Transport costs

EE382

- The theory of production
- Definitions of technical, cost, and allocative efficiency
- How time is divided in economics
- How transport costs behave in the short and long runs
- Returns to scale and economies of scale in the transport industries
- The relevance of production costs to the supply of transport services

Introduction

Transport costs fall into a variety of different classes

- Costs that impact on the individual user of a particular mode of transport who directly benefits from undertaking a journey known as Private costs
  - The fare in the case of public transport (financial costs)
  - The time involved in undertaking the journey (non financial costs)

- The costs of transport that fall on nonusers of the transport service who do not benefit from the transport service such as polluted air, congested road, noise and visual intrusions – refer to as public costs

- Production costs fall on the operators of a transport service or in the case of private transport the financial costs incurred when undertaking the activity

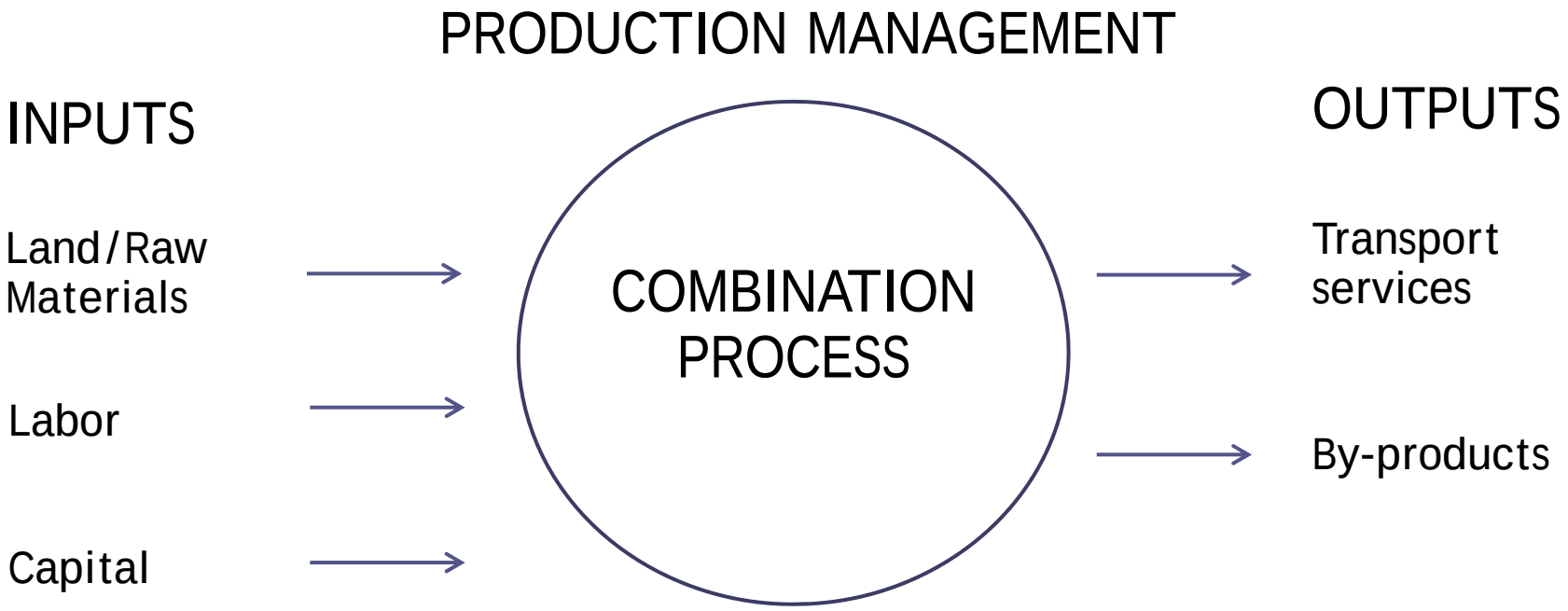
The efficient production of transport services

- In order to measure the output of the transport firm, such " service units" need to be quantitatively defined
  - What are transport operators actually attempting to achieve?
    - Move people from A to B
    - The output would be measured in terms of the number and level of services produced- could be expressed in terms of vehicle kilometers

Factors of production

- Land – All the natural raw materials and physical land
- Labor- Workers
- Capital- All man-made resources required for production
- Entrepreneurship – the risk-taking involved in establishing a production process

The production process



The production function

$$Q = f(A, L, K)$$

Q = quantity of output produced

A = quantity of land and raw materials used in the production process

L = quantity of labor used in the production process

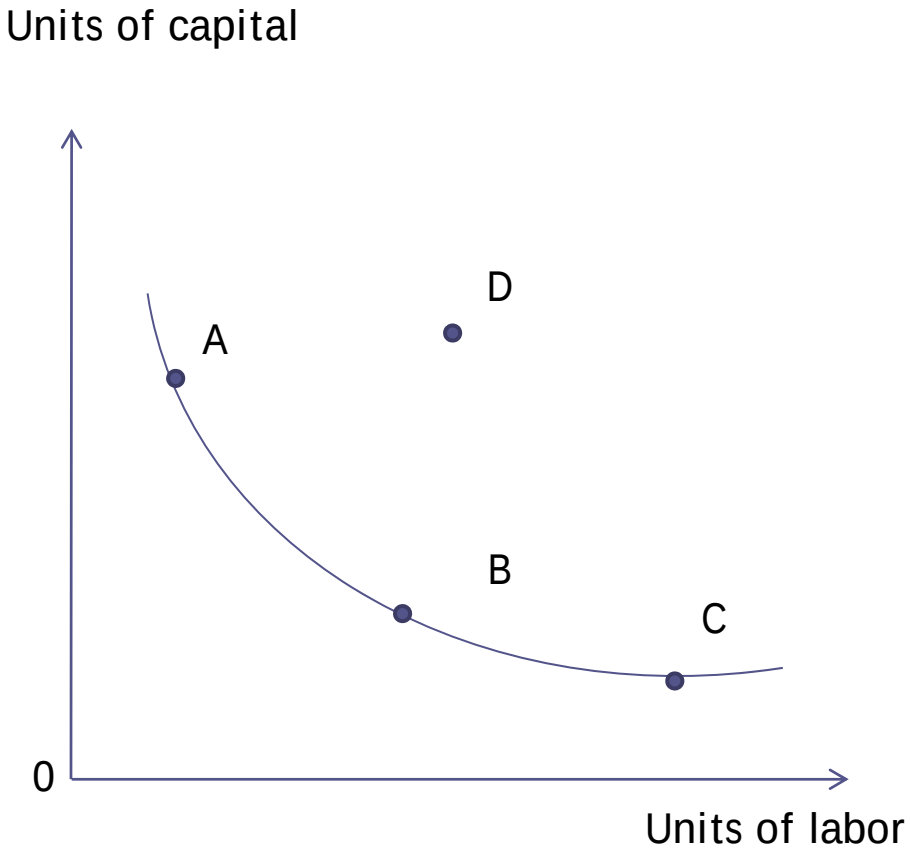
K = quantity of capital used in the production process

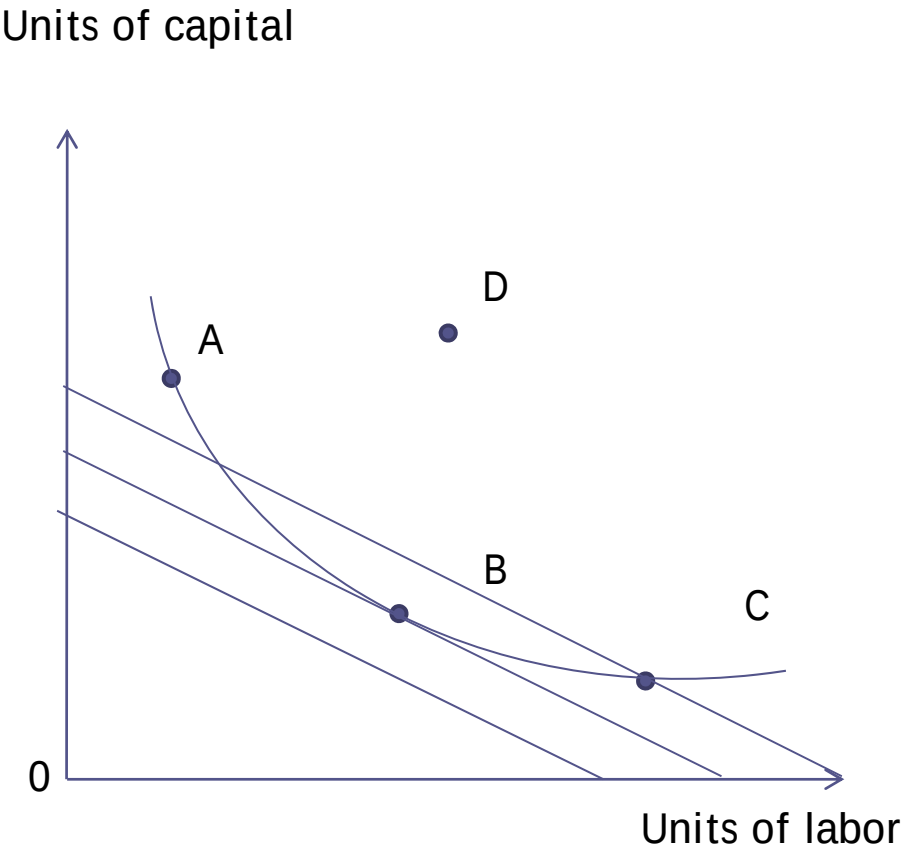
- Technical efficiency
  - The outputs to inputs ratio
  - Use minimum level of inputs to produce the maximum level of outputs

- Cost efficiency
  - Productive efficiency
  - The relative prices of labor and capital are examined and the one that produces the lowest cost combination deemed to be the best or more exactly the most cost efficient

- Allocative efficiency
  - Goods and services are produced cost efficiently and in the right quantities

Technical and cost efficiency





The economist's definition of time

The short run

- Period of time during which at least one of the factors of production is fixed

- Variations in the level of output can only be achieved through variation in one or more of the other inputs, normally labor

The long run

- Variations in the level of output can be achieved through variation of all of the outputs, thus the firm is not restricted to using only one of them

- Capital can be expanded

The very long run

- Period of time where all factors of production are variable, including the level of technology

- Production levels that are not possible today may be possible in the very long run due to an increase in the level of technology

Classification of costs

Fixed costs

- Input costs that are sometimes classified as ‘indivisibles’ or unavoidable costs
- Costs must be paid even if no output is produced or service provided and cannot be divided or bought in parts, e.g. you cannot purchase half an aircraft or bus
- Rents, depots, and stations

Variable costs

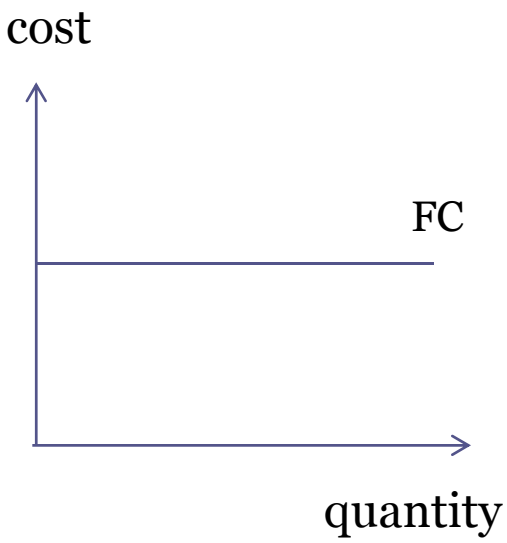
- Costs that changes as the level of output changes
- the wages of employees, fuel costs, power and electricity for heat and light

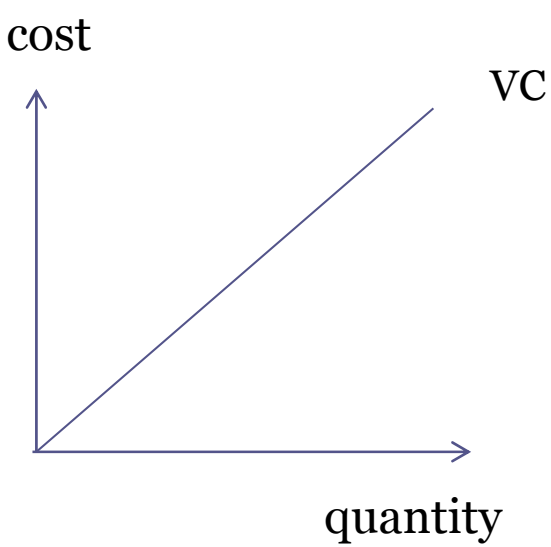
Semi-variable costs

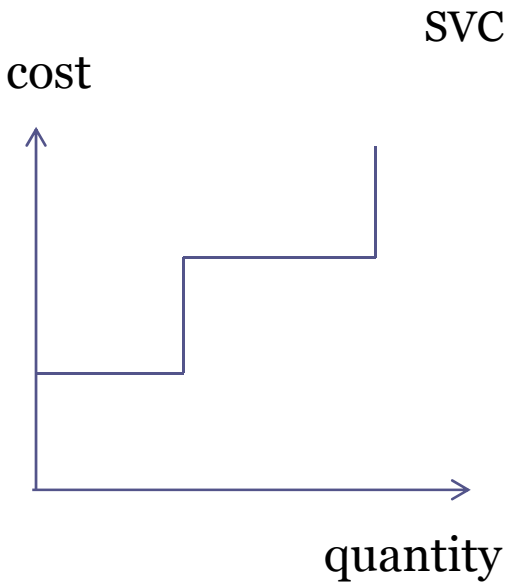
- Costs that are fixed over a certain range of output, but then change once the upper limit of that range is reached

- The road-haulage company may be about to make up to ten deliveries a day using three drivers, but to then make an eleventh delivery it may need to employ another driver – Labor cost was fixed up until ten deliveries a day and then jumped to a new rate for additional deliveries

The type of costs







Cost structure of the main mode of transport

	Fixed costs	Variable costs	Semi-variable costs
Car	• Capital outlay • Insurance • Road tax • Depreciation	• Petrol • Oil • Wear and tear	• Component parts such as tires and batteries
Train	• Capital outlay • Track costs • Insurance • Basic Admin. Charges	• Fuel • Wear and tear	• Components • Labor costs
Aeroplane	• Capital outlay • Insurance • Basic Admin. Charges	• Fuel • Wear and tear • Landing fees • In flight provisions • Air passenger duty (UK)	• Components • Labor costs
Bus	• Capital outlay • Insurance • Basic Admin. Charges	• Fuel • Wear and tear • Licenses	• Components • Labor costs
Sea	• Capital outlay • Insurance • Basic Admin. Charges	• Fuel • Wear and tear • Harbor fees • In-voyage provisions	• Components • Labor costs

Classification of costs according to their scale

Total cost- All of the costs are added up

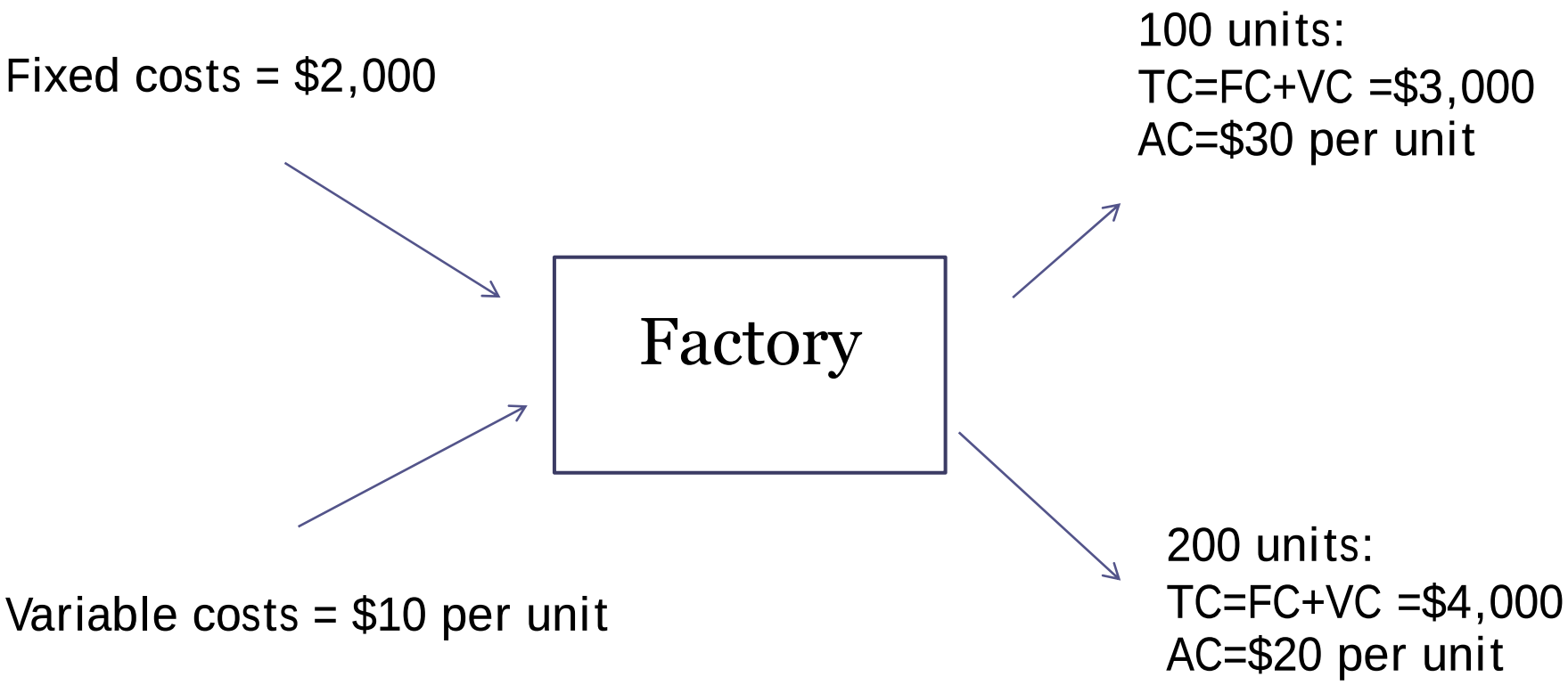
Average cost – the cost for each unit of output produced

$$AC = \frac{TC}{Q}$$

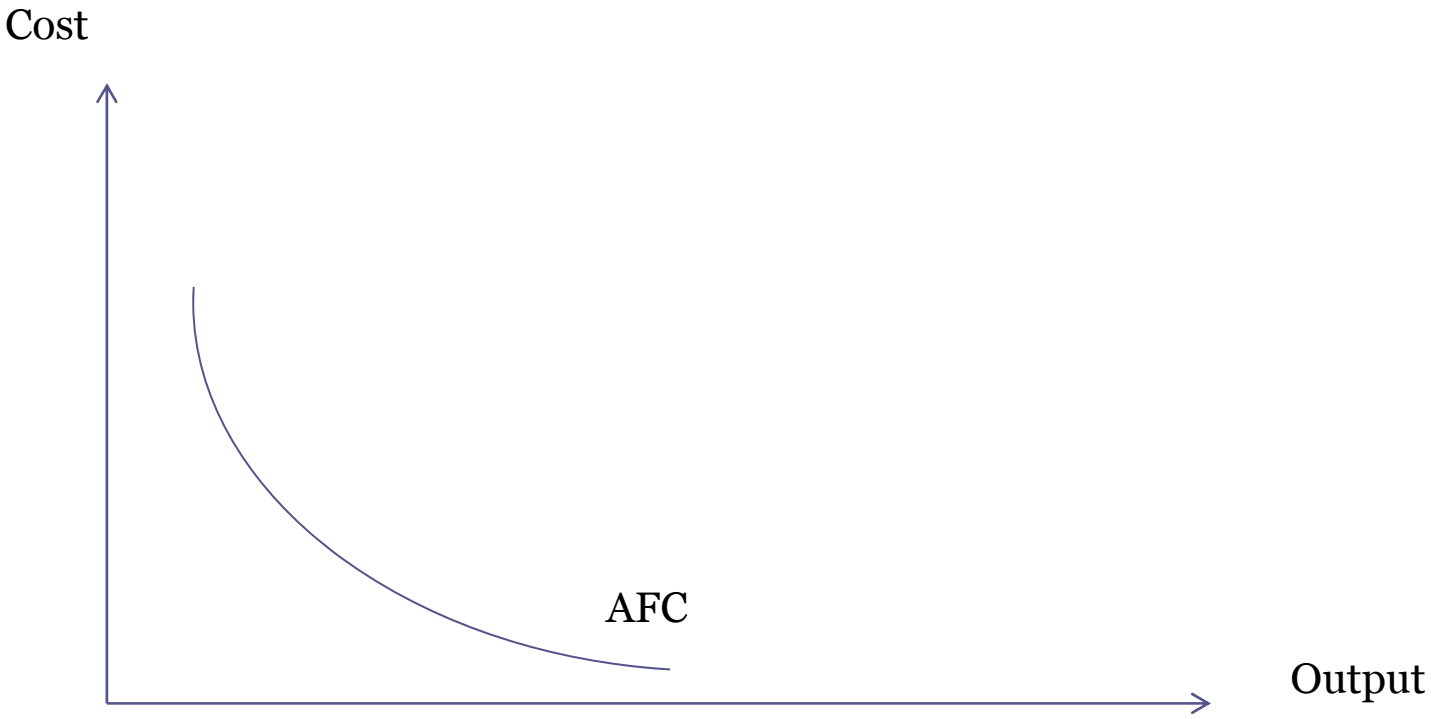
Average cost in the short run

- As output increases, average fixed cost falls

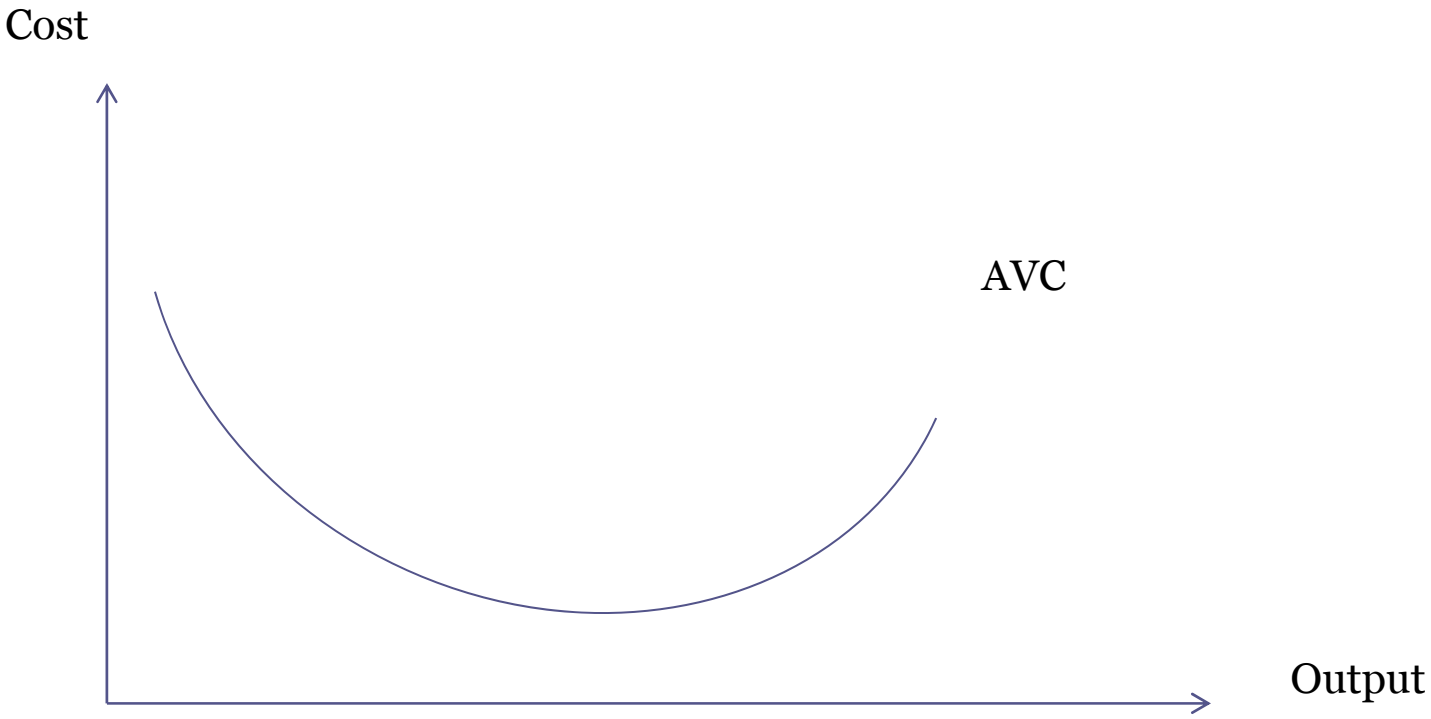
The reduction of the average fixed costs



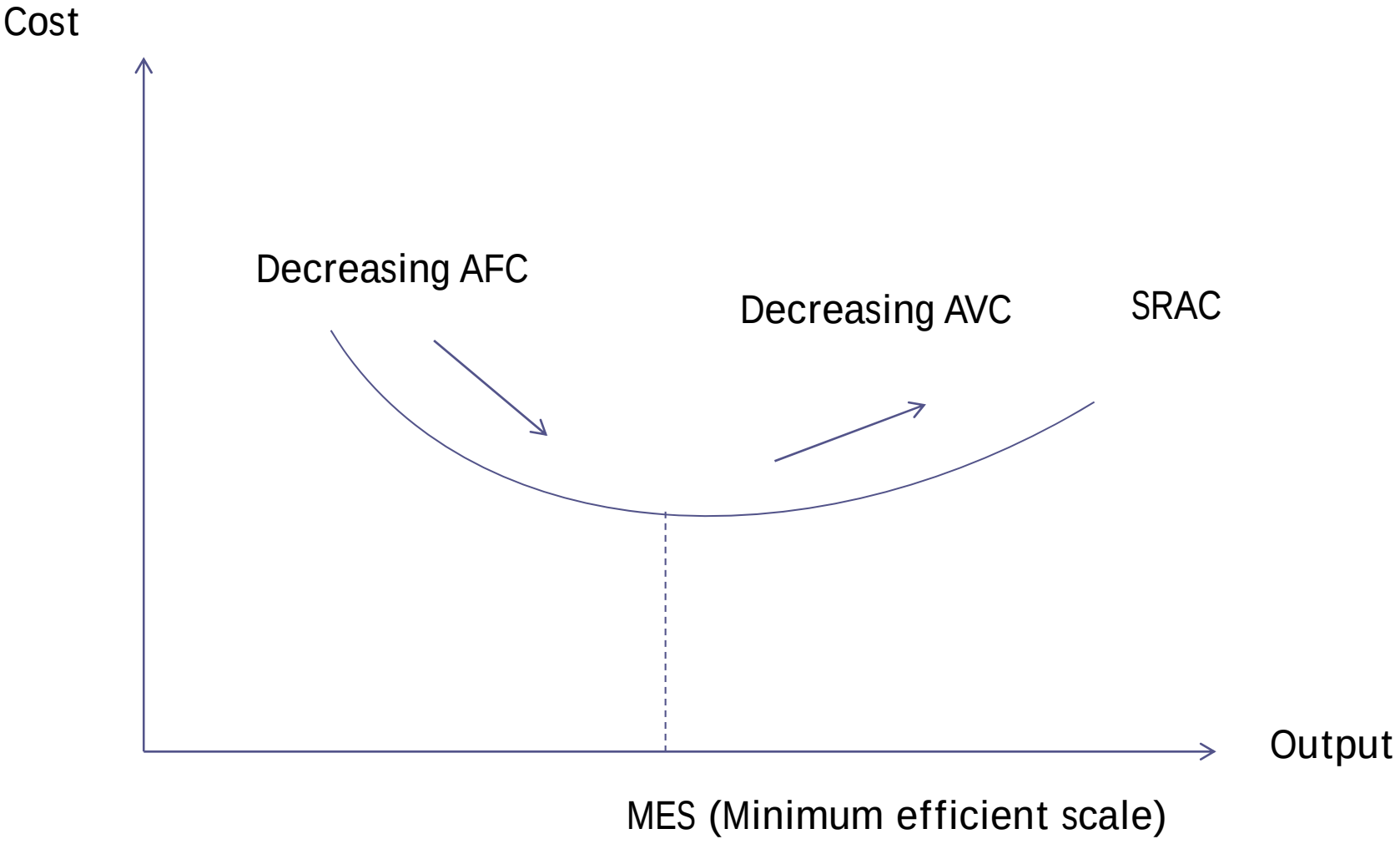
The short run AFC curve



The short run AVC curve



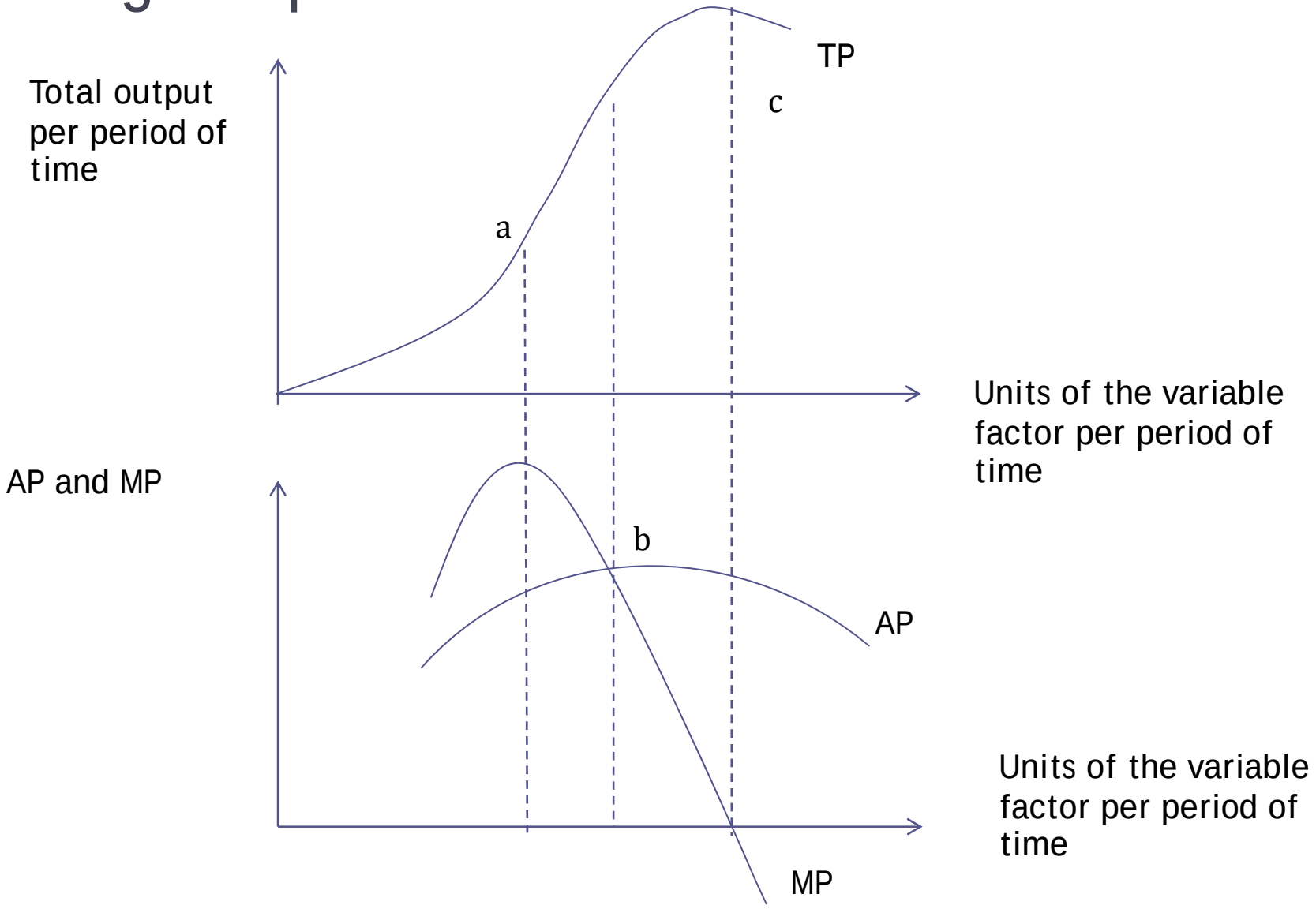
The SRAC curves



Cost and production in the short run

- One input is varied to produce variations in the level of output
- The average product is simply the total product divided by the number of units of the variable factor
- The marginal product is the change in the total product that results from adding one more unit of the variable factor into the production process

Short run production, total, average, and marginal product



The main issue to consider here is the shape and relative positions of these three curves

- Total product curve -S shape –
  - As more units of labor are added to the fixed amount of capital, production not only increases but increases at an increasing rate (up to point a) – is the point of the highest MP
  - Beyond point a – as more of the variable factor is added production still rises, but at a decreasing rate, reaching the highest point of AP curve at point b before eventually total product declines after point c
  - This tailing off effect after point a is known as the law of diminishing marginal returns

- Stage 1 production
  - MP is always increasing – TP is increasing at a rising rate
- Stage 2 production
  - Diminishing marginal returns
  - MP is positive (falling in value) – TP is increasing at a declining rate (point b to point c)
- Stage 3 production
  - MP is negative and TP is decreasing (beyond point c)

Variable labor and the production of bus services

Labor unit	Total product (thousands)	Average product (thousands)	Marginal product (thousands)
0	-	-	1
1	1	1.0	6
2	7	3.5	11
3	18	6.0	8
4	26	6.5	6
5	32	6.4	5
6	37	6.2	3
7	40	5.7	2
8	42	5.3	-1
9	41	4.6	

Case Study 1

Costs and production in transport operations

Mode cost comparisons

Operating cost	Airline British Airways 2005/6		Ferry Operator Caledonian Mac. 2005/6		Bus Company First Glasgow 2005/6		Railway Company Virgin West Coast Value 2005/6		Parcels Parcelforce Value 2005/6	
	Value	%	Value	%	Value	%	Value	%	Value	%
Labor costs	2346	30.0	45	51.7	45.4	**69.2**	102.2	17.7	5968	**71.8**
Vehicle costs	1302	16.6	18	20.7	5.8	8.8	171.7	29.8	1392	16.7
Infrastructure costs	0	0.0	0	0.0	0	0.0	141.4	24.5	0	0.0
Fuel costs	1632	**20.8**	9.5	10.9	10	**15.2**	15.6	2.7	0	0
Terminal costs	1514	19.3	12.6	14.5	0	0	17.5	3.0	530	6.4
Other overheads	1034	13.2	1.9	2.2	4.4	6.7	128.5	22.3	426	5.1
Totals	7828	100	87	100	65.5	100	576.9	100	8316	100
Fixed inputs	2816	**36**	29	**37.7**	5.8	8.8	330.5	**57.3**	1922	23.1
Variable inputs	5012	64	48	62.3	59.7	91.2	246.4	42.7	6394	76.9

Source: Cowie (2010) compiled from Company Annual Reports, 2005/6

- Cost differences variations in the structure of production in the modes examined
  - The relative levels spent on each input reveals a very high level of variation of input factors between modes
  - As staff costs are a direct measure of the relative proportion of labor used in the production of transport services
    - Parcel and bus operations are more labor intensive industries than the railways, ferries, and airlines
    - Railways, ferries, airlines would appear to be more capital intensive than the others shown
  - The relative level of fuel costs
    - The bus and airline companies are around the two highest relative shares of operating costs, suggesting that the level of fuel costs is independent of the labor and capital intensity of the production process within the industry

- A high level of fixed costs coupled with a capital-intensive production process would suggest large firms, which would act against market entry and competition in the market

- More labor intensive transport industries, such as the bus and parcel markets, competition in the market should be both achievable and sustainable

Costs in the short run production

Costs in the short run production

- Classifying costs
  - Costs can be classified by input such as labor costs
  - Costs can be classified by the associated production of various outputs such as passenger operations and freight operations, or scheduled and chartered flights in the case of an airline
  - Costs can be classified by the activity performed such as a railway could group its costs under the headings of sales and marketing costs train service costs, infrastructure costs, station costs
  - Within transportation economics costs are generally classified into fixed and variable
- Depreciation
- Short run average and marginal costs

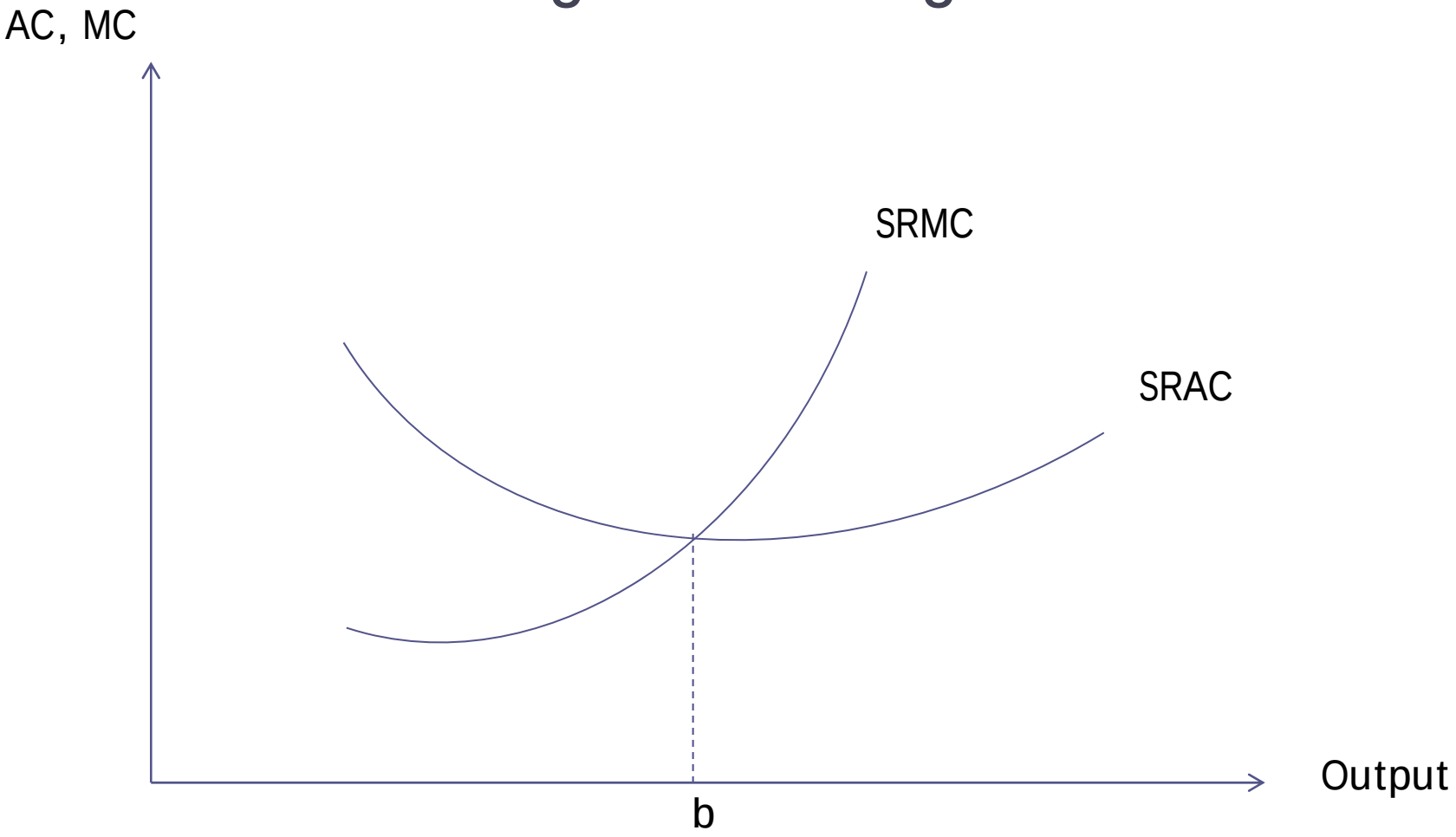
Depreciation

- The reduction in economic value to the firm of using an asset in the production process
  - Straight line method
    - The scrap value is subtracted from the purchase price and then divided by the number of expected years of usage
  - The reducing balance method
    - A percentage of the value is written off each year until the scrap value is reached

Illustration of depreciation by straight line and reducing balance methods

Year	Straight line method			Reducing balance method		
	Value at the beginning of year	Annual depreciation charge	Value at the end of year	Value at the beginning of year	Annual depreciation charge (21.3%)	Value at the end of year
1	110,000	10,000	100,000	110,000	23,430	86,570
2	100,000	10,000	90,000	86,570	18,439	68,131
3	90,000	10,000	80,000	68,131	14,512	53,619
4	80,000	10,000	70,000	53,619	11,421	42,198
5	70,000	10,000	60,000	42,198	8,988	33,210
6	60,000	10,000	50,000	33,210	7,074	26,136
7	50,000	10,000	40,000	26,136	5,567	20,569
8	40,000	10,000	30,000	20,569	4,381	16,188
9	30,000	10,000	20,000	16,188	3,448	12,740
10	20,000	10,000	10,000	12,740	2,714	10,026

Short run average and marginal cost curves



Variable and fixed costs of short-run production of bus services

Production				Costs				
Labor units	Output produced (000s)	AP (000s)	MP (000s)	TFC	TVC	TC	ATC	MC
0	-	-	1	80000	-	80000	-	30.00
1	1	1.0	6	80000	30000	110000	110.00	**5.00**
2	7	3.5	11	80000	60000	140000	20.00	2.73
3	18	6.0	8	80000	90000	170000	9.44	3.75
4	26	6.5	6	80000	120000	200000	7.69	5.00
5	32	6.4	5	80000	150000	230000	7.19	6.00
6	37	6.2	3	80000	180000	260000	**7.03**	10.00
7	40	5.7	2	80000	210000	290000	7.25	15.00
8	42	5.3	-1	80000	240000	320000	7.62	-
9	41	4.6	-	80000	270000	350000	8.54	

Variable and fixed costs of short-run production of bus services

- TFC = £80,000
- TVC = the number of labour units employed times the cost of each unit
- TC = TFC+TVC
- ATC=TC/Q
- MC is the cost of the last unit produced
  - For example, labour is increased from one to two units, output increases by 6,000 units and costs rise by £30,000. The marginal cost of the last unit therefore is the difference in output divided by the difference in costs and hence is £5

- The highest level of labour productivity occurs at 4 units
- The lowest average cost occurs when 6 labour units are employed

- The reason for this difference is because the average cost also includes the capital cost, while no account is taken of capital inputs under the previous calculation as all variations in output were apportioned to the labour factor

- This is one reason why productivity measures based on a single input such as labour in this case, can be misleading

Case Study 2

The importance of average cost in the business model of low-cost airlines

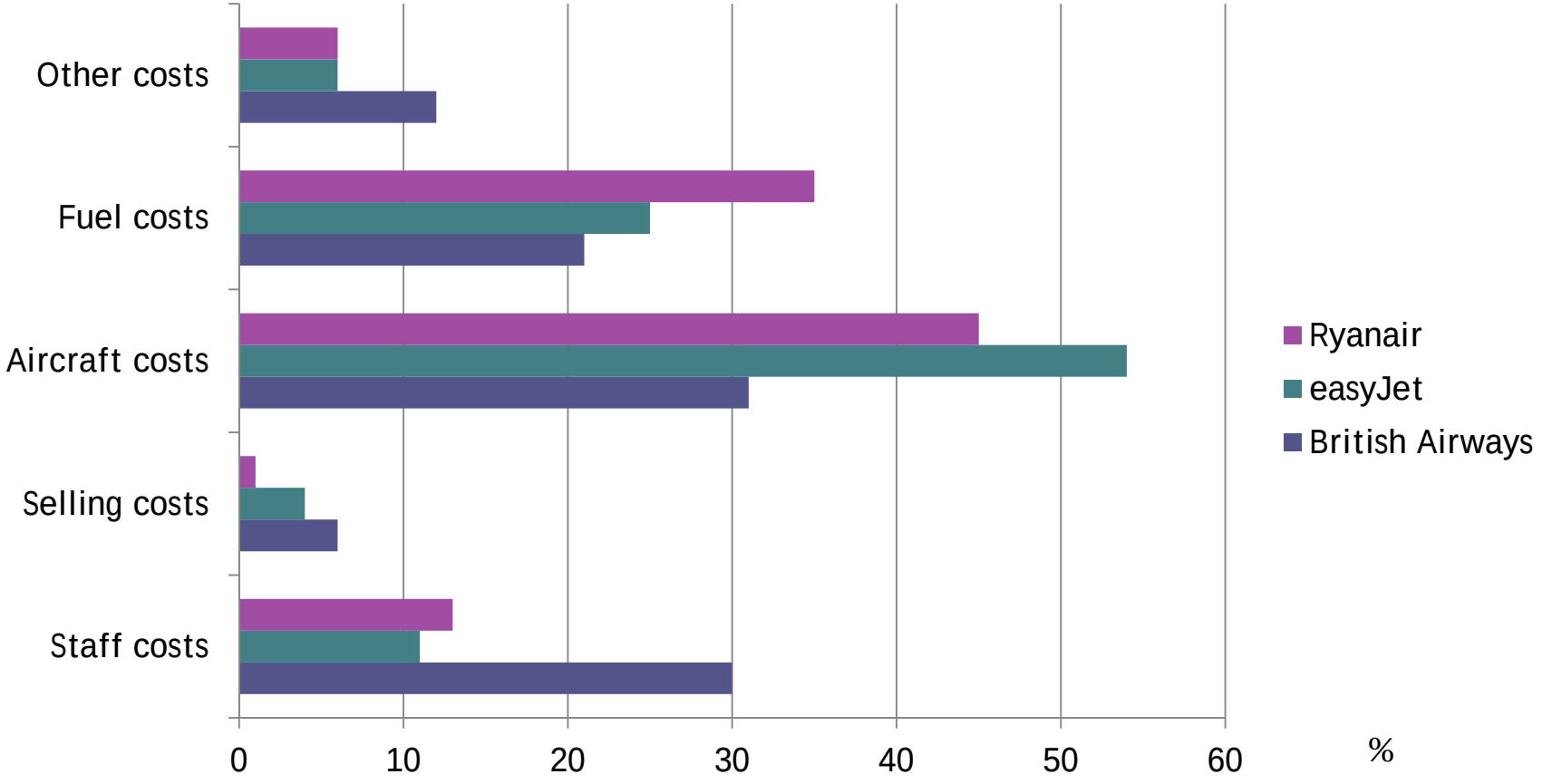
The general ‘model’ of the low cost carrier can be summarized as consisting of the following main elements:

- Low staff costs
- Low aircraft turnaround times
- Route network based around secondary or regional airports rather than major hubs since they are usually less congested
- On line ticket sales only with ticketless travel
- Cabin crew perform other duties turnarounds, such as cleaning the inside of the aircraft
- Simplified point-to-point operations rather than complex hub and spoke
- All ‘extra’ beyond the basic seat incur an additional charge, e.g. in flight catering or priority in boarding
- No spare aircraft capacity held in reserve to cover in the case of unforeseen breakdowns or delays
- Fleet based on a single aircraft type to reduce maintenance costs

Operating costs, British Airways, easyJet and Ryanair, 2006

Airline	British Airways		EasyJet		Ryanair	
	Actual	%	Actual	%	Actual	%
Staff costs	2346	30	75.2	11	171.4	13
Selling costs	449	6	26	4	13.9	1
Aircraft costs	2446	31	366.8	54	590.1	45
Fuel costs	1632	21	165.9	25	462.5	35
Other costs	955	12	42.2	6	85.6	6

Percentage breakdown, operating costs, BritishAirways, easyJet and Ryanair, 2006

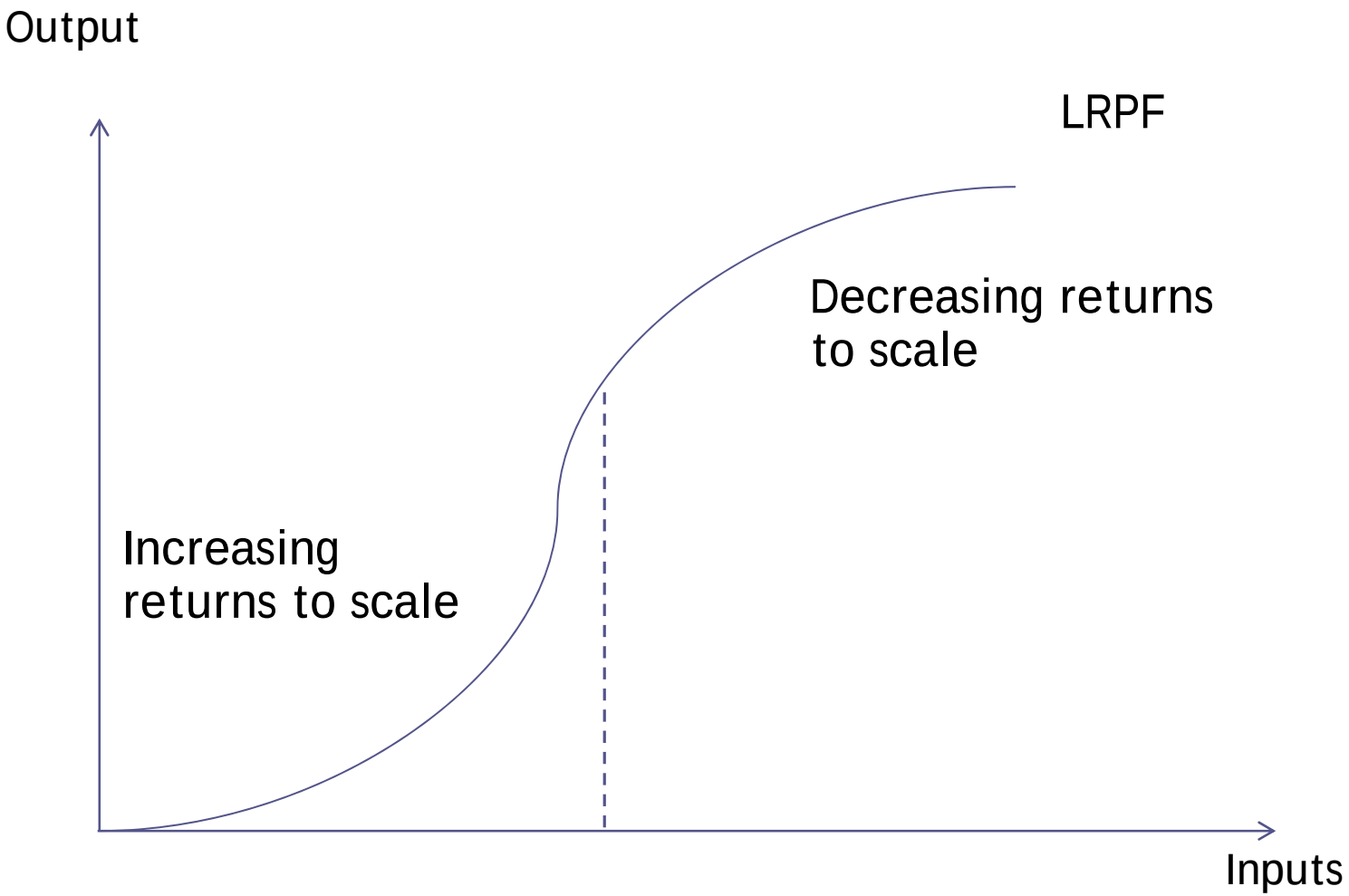


Cost of production in the long run

Cost of production in the long run

- All input factors are variable
- The long run production function is S shaped in nature
- At first, there are large gains when firm size increases – the relative percentage gain in output is greater than the relative percentage increase in inputs – increasing return to scale
- Once firm size rises past point b, the proportionate gains from adding more inputs are not as large as before, hence the firm experiences decreasing returns to scale

The long run production function



Sources of increasing returns to scale

- Specialization of labor
  - Larger firms allow more specialization of the workforce to occur

- Scheduling of inputs
  - As firm size increases, there exists greater flexibility is how the inputs can be combined and hence better utilization of all of the inputs may be expected
  - Example
    - in larger road haulage companies- there may be more flexibility in the scheduling of drivers to ensure that the vehicle stock is operated over the longest possible number of hours- this would ensure higher total productivity

- Capital inputs
  - Some capital inputs can be very expensive to purchase
    - Increasing a railway line from single to double track increases capacity by a factor of four- potentially significantly increasing the productivity of rail services
  - Specialization
    - Using the sole trader example, the company vehicles consist of a single solitary van
      - this van will have to fulfill all of the transport requirements of the company
      - As firm size increases, then the company fleet can be increased not only in size but also in scope, hence more suitable vehicles can be used for more suitable tasks - this should lead to higher productivity
  - Larger companies carry a larger number of spares and maintenance facilities, hence downtime of capital equipment at such should be reduced and consequently higher productivity achieved

- Indivisibilities
  - Means that certain factors are available only in some minimum sizes E.g. machinery
  - Such inputs cannot be divided into small sizes to suit the small scale of production E.g. there cannot be half a machine, half a computer etc.
  - Such inputs have to be employed even if the scale of production is small
  - Therefore, as the scale of production increases, these indivisible factors are utilized better and more efficiently
  - This leads to increasing returns to scale

Sources of decreasing returns to scale

- Loss of control
  - As firm size increases, there is a loss of control over the whole organization- decreases overall productivity

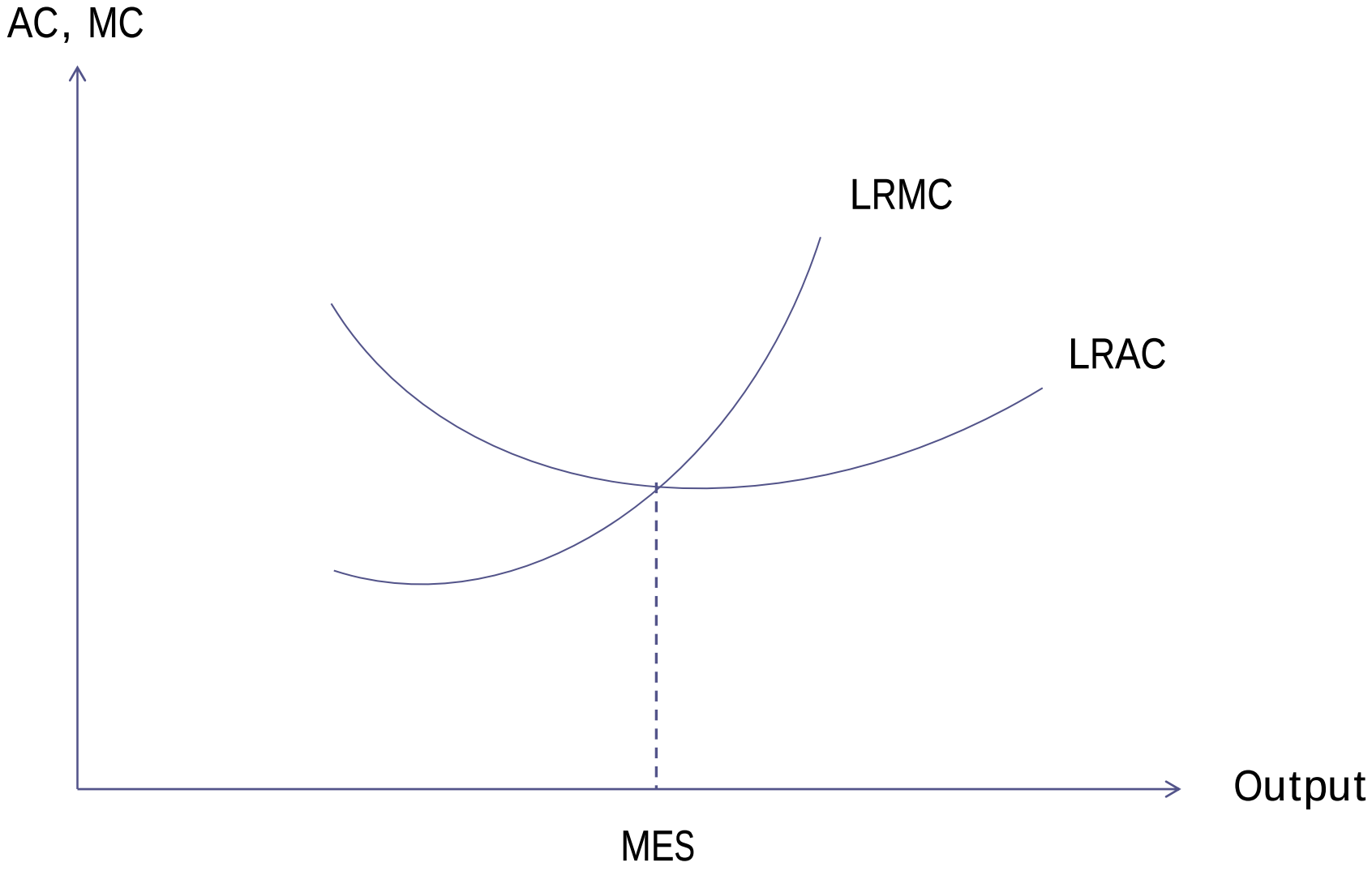
- Geographic location
  - Bus industry- a firm initially sets up business it will probably be on or near to the optimal location
    - Increasing size in the longer term means building other production facilities such as depots and these will not necessarily be at the best location
    - This can result in long distances between the depot and the market served, hence a significant proportion of time is spent in driving vehicles between the two and not actually providing transport services- productivity decreases

- Administration procedures
  - Larger firms often require many more layers of middle and upper management, plus administration procedures, in order to control costs and processes within the organization
  - This refers to the time dimension that such form filling requires and hence the opportunity cost of this form filling is the distraction of employees from the production process

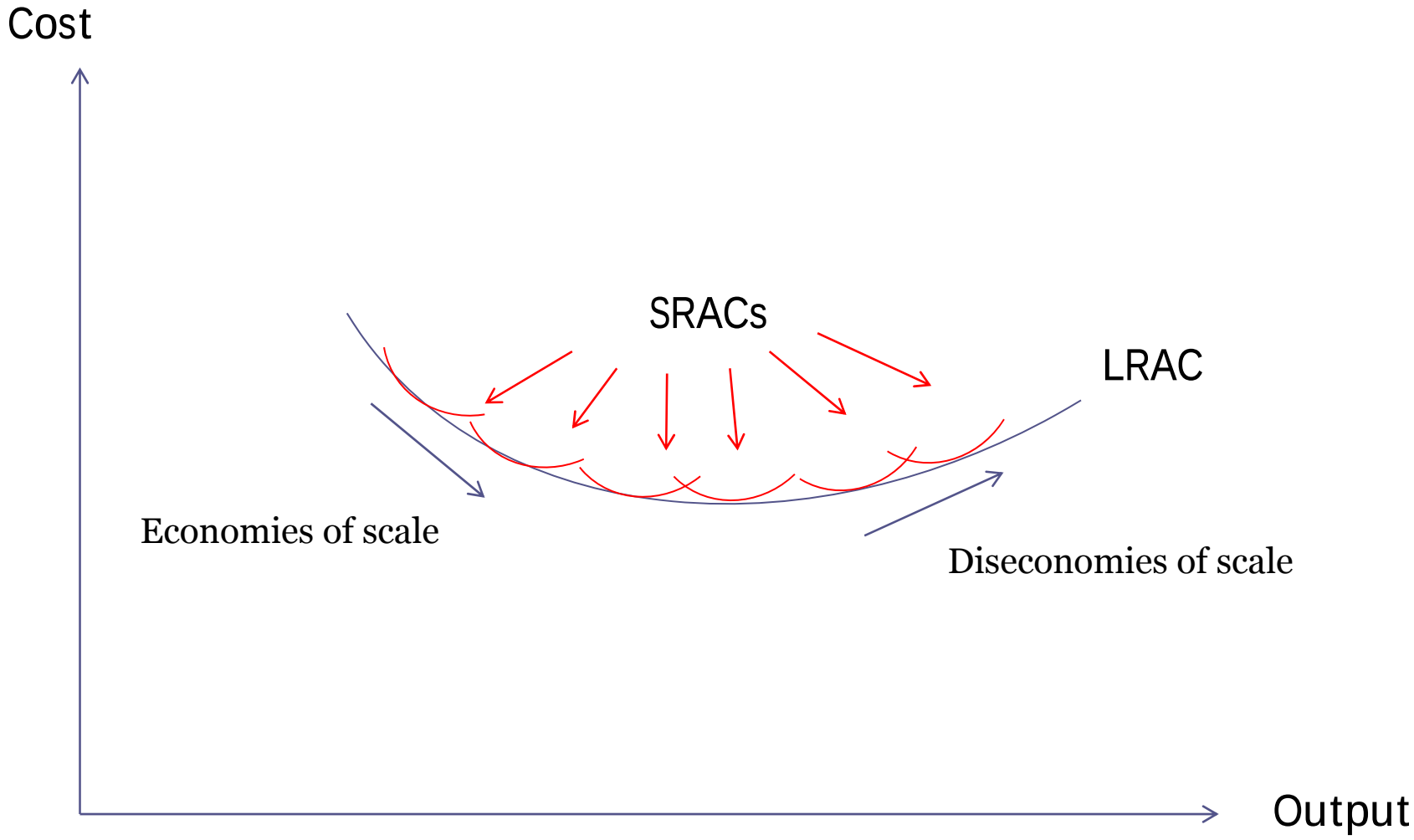
Average and marginal costs in the long run

- Average costs as first fall as firm size (as measured by output) increases - Economies of scale
- Continues up to the point where AC are minimized at the optimum level of production, known as the minimum efficiency scale (MES)
- After this point the trend is reversed and AC rises as firm size increases – Diseconomies of scale

Long run average and marginal costs



Long run average cost curve



Sources of economies of scale

- Increasing returns to scale
  - As firm size increases it encounters increasing returns to scale
  - Increased productivity – relatively lower levels of the inputs need to be employed to produce higher levels of output, hence the average costs per unit of output falls

- Bulk buying
  - Larger firms can normally obtain some form of discount for buying capital equipment and suppliers in larger numbers, and hence average costs would be expected to be lower for larger firm
  - Bus companies

- Financial economies
  - Larger firms are normally better placed to secure additional finance as they can offer greater security
  - Interest rates may be lower as there is a lower risk involved to the finance company, hence AC are lower

Sources of diseconomies of scale

- Decreasing returns to scale
  - A number of sources of technical inefficiencies that lead to reduced productivity for larger firms, thus the average output per unit of input falls
  - In order to produce higher levels of output, therefore, relatively higher numbers of inputs need to be employed, and this adds to costs causing diseconomies of scale

Case Study 3

Economies of scale and reform in railway operations

Rail industry

- High capital requirement in the provision of rail services
- Economies of scale are significance
- Company size needs to be large in order to capture all of these effects

- Most of main railways were taken under the control of a single company so that economies of scale could be achieved

- Traditional view
  - Infrastructure and services are part of an integrated system and economies of scale in both are significant

- Revisionist view
  - In recent years, every European country has re-organized their railway systems with many separating both organizationally and financially infrastructure from services
  - E.g. In Sweden- all infrastructure functions were separated out into the Swedish National Rail Administration while services remained within the Swedish State Operator
  - Under this belief, the central premise is that economies of scale are only associated with the infrastructure and not with services
  - The advantage of a system over the traditional railway is that different operators can operate on the network and hence some form of competition introduced into the provision of rail services

Empirical studies evidence

- A study of 15 Western European (integrated) railways found diseconomies of scale for larger train systems such as (West) Germany and Britain, and increasing returns for small rail system such as Ireland, Switzerland, and Belgium (Preston, 1994)
- The minimum efficiency scale for integrated railways was around the size of the Danish and Belgian rail networks (Shires and Preston,1999)

- The implication, if only economies of scale are considered, is that countries with large networks such as Britain should organize their rail system into three to four integrated railways (perhaps on a regional basis) rather than as one single national operator. Such a structure would place each system close to the MES point and hence eradicate diseconomies of scale

- Scale effects to be significant in the Swiss industry (Cowie, 1999) Switzerland is made up of a single national operator, CFF, on the main lines, and around 60 to 70 mainly publicly owned local railways on the local lines, varying in size from as small as 4 km. up to around 400 km. in length

- Significant scale effects in such small systems would again be consistent with a U-shaped cost curve

- The gains that could be achieved in terms of lowering average cost for smaller systems by increasing output would be higher than for medium-sized operators

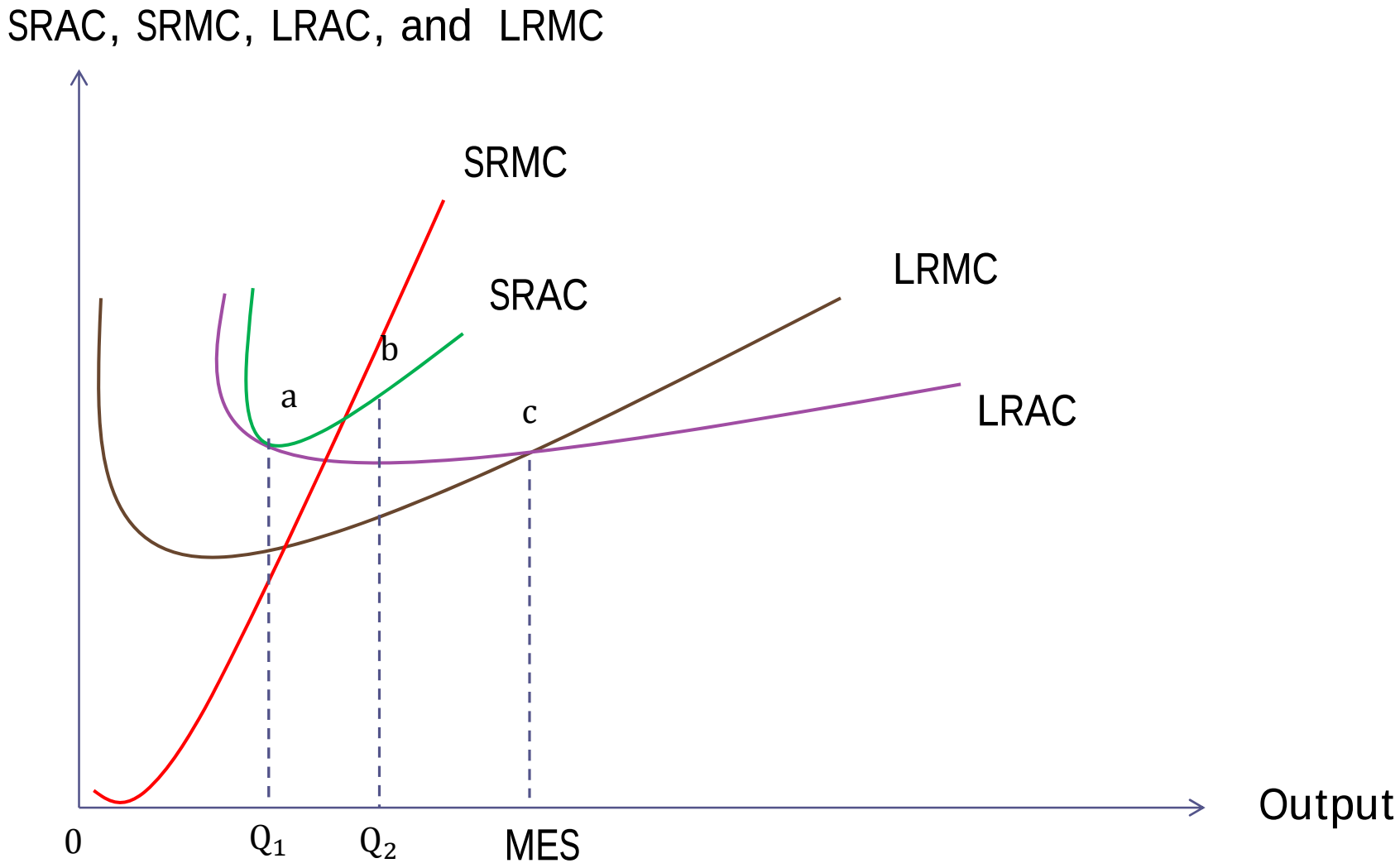
- The British train-operating companies and found that scale effects were significant, hence suggesting that the pure revisionist view, that there are no economies in operation, was not true (Cowie, 2002)

- In Britain there should be around four to five train-operating companies rather than the current number of seventeen. (Preston, 1994) The research also suggested by implication that there existed significant economies of scale in the provision of infrastructure

- Economies of scale have a major impact on the consideration of the best size of railway to produce rail services, as clearly if scale effects are considerable then costs can be significantly reduced by having a very large operator

Short and Long run average costs

Long and short run average and marginal cost curves



Other types of cost important in transport economics

- Opportunity cost
  - The second best alternative forgone as a result of making an economic decision
- Time costs

- Specific costs
  - Costs which can be attributed to specific consumers
  - Costs of loading cargo onto an aircraft
- Joint costs
  - Arises when the provision of one product necessarily causes the provision of a second product
  - Return trips
- Common costs
  - Shared amongst different consumers but in unknown proportions
  - Road

Reference

- Mallard G., and Glaister S. (2008). Transport Economics: Theory, Application and Policy. Palgrave Macmillan.

- Cowie J. (2010). The Economics of Transport. Routledge.