CHF 100'000 for a manufacturing machine and its installation. The estimated life-time of the machine is 10 years.
  The machine has no alternative use.

- CHF 50'000 income / year.

- CHF 46'000 costs / year (raw material, other production factors).

- Should the machine be used any longer?
  - The annual depreciation costs are CHF 10'000 (sunk costs).
  - The accounting department shows a loss.
  - The machine's opportunity cost is zero.
  - Since the use of the machine generates a contribution to the margin of CHF 4'000 the company may benefit from this usage.

B. Fixed and Variable Costs

Fixed and Variable Costs (short run)

- Costs of Production can be further divided into:

- **Fixed costs:** costs that are not determined by the quantity of output produced.
  - Example: rent of a building with a long term contract or capital cost of an investment in machines

- **Variable costs:** costs that are dependent on the quantity of output produced .

  ↳ Example: costs of raw materials, cost of fuel for machinery

Total Costs (short run)

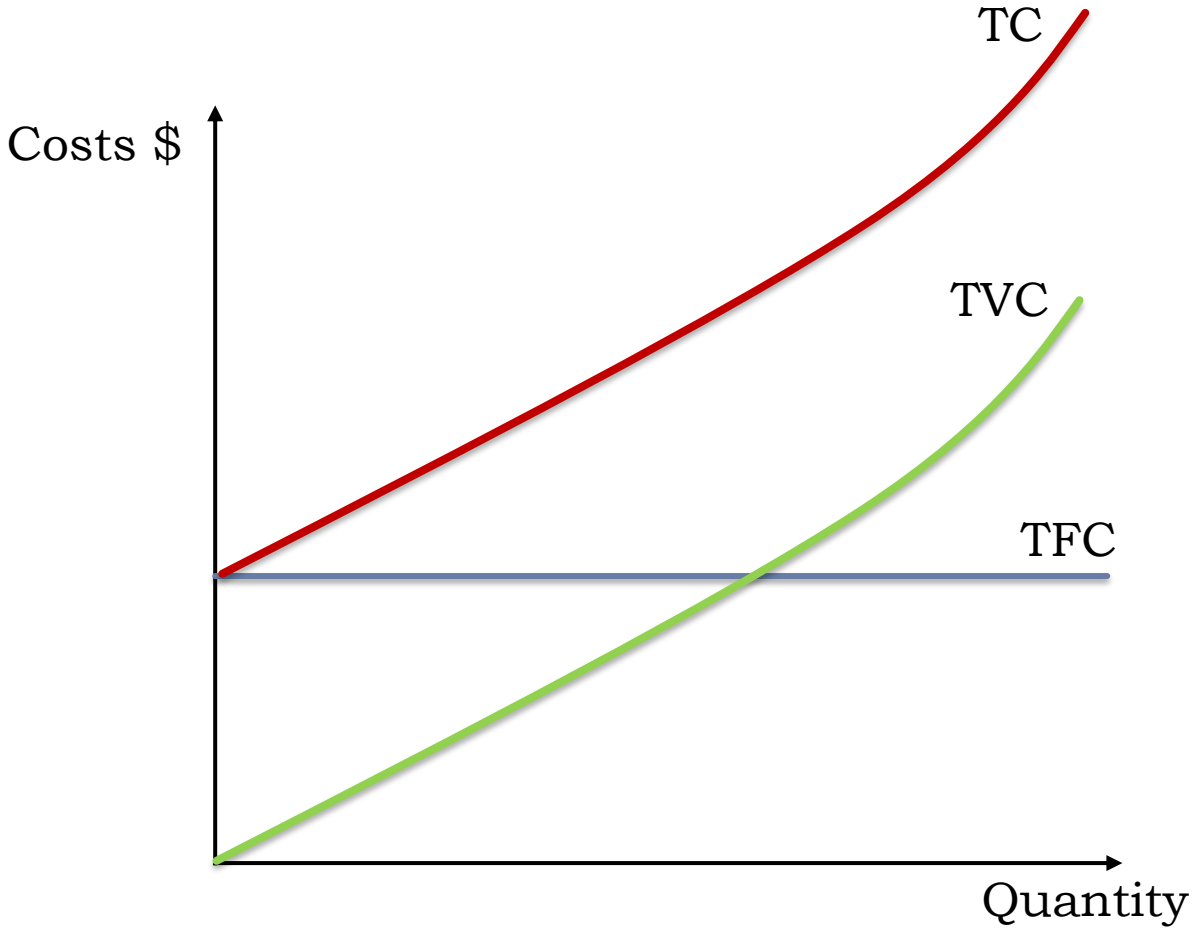
With the new information about the types of cost we can redefine the total costs.

TC = TFC + TVC

TC: Total Costs

TFC: Total Fixed Costs

TVC: Total Variable Costs



Average Costs (short run)

Average Fixed Cost:

$$AFC = \frac{\text{Fixed Cost}}{\text{Quantity}} = \frac{FC}{Q}$$

Average Variable Cost:

$$AVC = \frac{\text{Variable Cost}}{\text{Quantity}} = \frac{VC}{Q}$$

Average Total Cost:

$$ATC = \frac{\text{Total Cost}}{\text{Quantity}} = \frac{TC}{Q}$$

Marginal cost (MC) the increase in total cost that arises from an extra unit of production.

Marginal Cost:

$$MC = \frac{\text{Change in total cost}}{\text{Change in quantity}} = \frac{\Delta TC}{\Delta Q}$$

Costs (short run): Example - 1

TABLE 5.2 The Various Measures of Cost: Luciano's Lemonade Stand

Quantity of lemonade glasses (per hour)	Total cost (€)	Fixed cost (€)	Variable cost (€)	Average fixed cost (€)	Average Variable cost (€)	Average total cost (€)	Marginal cost (€)
0	3.00	3.00	0.00	—	—	—	
							0.30
1	3.30	3.00	0.30	3.00	0.30	3.30	
							0.50
2	3.80	3.00	0.80	1.50	0.40	1.90	
							0.70
3	4.50	3.00	1.50	1.00	0.50	1.50	
							0.90
4	5.40	3.00	2.40	0.75	0.60	1.35	
							1.10
5	6.50	3.00	3.50	0.60	0.70	1.30	
							1.30
6	7.80	3.00	4.80	0.50	0.80	1.30	
							1.50
7	9.30	3.00	6.30	0.43	0.90	1.33	
							1.70
8	11.00	3.00	8.00	0.38	1.00	1.38	
							1.90
9	12.90	3.00	9.90	0.33	1.10	1.43	
							2.10
10	15.00	3.00	12.00	0.30	1.20	1.50	

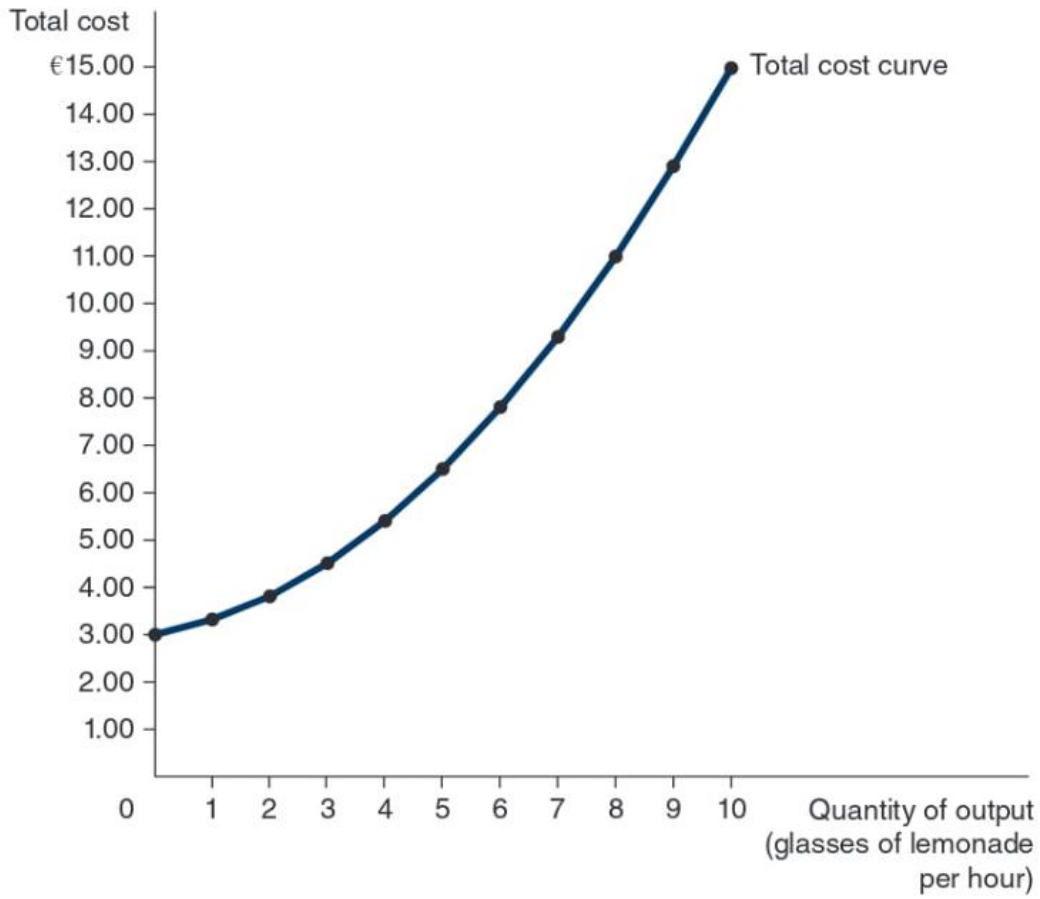
Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 5, p. 110

Costs (short run): Example

FIGURE 5.2

Luciano's Total Cost Curve

Here the quantity of output produced (on the horizontal axis) is from the first column in Table 5.2, and the total cost (on the vertical axis) is from the second column. As in Figure 5.1, the total cost curve gets steeper as the quantity of output increases because of diminishing marginal product.



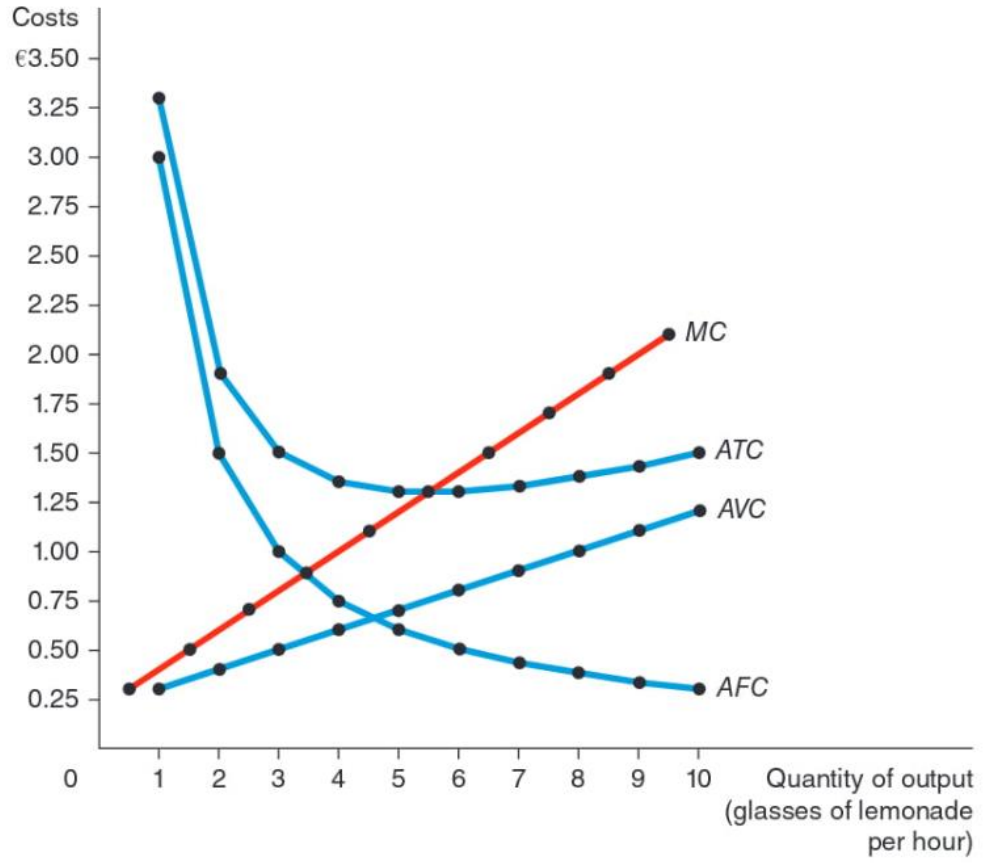
Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 5, p. 110

Costs Curves: Example

FIGURE 5.3

Luciano's Average Cost and Marginal Cost Curves

This figure shows the average total cost (ATC), average fixed cost (AFC) average variable cost (AVC) and marginal cost (MC) for Luciano's Lemonade Bar. These curves are obtained by graphing the data in Table 5.2. These cost curves show (1) marginal cost rises with the quantity of output; (2) the average total cost curve is U-shaped; and (3) the marginal cost curve crosses the average total cost curve at the minimum of average total cost.



Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 5, p. 112

Costs (short run): Example – 2 (mathematical functions)

- **Total cost function** = $7Q^2 + 5Q + 1500$
- If Q= 0 -> TC = 1500

$$\textbf{ATC} = \frac{7Q^2 + 5Q + 1500}{Q}$$

$$\textbf{AFC} = \frac{1500}{Q}$$

$$\textbf{VC} = 7Q^2 + 5Q$$

$$\textbf{MC} = \frac{dTC}{dQ} = 14Q + 5$$

$$\textbf{AVC} = \frac{7Q^2 + 5Q}{Q}$$

Marginal Costs (mathematical functions)

- **Marginal cost (MC)**

➢ Linear function: first derivative of the total cost function with respect to output

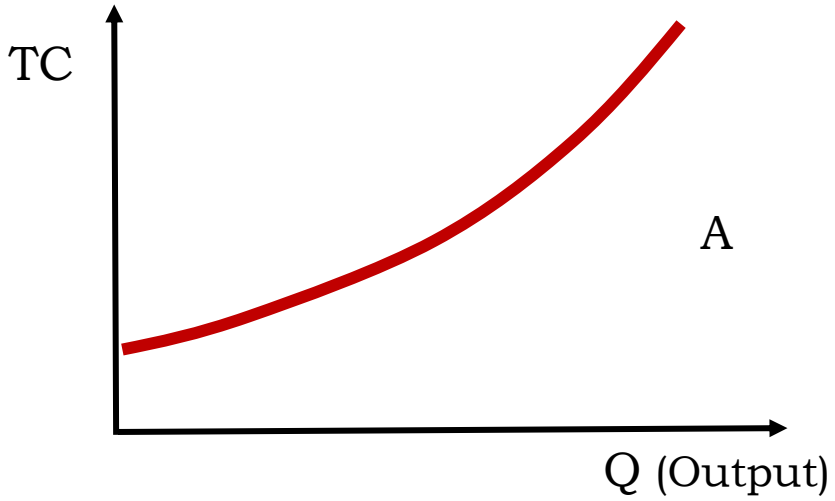
$$TC = \alpha + \beta Q \qquad \frac{\partial TC}{\partial Q} = MC = \beta$$

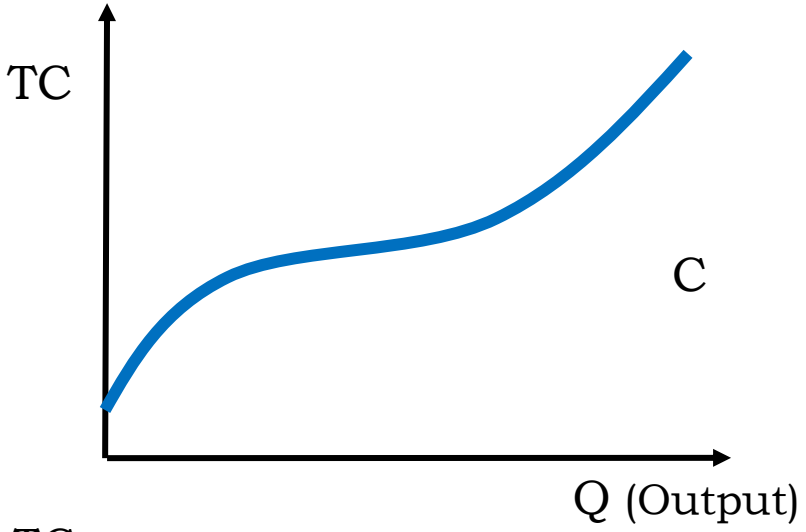
➢ Log-log function: first derivative of the total cost function with respect to output

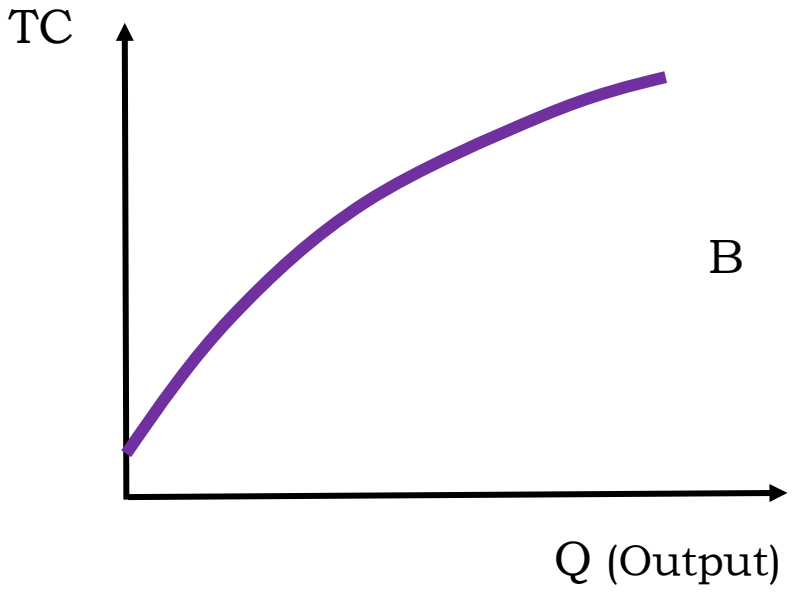
$$\ln TC = \alpha + \beta \ln Q \qquad \frac{\partial \ln TC}{\partial \ln Q} = \underbrace{\frac{\partial TC}{\partial Q}\frac{Q}{TC}}_{\text{Cost elasticity}} = \beta$$

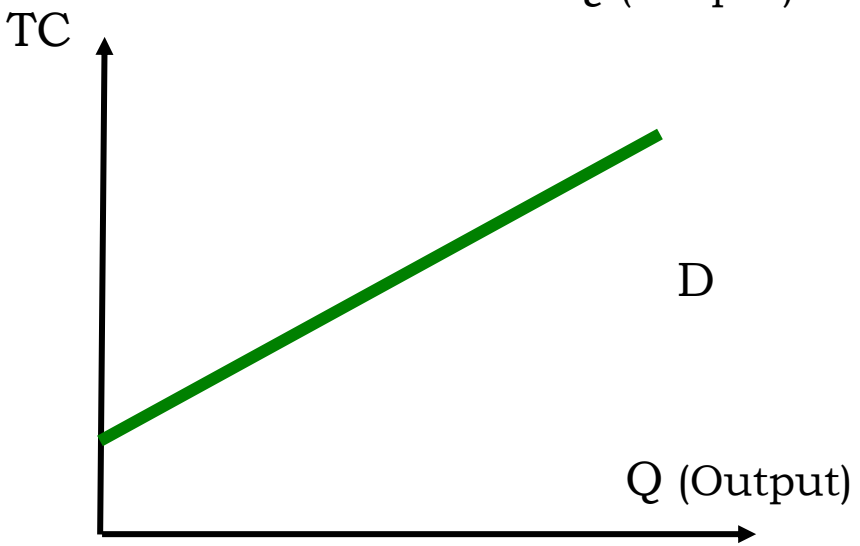
C. Cost Curves and their Shapes

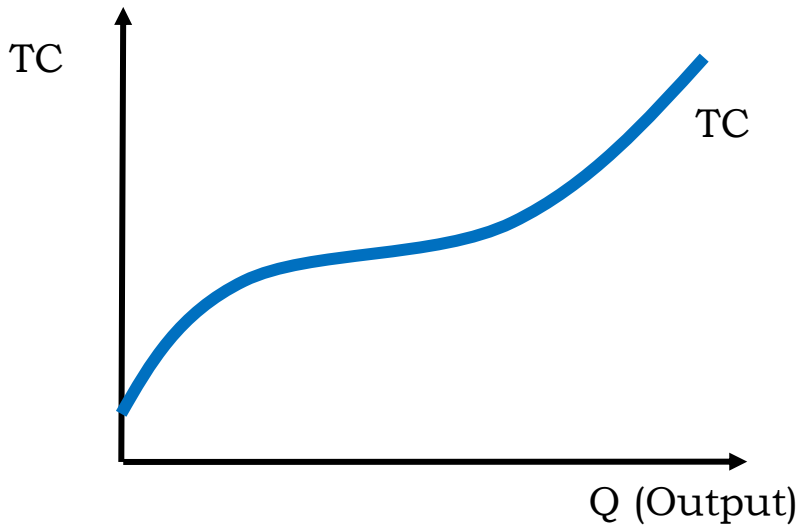
Different Shapes of the short run Total Cost Curve

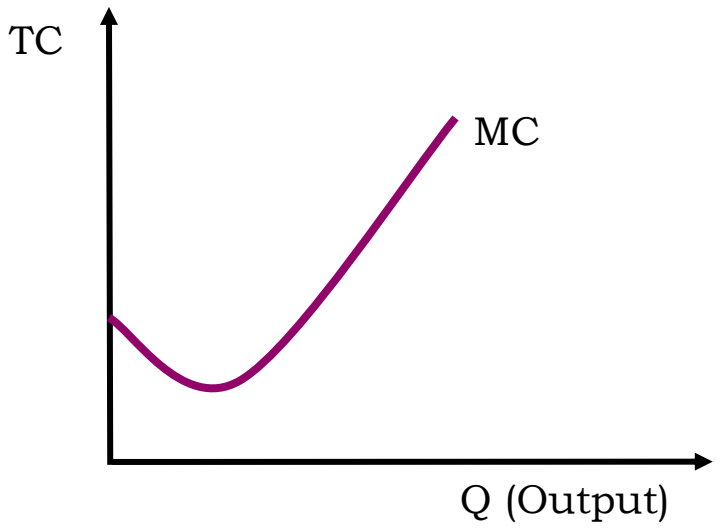






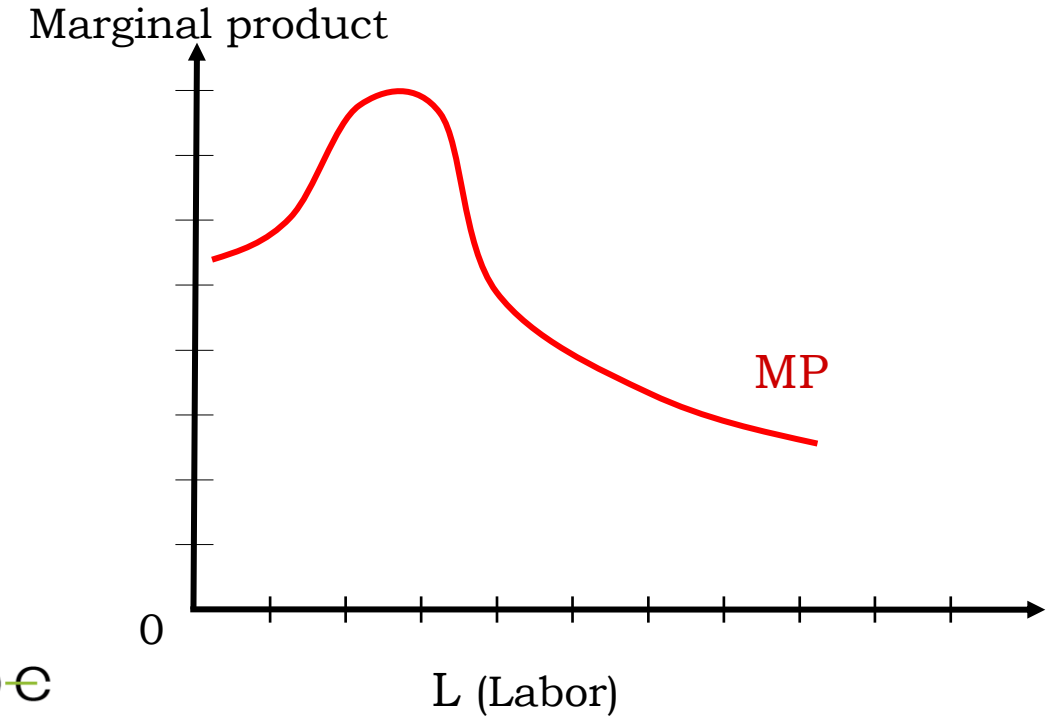


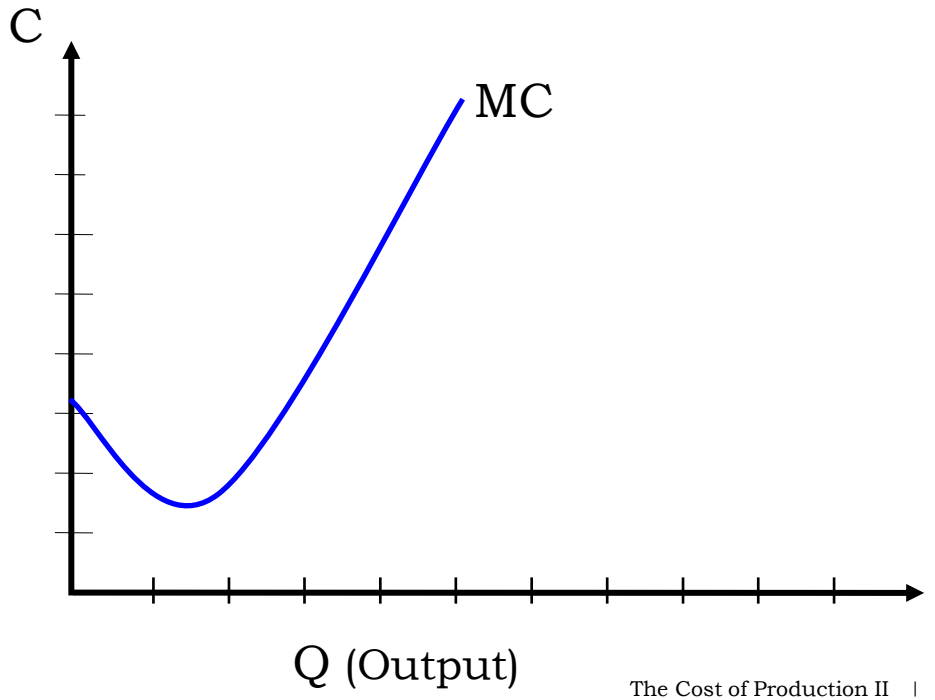

TC
TC
Q (Output)


TC
MC
Q (Output)

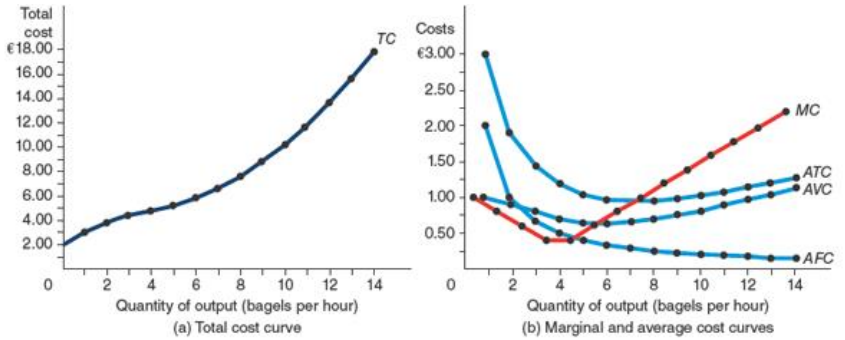
U-shaped Cost Curves

- In the short run, when factors such as capital are fixed, variable factors tend to show an initial phase of increasing marginal product (a firm is capable of engaging in specialization) followed by decreasing marginal product
- Decreasing marginal cost followed by increasing marginal cost





Bella's cost curves



Quantity of bagels (per hour) *Q*	Total cost (€) *TC = FC + VC*	Fixed cost (€) *FC*	Variable cost (€) *VC*	Average fixed cost (€) *AFC = FC/Q*	Average variable cost (€) *AVC = VC/Q*	Average total cost (€) *ATC = TC/Q*	Marginal cost (€) *MC = ΔTC/ΔQ*
0	2.00	2.00	0.00	—	—	—	
							1.00
1	3.00	2.00	1.00	2.00	1.00	3.00	
							0.80
2	3.80	2.00	1.80	1.00	0.90	1.90	
							0.60
3	4.40	2.00	2.40	0.67	0.80	1.47	
							0.40
4	4.80	2.00	2.80	0.50	0.70	1.20	
							0.40
5	5.20	2.00	3.20	0.40	0.64	1.04	
							0.60
6	5.80	2.00	3.80	0.33	0.63	0.96	
							0.80
7	6.60	2.00	4.60	0.29	0.66	0.95	
							1.00
8	7.60	2.00	5.60	0.25	0.70	0.95	
							1.20
9	8.80	2.00	6.80	0.22	0.76	0.98	
							1.40
10	10.20	2.00	8.20	0.20	0.82	1.02	
							1.60
11	11.80	2.00	9.80	0.18	0.89	1.07	
							1.80
12	13.60	2.00	11.60	0.17	0.97	1.14	
							2.00
13	15.60	2.00	13.60	0.15	1.05	1.20	
							2.20
14	17.80	2.00	15.80	0.14	1.13	1.27	

Source: Mankiw & Taylor (2023), "Microeconomics"

D. Costs in the Long Run

Costs in the Short and Long Run

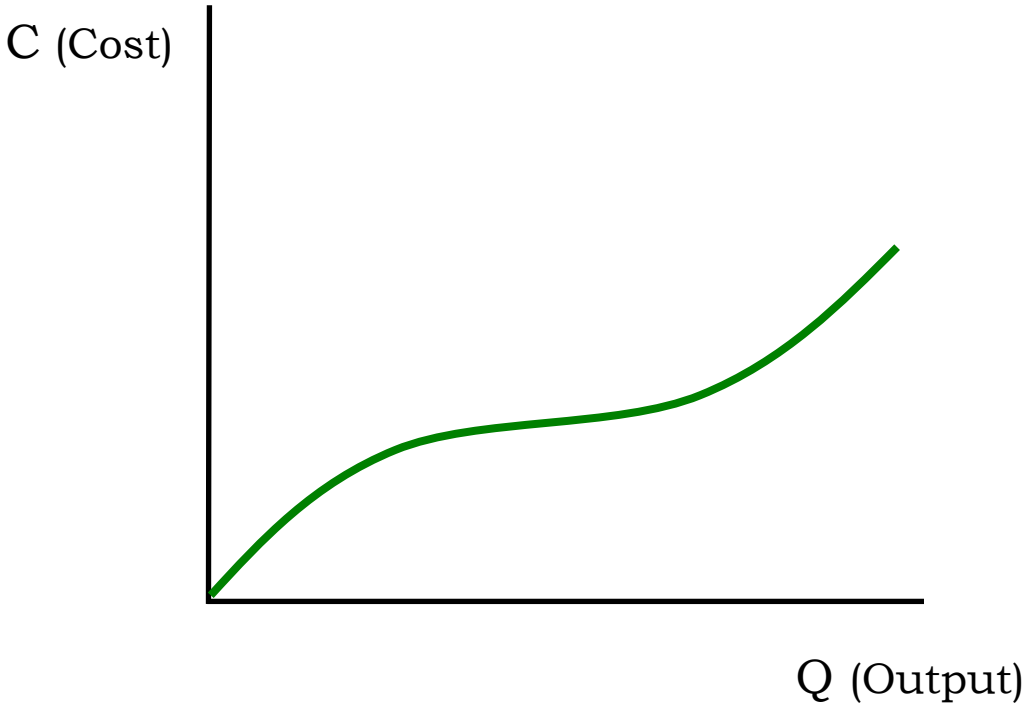
- For many firms, the division of total costs between fixed and variable costs depends on the **time horizon** being considered.

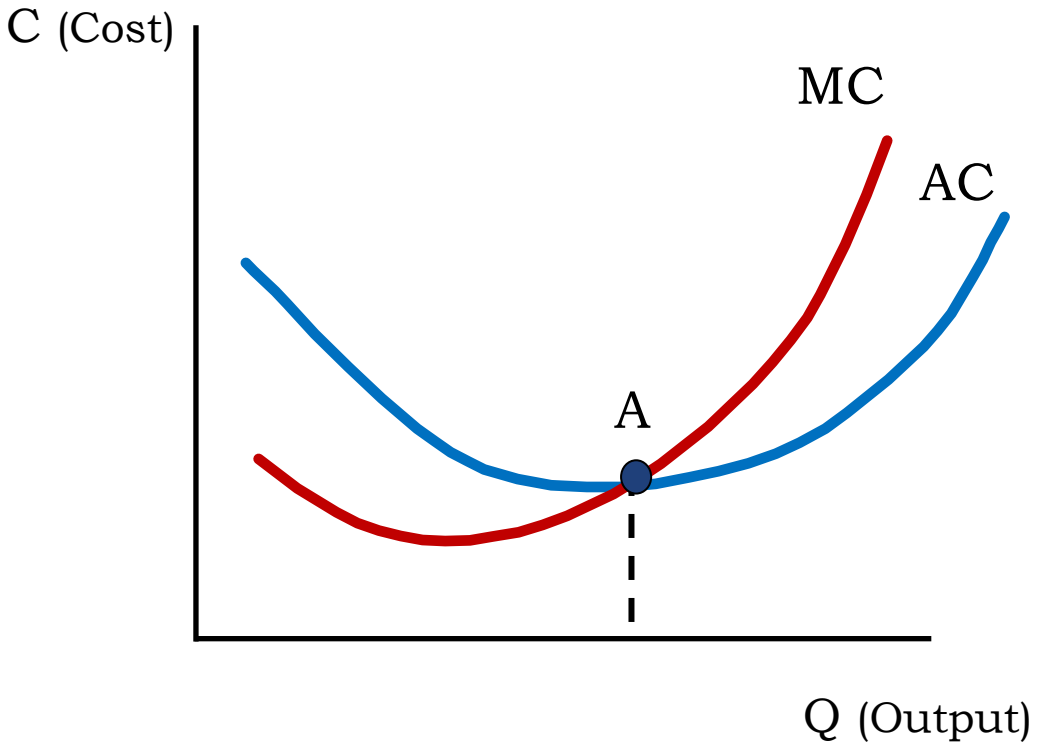
- In the **short run**, some costs are fixed.

- In the **long run**, fixed costs become variable costs.

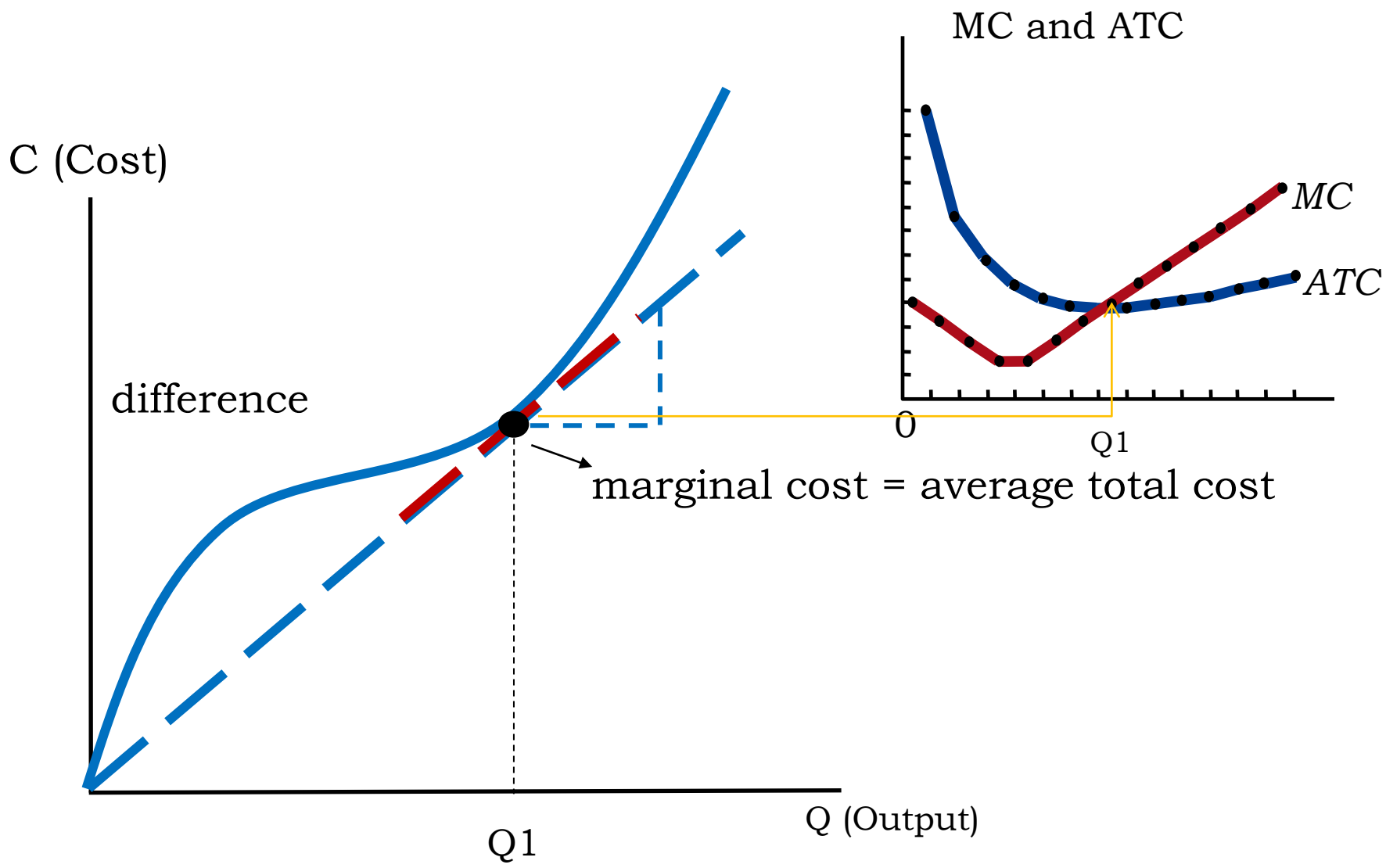
- **Because many costs are fixed in the short run but variable in the long run, a firm's long run cost curv differs from its short run cost curve.**

Total Costs in the Long Run



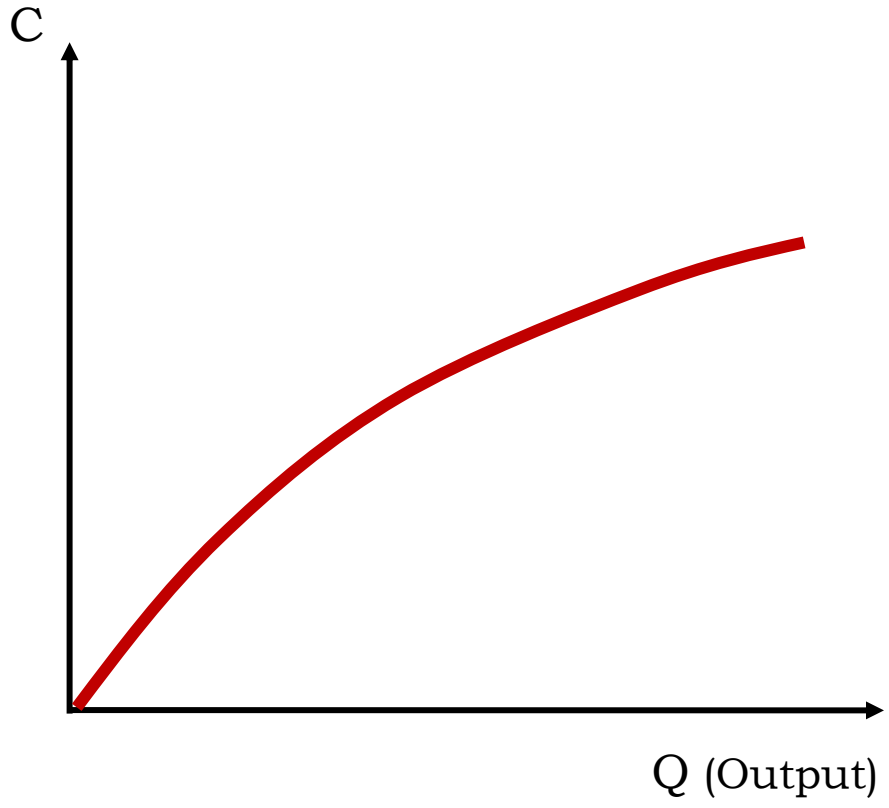


Cost Curves

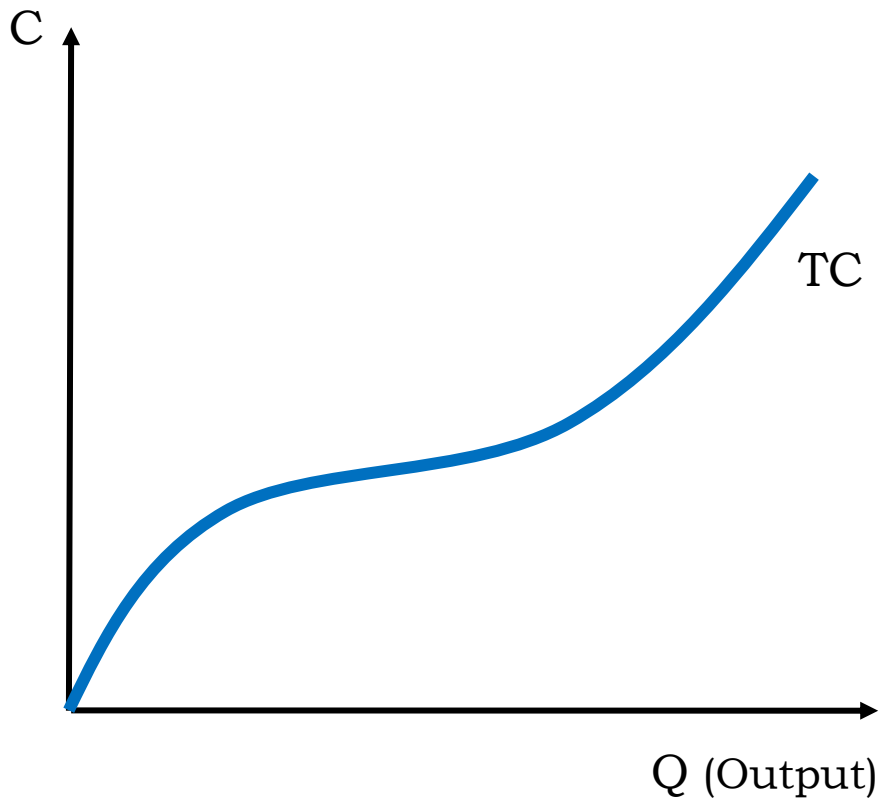

MC and ATC
MC
ATC
0
Q1
C (Cost)
difference
marginal cost = average total cost
Q1
Q (Output)

Different Shapes of the Total Cost Curve

Non-competitive markets

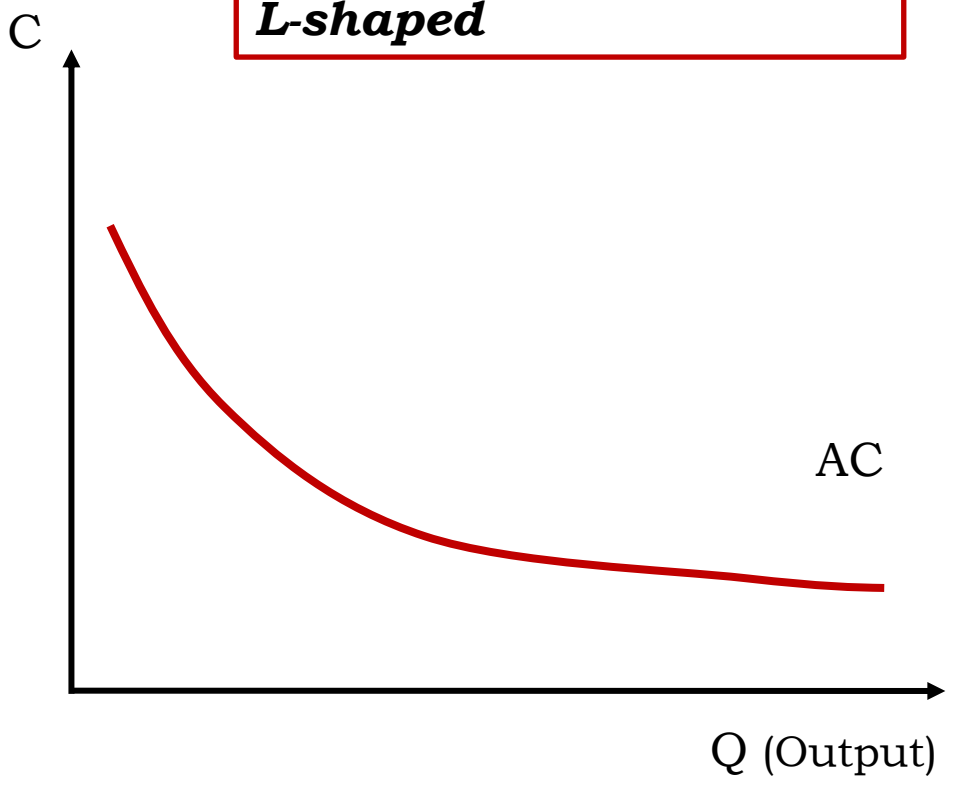


Competitive markets



Different Shapes of the Average Cost Curve

Non-competitive markets
L-shaped



Competitive markets
U-shaped

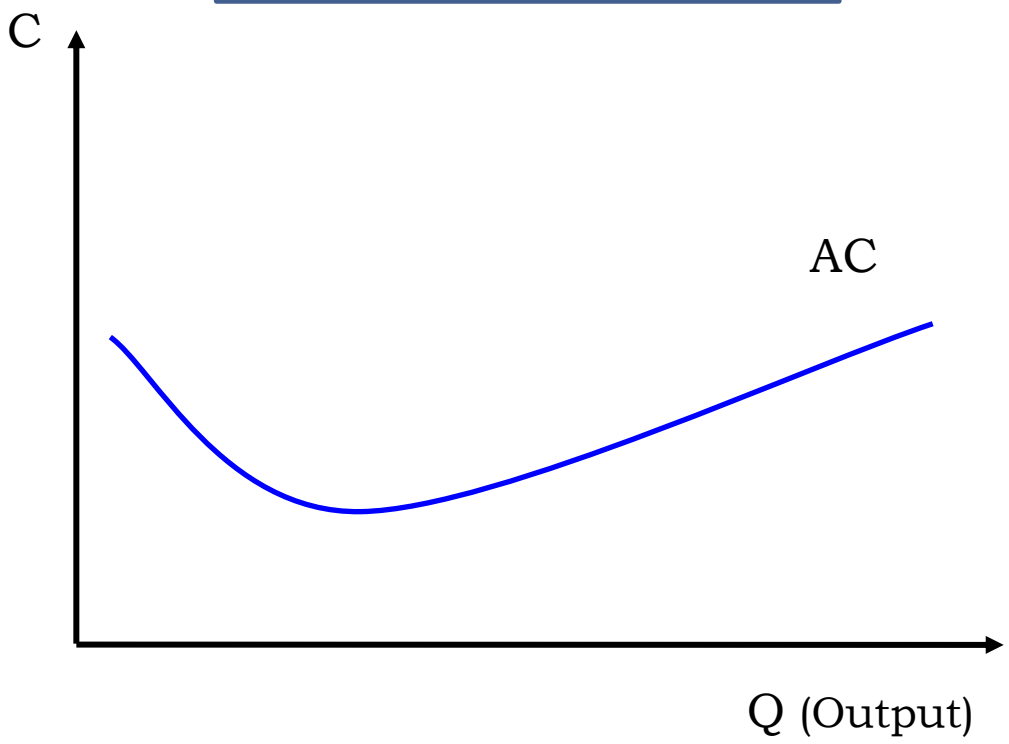


TABLE 5.3 The Many Types of Cost: A Summary

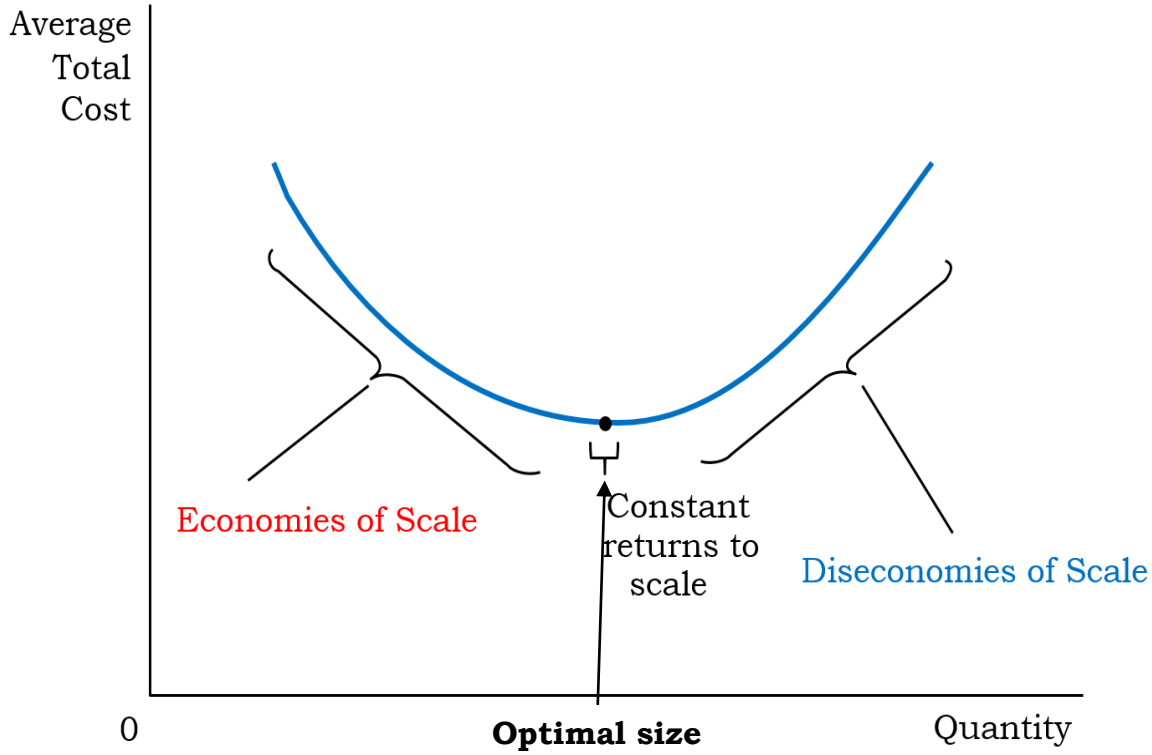
Term	Definition	Mathematical description
Explicit costs	Costs that require an outlay of money by the firm	—
Implicit costs	Costs that do not require an outlay of money by the firm	—
Fixed costs	Costs that do not vary with the quantity of output produced	FC
Variable costs	Costs that vary with the quantity of output produced	VC
Total cost	The market value of all the inputs that a firm uses in production	$TC = FC + VC$
Average fixed cost	Fixed costs divided by the quantity of output	$AFC = FC/Q$
Average variable cost	Variable costs divided by the quantity of output	$AVC = VC/Q$
Average total cost	Total cost divided by the quantity of output	$ATC = TC/Q$
Marginal cost	The increase in total cost that arises from an extra unit of production	$MC = \Delta TC/\Delta Q$

Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 5, p. 116

E. Economies of Scale and Scope

Economies and Diseconomies of Scale

- **Economies of scale** refer to the property whereby long run average total cost falls as the quantity of output increases.
- **Diseconomies of scale** refer to the property whereby long run average total cost rises as the quantity of output increases.
- **Constant returns to scale** refers to the property whereby long run average total cost stays the same as the quantity of output increases



Source: Mankiw & Taylor (2020), "Microeconomics", Chapter 5, p. 115

Reasons for Economies of Scale

Possible reasons for declining average cost when output increases:

- Large initial investments in production capacity;
- **Transaction cost** does not increase proportionately with output;
- If the firm operates on a larger scale, **workers can specialize** in the activities in which they are most productive.

Economies and Diseconomies of Scale

$$\mathbf{ES} = \frac{1}{\textit{Cost elasticity}} = \frac{1}{\frac{\partial TC}{\partial Q}\frac{Q}{TC}}$$

- ES>1: economies of scale
- ES<1: diseconomies of scale
- ES=1: constant returns to scale

$$ln\,TC = \alpha + \beta \ln Q \qquad \frac{\partial\, ln\, TC}{\partial\, ln\, Q} = \beta = \frac{\partial TC}{\partial Q}\frac{Q}{TC}$$

$$ln\,TC = 2 + 0.5 lnQ$$

$$\mathbf{ES} = \frac{1}{\frac{\partial TC}{\partial Q}\frac{Q}{TC}} = \frac{1}{0.5} = 2$$

The Intuition Behind the Estimation of a Cost Function with Econometric Methods (Bus Companies Operating in Switzerland, N=57)

	N	r	q	ct	lnTC	lnQ	lnN
1	1	7100	34	207	5.332719	3.526361	8.86785
2	2	13000	53	278	5.627621	3.970292	9.472705
3	3	64000	583	824	6.71417	6.368187	11.06664
4	4	34400	177	934	6.839477	5.17615	10.44581
5	5	14000	92	331	5.802118	4.521789	9.546813
6	6	13500	63	305	5.720312	4.143135	9.510445
7	7	25800	149	780	6.659294	5.003946	10.15813
8	8	40500	208	1577	7.36328	5.337538	10.60906
9	9	37500	153	768	6.64379	5.030438	10.5321
10	10	20800	124	989	6.896694	4.820282	9.942708
11	11	36200	219	925	6.829794	5.389072	10.49681
12	12	35000	596	3231	8.080547	6.390241	10.4631
13	13	632600	4357	24110	10.09038	8.379539	13.35759
14	14	144000	259	1550	7.34601	5.556828	11.87757
15	15	23000	98	965	6.872128	4.584968	10.04325
16	16	2100	8	65	4.174387	2.079442	7.649693
17	17	25000	197	953	6.859615	5.283204	10.12663
18	18	40860	405	2350	7.762171	6.003887	10.61791

$$lnTC=\alpha + \beta 1\ lnQ + \beta 2\ lnN + \varepsilon$$

Data collection process

Econometric analysis

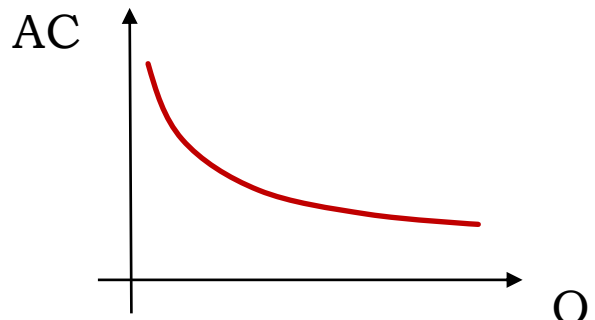
```
. reg lnTC lnQ lnN
```

Source	SS	df	MS		
Model	98.6619084	2	49.3309542	Number of obs	= 57
Residual	11.3499543	54	.21018434	F(2, 54)	= 234.70
				Prob > F	= 0.0000
				R-squared	= 0.8968
				Adj R-squared	= 0.8930
Total	110.011863	56	1.96449755	Root MSE	= .45846

lnTC	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnQ	.8941298	.0735741	12.15	0.000	.7466225	1.041637
lnN	.0814724	.1003221	0.81	0.420	-.1196612	.282606
_cons	1.464106	.7450593	1.97	0.055	-.029648	2.95786

$$\text{lnTC}= 1.464 + 0.894\ lnQ + 0.081\ lnN$$

ES = 1.12



Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Energy Conversion, Transportation/Transmission, and Storage

Scale economies and optimal size in the Swiss gas distribution sector

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HIGHLIGHTS

- Presence of unexploited scale economies for small and medium sized companies.
- Scale economies vary considerably with customer density.
- Higher density or greater complexity is associated with lower optimal size.
- Optimal size varies across the companies through unobserved heterogeneity.
- Firms with low density can gain more from expanding firm size.

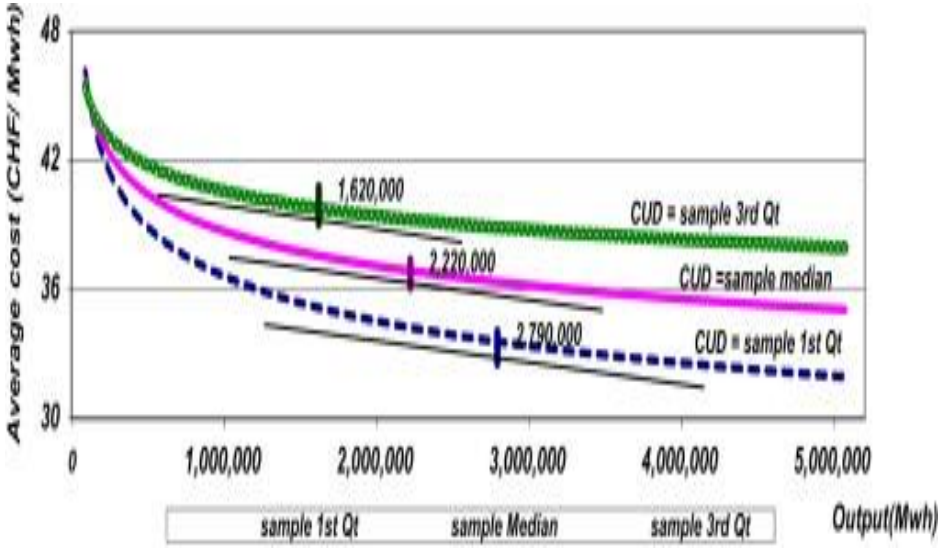
ARTICLE INFO

Article history:
Received 3 October 2012
Received in revised form
30 August 2013
Accepted 7 September 2013

Keywords:
Gas distribution
Unobserved heterogeneity
Scale economies
Optimal size

ABSTRACT

This paper studies the cost structure of Swiss gas distribution utilities. Several econometric models are applied to a panel of 26 companies over 1996–2000. Our main objective is to estimate the optimal size and scale economies of the industry and to study their possible variation with respect to network characteristics. The results indicate the presence of unexploited scale economies. However, very large companies in the sample and companies with a disproportionate mixture of output and density present an exception. Furthermore, the estimated optimal size for majority of companies in the sample has shown a value far greater than the actual size, suggesting remarkable efficiency gains by reorganization of the industry. The results also highlight the effect of customer density on optimal size. Networks with higher density or greater complexity have a lower optimal size.



Economies of Scope

- Most companies do not offer just one single product but a wide range of products → from multi-product firms.
- If the joint output of a single firm is greater than the output that could be achieved by two different firms when each produces a single product, we speak of **economies of scope.**
- If the cost of producing two outputs by one firm is lower than the cost of producing one output with a firm and the other with another, **we have economies of scope**.

$$SC = \left(\frac{C(Q_1) + C(Q_2) - C(Q_1, Q_2)}{C(Q_1, Q_2)} \right)$$

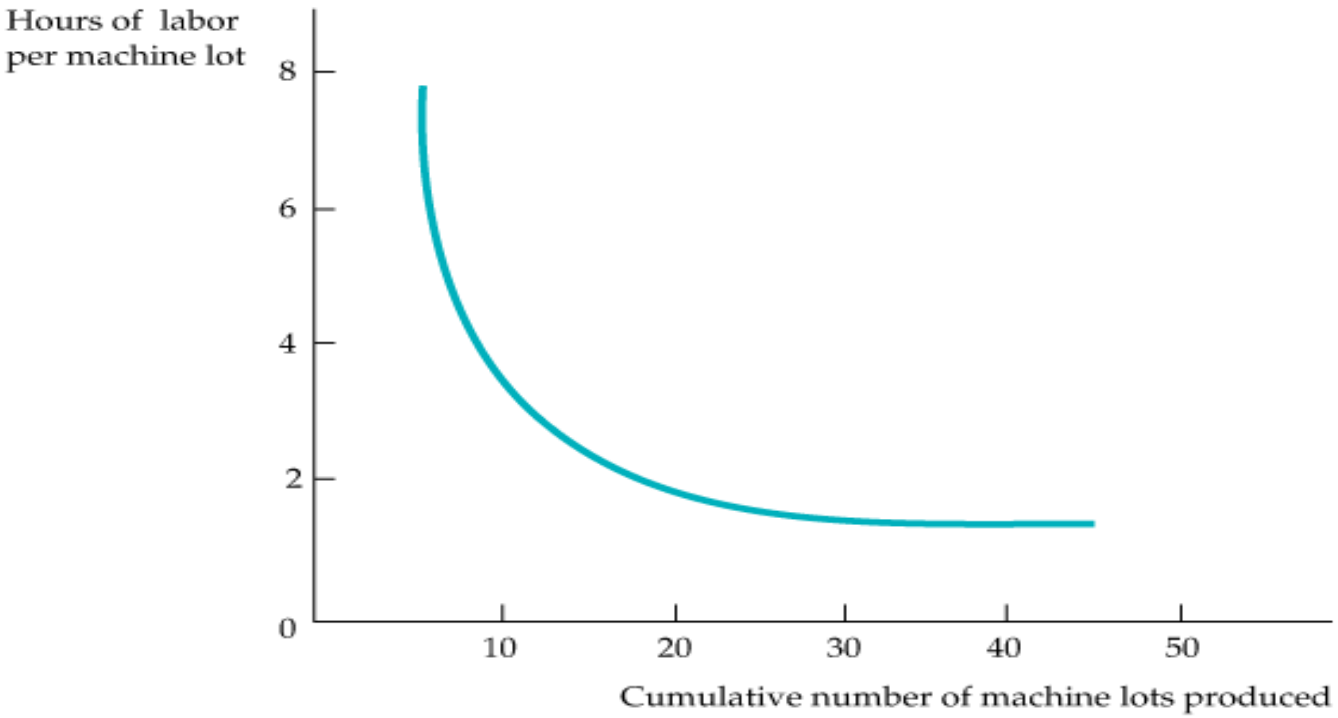
$$SC > 0 \text{ economies of scope}$$

Reasons for Economies of Scope

- Joint production → better utilization of inputs (some inputs can be shared)
- Better load factor on machines because of product differentiation
- Better utilization of labor because of product differentiation
- Risk diversification in fields of R&D

F. Learning Curve

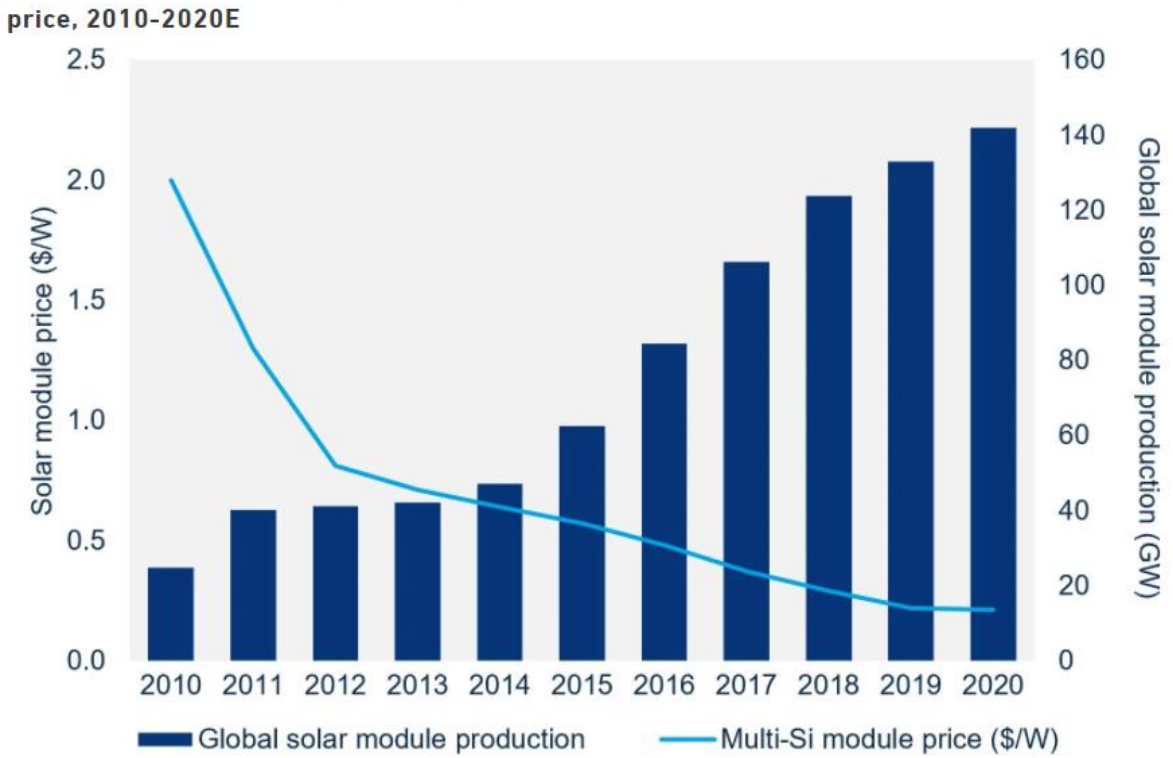
Learning Curve and Economies of Scale



Source: Pindyck & Rubinfeld (2018), "Microeconomics", Chapter 7, p. 271

A firm's production cost may fall over time as **managers and workers become more experienced and more effective** at using the available plant and equipment. The learning curve shows the extent to which hours of labor needed per unit of output fall as the cumulative output increases.

Learning and Scale Effects



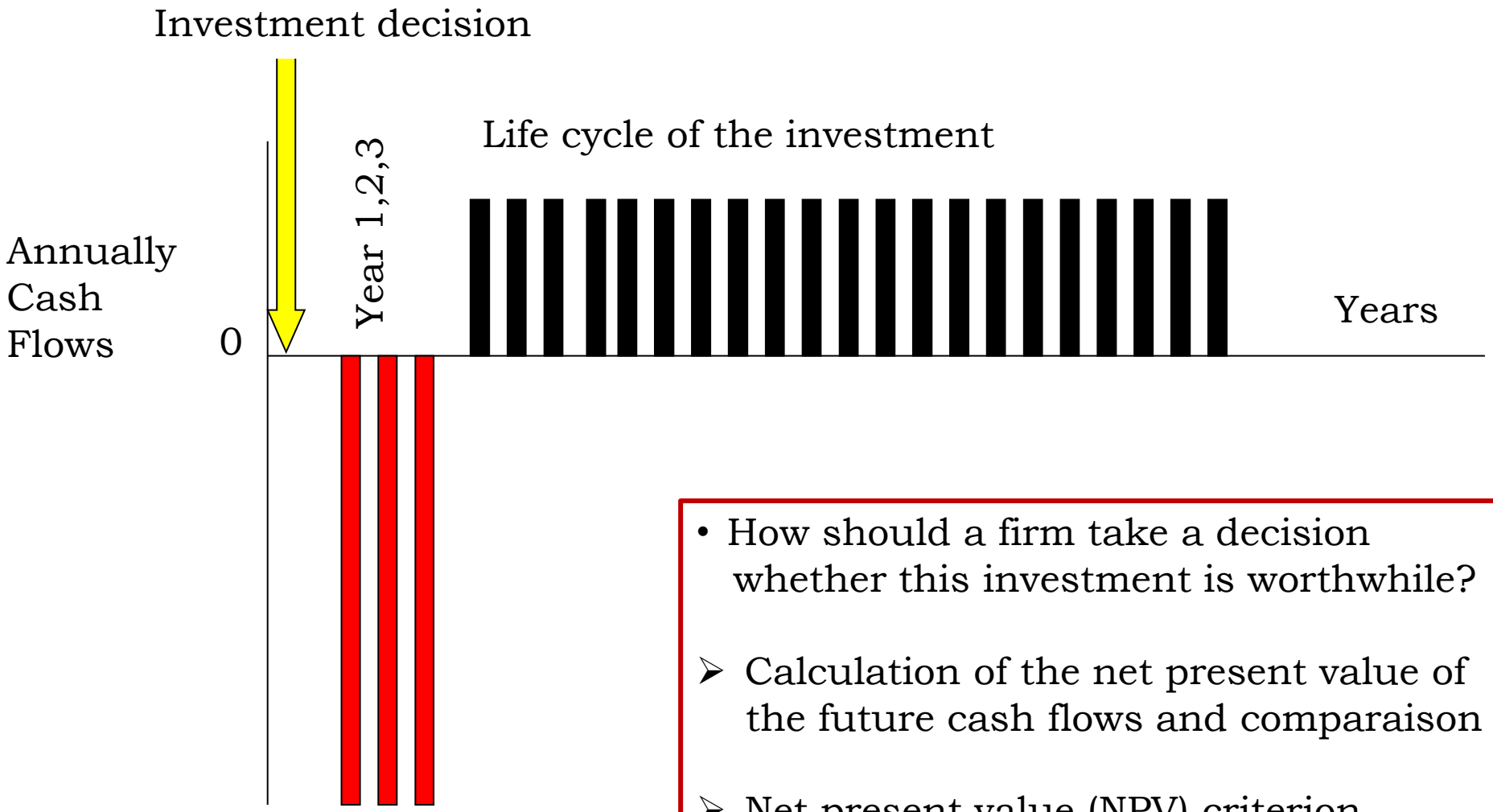
Source: Wood Mackenzie

G. The Investment Selection Process

The Investment Selection Process

- Investment: production of good or acquisition of a good or an asset that will be used to produce other goods
  - ➢ consumer goods such as vegetables and investment goods such as machines
- Investments show **benefits and costs over a long period of time**
- Investment analysis can be done by
  - ↳ **Firms**
  - ↳ **Households** (Building a new house, buying a car, go to the university,…)
  - ↳ **State** (building a new road, a park, a tunnel…)
- From the society point of view, all costs and benefits should be considered (external costs and external benefits)

Investment and Cash Flows (firm perspective)



- How should a firm take a decision whether this investment is worthwhile?

➢ Calculation of the net present value of the future cash flows and comparaison with the cost

➢ Net present value (NPV) criterion

Cash Flow Analysis for an investment project

Simplified example (no income tax)

		2000	2001	2002	2003	2004	2005	2006
1	Capital Expenditures	-205	-95	0	0	0	0	0
	Buildings	-120	0	0	0	0	0	0
	Equipment	-85	-95	0	0	0	0	0
2								
	Revenues	0	0	160	200	210	215	215
	Costs	0	0	108	110	110	110	110
4	Net cash flow	-205	-95	52	90	100	105	105

Evaluating Investment Projects

Net Present Value

$$NPV = \sum_{t=1}^{n} \frac{F_t}{(1+i)^t} - IV$$

F_t: Net cash flow in year t

IV: Investment in year 0

i: Discount rate

- We can think of i as the firm's *opportunity cost of capital* ➔ rate of return that one could earn by investing in alternative projects with similar risk
- We need a discount rate because revenues and costs accrue at different dates

- Numbers in the calculation may be in real or nominal terms, as long as they are consistent.

Time Value of Money

- Discount factor: interest rate used to determine the present value of future incomes/cash flows

$$\text{Discount factor} = \frac{1}{(1+i)^t}$$

- Where: i =discount rate; t =years

- The fundamental procedure used by economists is based on the premise that 1 franc today is worth more than 1 franc tomorrow.

  - ***Capital productivity argument***: capital is productive; today's Franc can be invested in the most profitable alternative to obtain a gain; the foregone gain in case of not investing in the most profitable alternative is called the **opportunity cost** ➔ Application of a discount factor (a number less than 1)

Present Value of a Project (discount rate)

- Investments with future cash flows that are certain: risk-free interest rate

➢ ***i*** = *risk free return* (for example interest rate on government bond)

- Investments with future cash flows that are not certain:

➢ ***i*** = *risk free return* + *risk premium*

➢ Risk premium calculated with the Capital asset pricing model

The **WACC (**weighted–average cost of capital, or “company cost of capital”)

To finance a project a firm can use **equity capital**, **debt capital** or a combination. With a combination then firms tend to use in the computation of the NPV the weighted average cost of capital (WACC)

$$\mathbf{WACC} = \mathbf{w_e} * \mathbf{i_e} + \mathbf{w_d} * \mathbf{i_d}$$

where:

w_e = Percentage of Financing from Equity
i_e = Cost of Equity
w_d = Percentage of Financing from Debt
i_d = Cost of Debt

Most challenging parts of an investment analysis

- Most challenging parts of the analysis:
- estimate the future cash flows, e.g. estimate the future revenues and costs …oil price in 20 years?
- Select the discount rate (*risk free return* + *risk premium*)

Investment decisions by consumers

- To make the right investment decision, consumers also must calculate **PDV (Present Discounted Value) of the cost** of buying and operating a product a by assuming a lifetime of n years and no sale with the following formula.

$$\text{PDV} = P_a + OC_a + \frac{OC_a}{(1+i)^1} + \frac{OC_a}{(1+i)^2} + \ldots + \frac{OC_a}{(1+i)^n}$$

P_a is the purchase price of the product

OC_a is the average annual operating cost of the product

- For the discount factor, the consumer should apply the same approach used by firms: the discount rate i is the opportunity cost of capital

Discounting in investment analysis

- From a consumers point of view two arguments for discounting future benefits and costs (*Time value of money*)

  - ***Time preference argument*:** people prefer to spend now rather than later (consumers are generally "impatient" ; risk of becoming ill or dying and not being able to enjoy next year's income).

  - ***Capital productivity argument***: capital is productive; today's Franc can be invested in the most profitable alternative to obtain a gain; the foregone gain in case of not investing in the most profitable alternative is called the **opportunity cost.**