4. TRANSPORT COSTS

Readings for Lecture 4

- Button, K. (2005). The economics of cost recovery in transport: introduction. *Journal of Transport Economics and Policy*, *39*(3), 241-257.
- Glaeser, E. L., & Kohlhase, J. E. (2004). Cities, regions and the decline of transport costs. *Papers in regional Science*, *83*(1), 197-228.

Learning Outcomes

- How transport costs behave in the short run 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

4.1 Theory

Introduction

- A major factor affecting supply is the cost of production
- Monetary costs + Time costs = Generalised costs of transport
- How to maintain downward pressure on public transport costs?

Cost categories

- Monetary costs; Time costs
- Infrastructure costs; Operators costs
- Environmental costs; Accident costs

Costs classification

Fixed costs (FC) = costs that are the same irrespective of the level of output that is produced

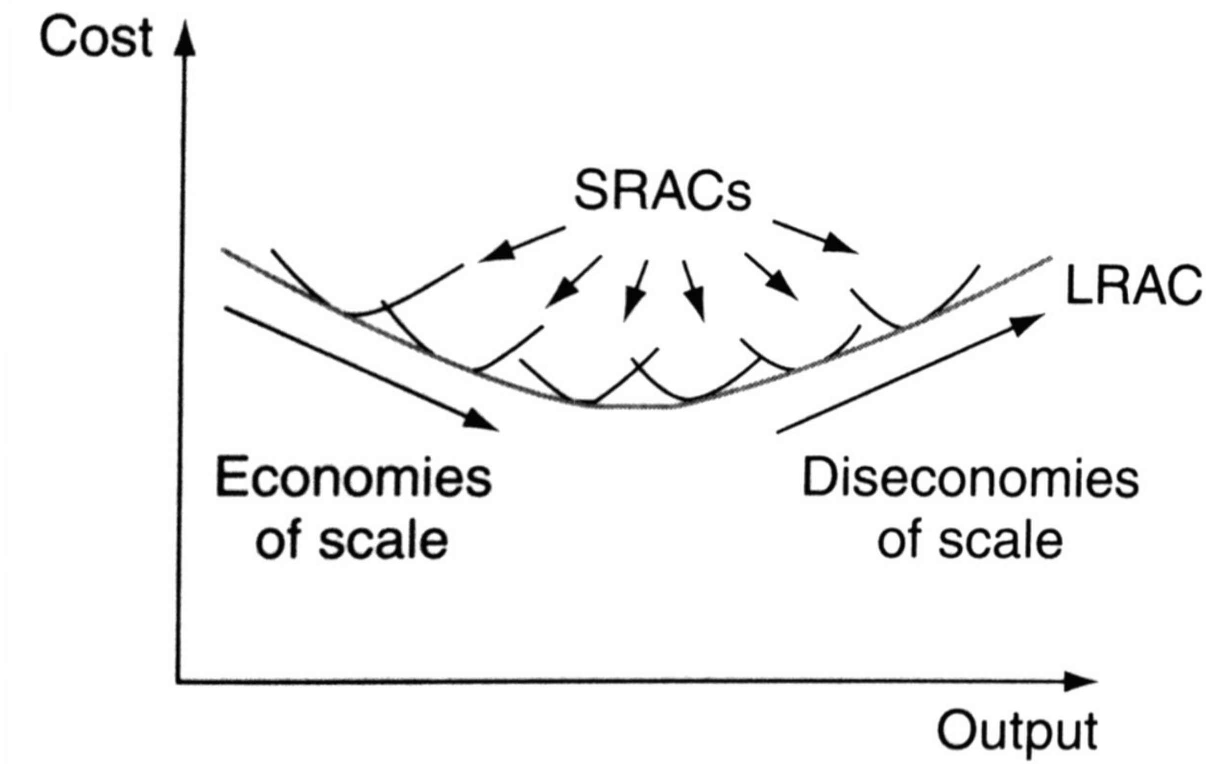
Variable costs (VC) = costs that change as the level of output changes

Semi-variable costs (SVC) = costs that are fixed over a certain range of output, but then change once the upper limit of that range is reached

Short run and long run

- Short run = at least one factor of production is fixed
- Long run = variations in output can be achieved through variation of all of the inputs

The long run average cost curve



Long run costs curves

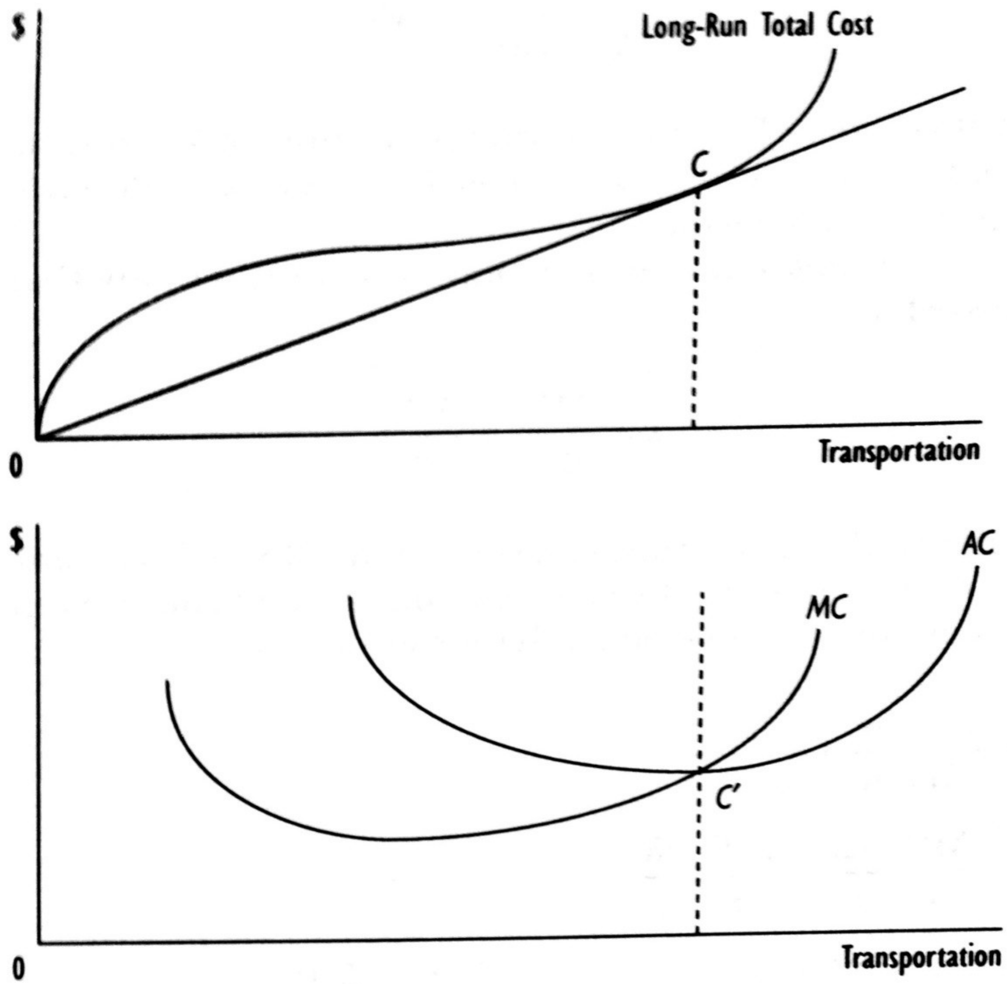


Figure 5.4 Total, average, and marginal cost curves.

The relationship between economies of scale and cost elasticity

Former equation tells us that, for constant input prices, there is an inverse relationship between production RTS and elasticity of total cost with respect to output:

Returns to Scale	Value of s	Value of $E_{C,T}$
Increasing	> 1	< 1
Constant	$= 1$	$= 1$
Decreasing	< 1	> 1

Therefore, analysis of firm cost s provides economically relevant information on a firm’s production technology without having to separately estimate a firm’s production function.

Changes in long run market supply

Increase in Supply from $S_T^{\text{lr}}(p)$ to $S_T''^{\text{lr}}(p)$ due to:	Decrease in Supply from $S_T^{\text{lr}}(p)$ to $S_T'^{\text{lr}}(p)$ due to:
Increase in the number of firms	Decrease in the number of firms
Decrease in the prices of inputs	Increase in the prices of inputs
Increase in subsidies given to T	Decrease in subsidies given to T
Decrease in taxes on T	Increase in taxes on T
Improvements in technology γ	

Estimating long run cost functions

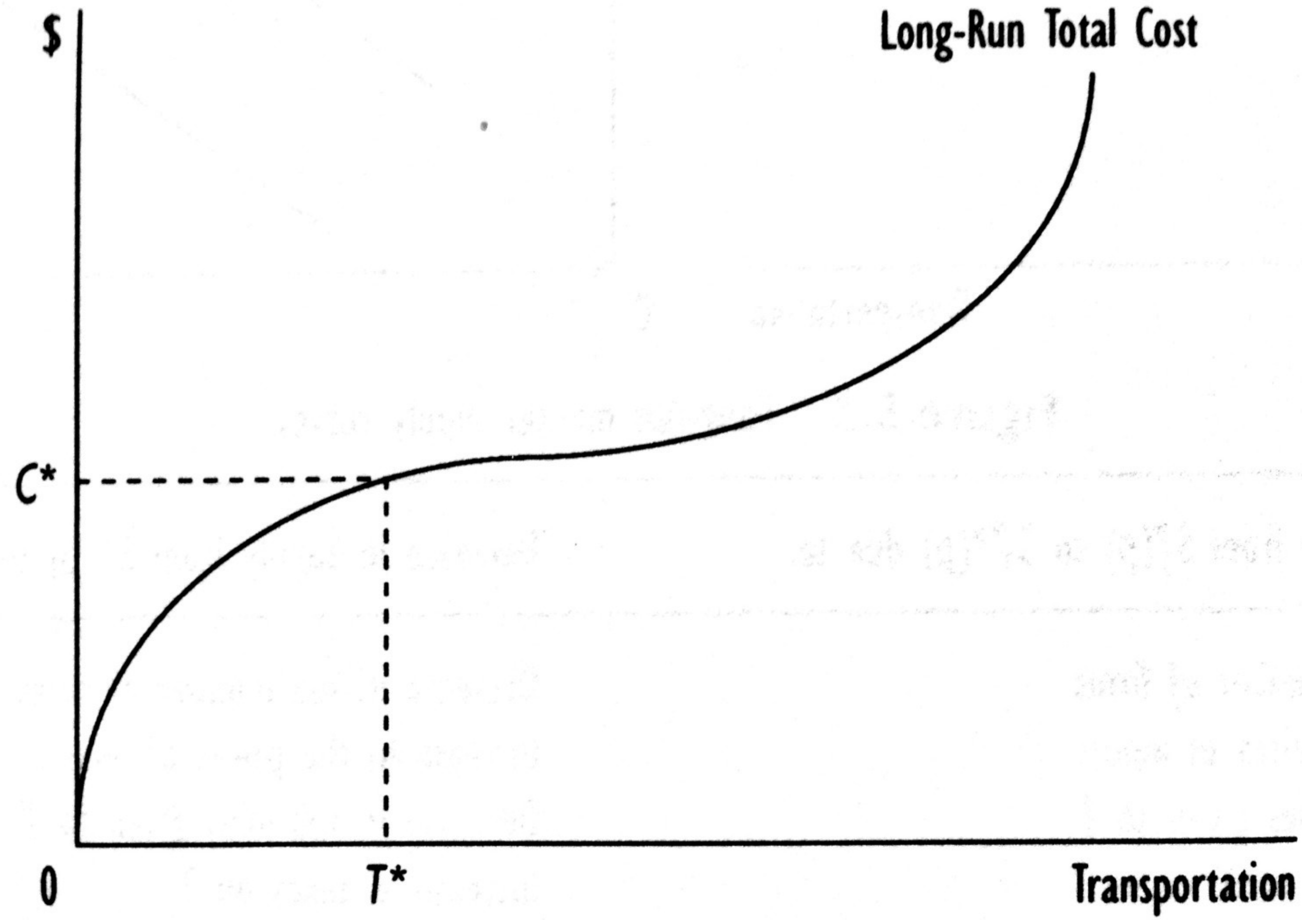


Figure 5.6 Predicted cost–output combination.

Cobb Douglas cost function

$$T = AL^a K^b, \quad a, b > 0$$

$$\ln C(T; w, r, \gamma) = \alpha_0 + \alpha_1 \ln T + \alpha_2 \ln w + \alpha_3 \ln r + \varepsilon$$

Flexible cost functions (translog)

Regressor	Coefficient	Interpretation
Constant term	α_0	Logarithm of total cost at the sample mean
$(\ln T - \ln \bar{T})$	α_1	Elasticity of total cost with respect to output T at the sample mean
$(\ln w - \ln \bar{w})$	α_2	Share of labor in total costs, evaluated at the sample mean
$(\ln r - \ln \bar{r})$	α_3	Share of capital in total costs, evaluated at the sample mean
$(\ln \gamma - \ln \bar{\gamma})$	α_4	Percentage change in total cost from a 1% change in technology, evaluated at the sample mean

$$\ln C(T; w, r, \gamma) = \alpha_0 + \alpha_1(\ln T - \ln \bar{T}) + \alpha_2(\ln w - \ln \bar{w})$$
$$+\alpha_3(\ln r - \ln \bar{r}) + \alpha_4(\ln \gamma - \ln \bar{\gamma})$$
$$+\text{“second– order and interaction terms”} + \varepsilon$$

Short run – level of capital fixed

- In the short run at least one factor of production is fixed (we assume capital)
- In the short run, a discussion of returns to scale is no longer relevant, since all inputs cannot change in the same proportion.
- Adding more workers to a fixed amount of capital reduces MP_L = law of diminishing returns.

Short run cost curves

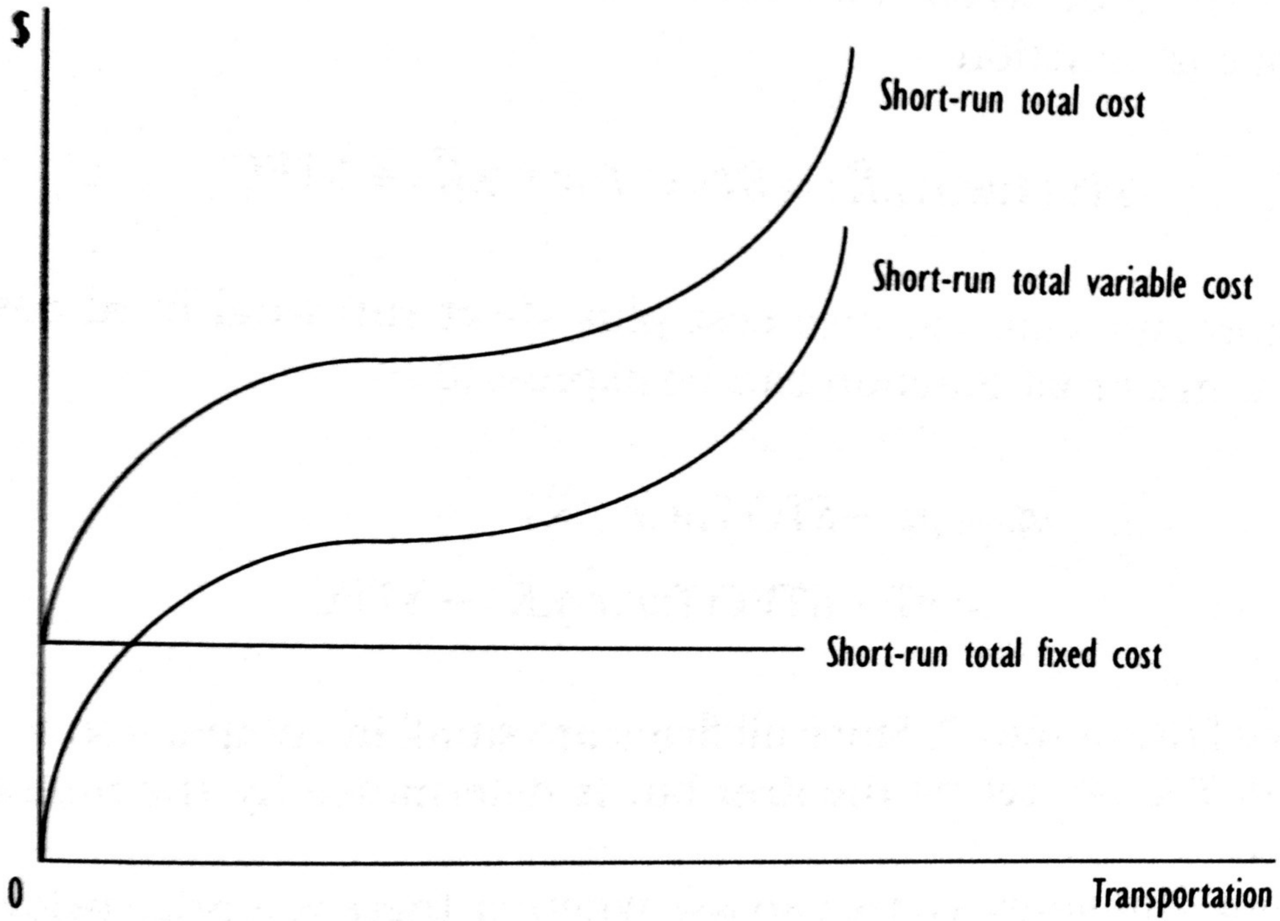
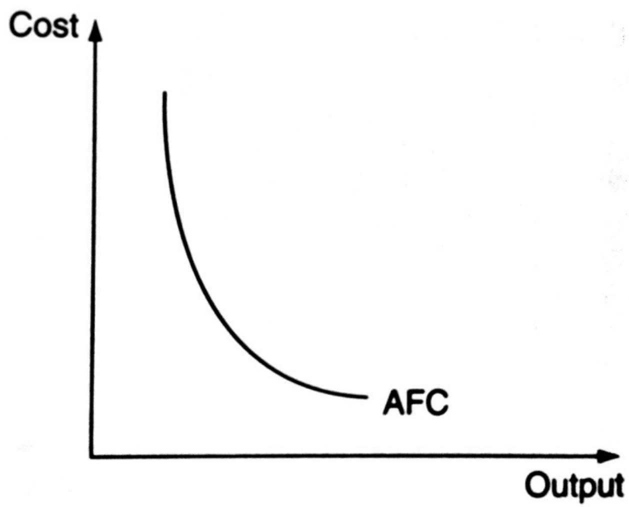
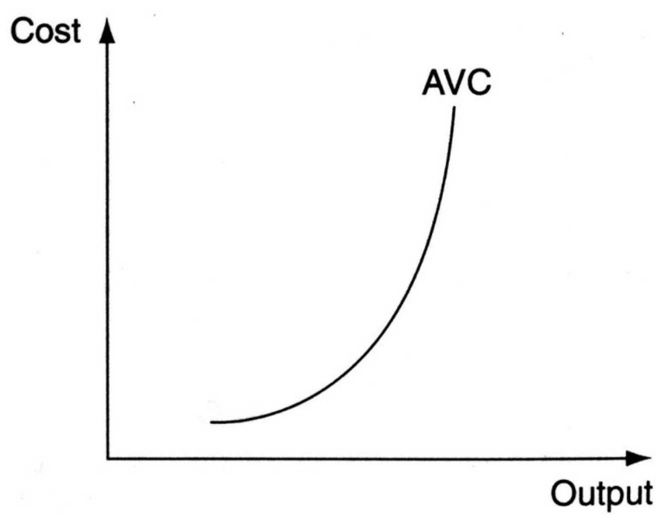
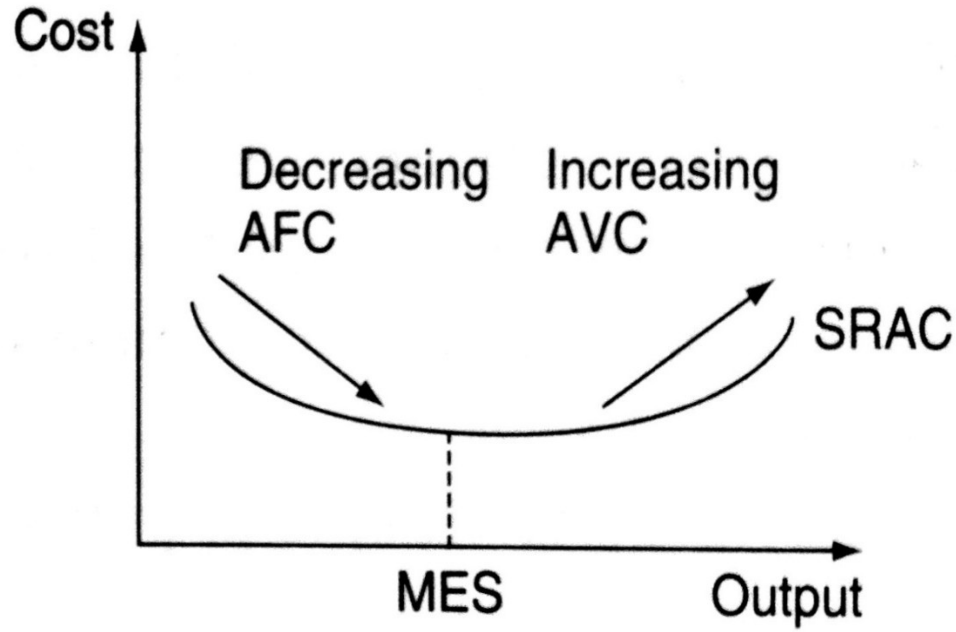


Figure 6.1 Short-run total cost curves.

The short run average cost curve







Short run cost curves

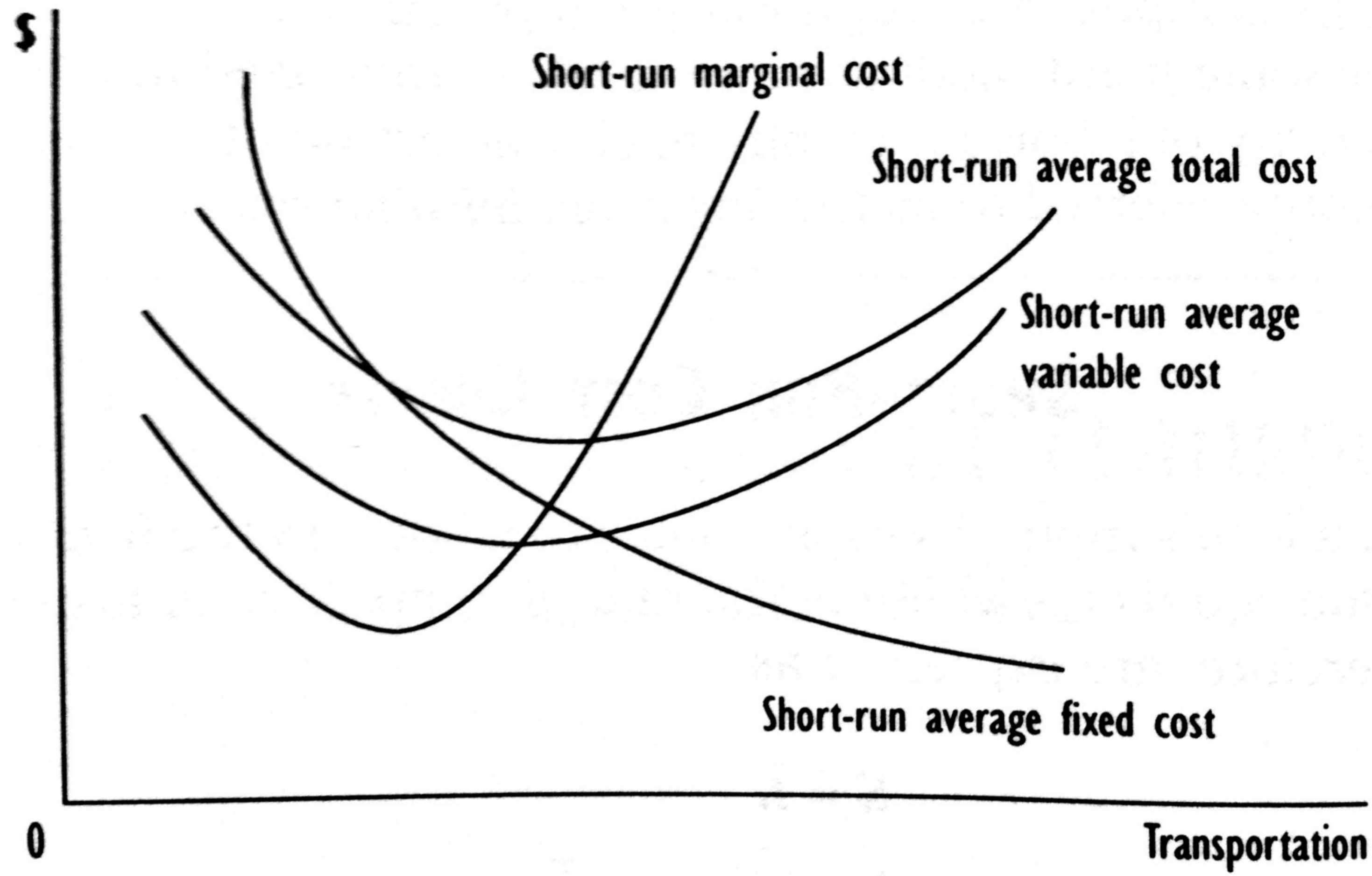


Figure 6.2 Short-run cost average and marginal cost curves.

Short run market supply

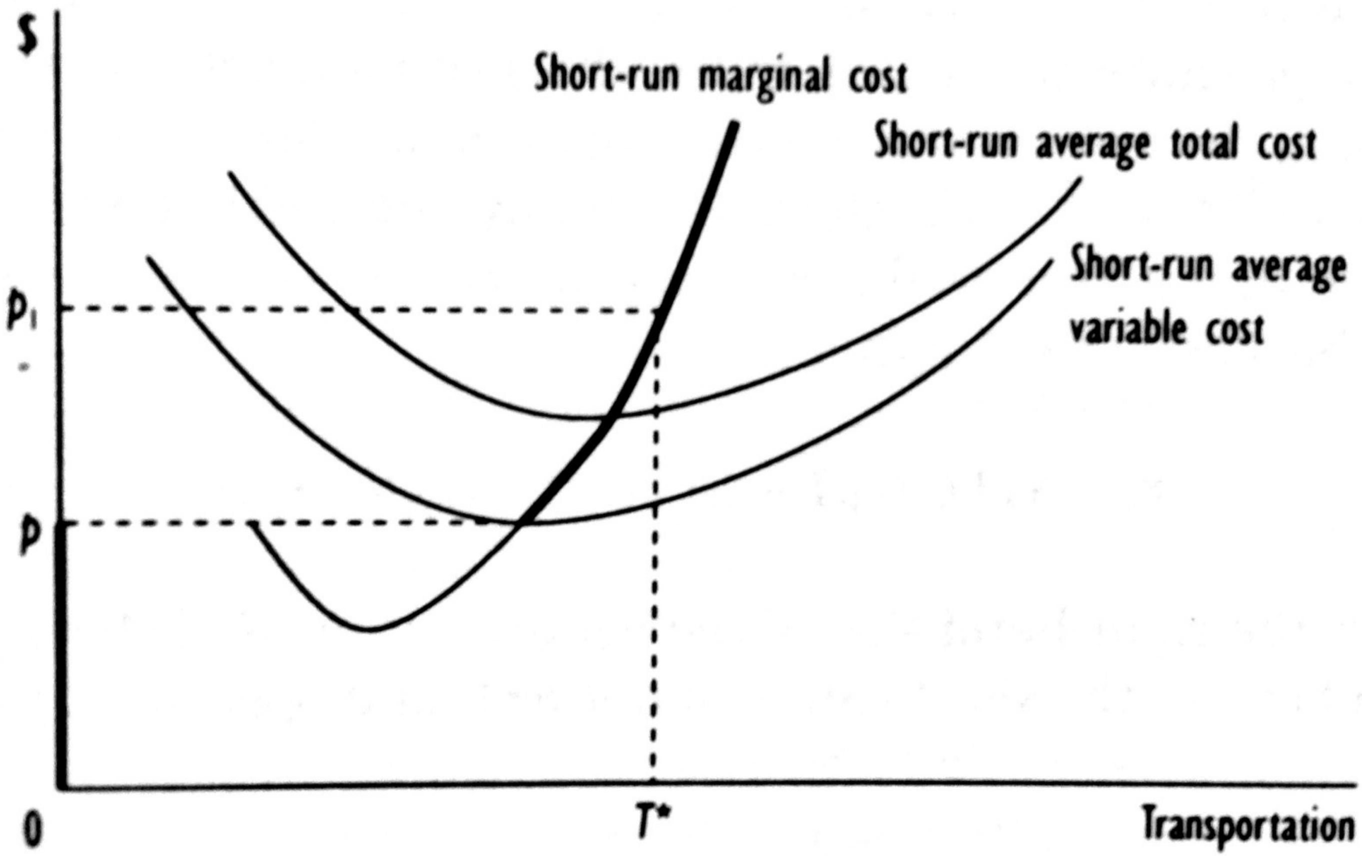


Figure 6.3 The short-run firm supply curve. ——, Short-run supply curve; *p*, the price below which firm output falls to zero.

The relationship between short run and long run costs

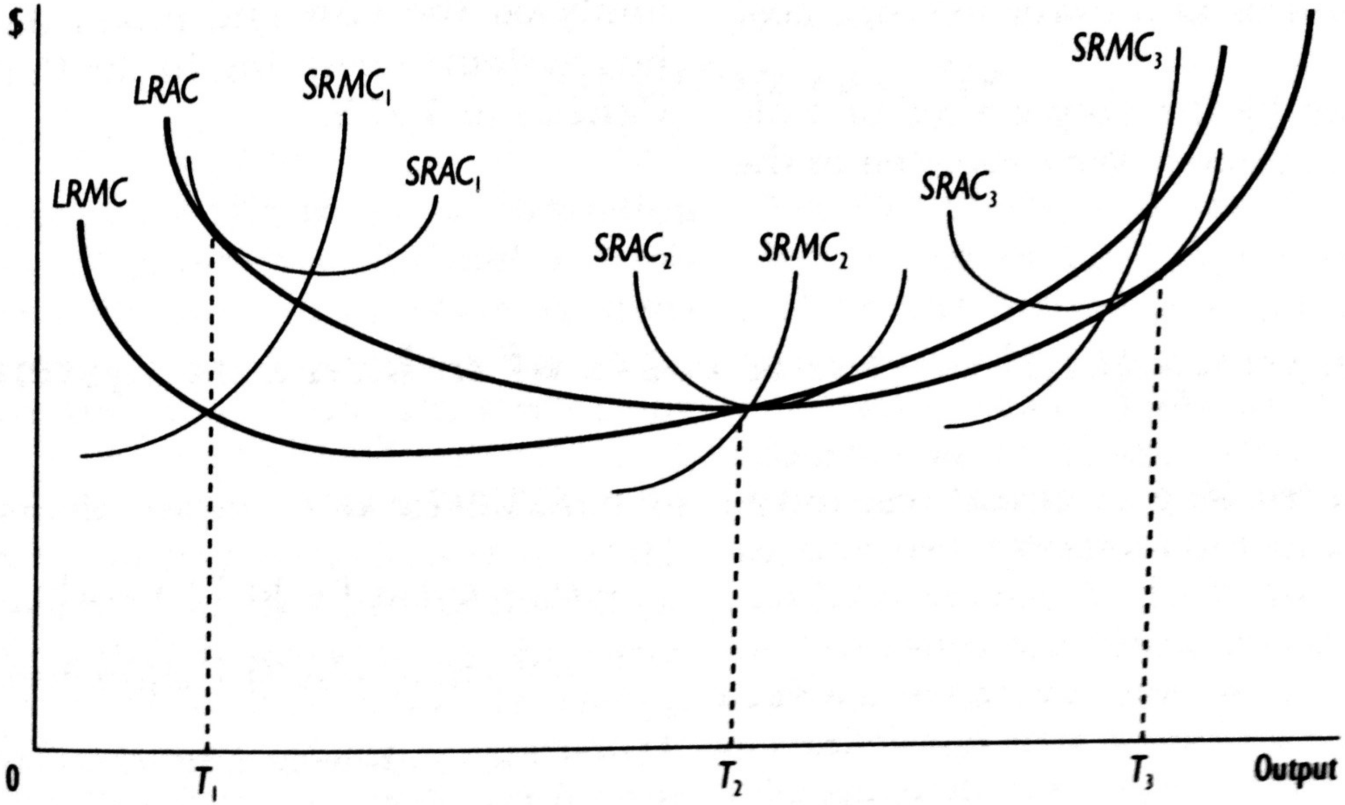


Figure 6.4 Cost curve tangencies and lowest cost outputs. T_i (i = 1, 2, 3), lowest-cost output in the short run and long run when scale of plant is K_i.

Exercises (1)

1. Identify reasons why airlines would want to take over other airlines.
2. Please provide one particular industry as an example to illustrate that MC is not U shaped.
3. Please provide one particular industry as an example to illustrate that MC is U shaped.
4. What is the difference between economies of scale and economies of density?

Exercises (2)

1. What is the difference between economies of scale and economies of scope?
2. For many airlines in the short run, a major portion of the cost of production such as aircraft and terminal space are fixed. Should these very large FCs be ignored when the revenue managers are making output and pricing decisions? Why?
3. Critically evaluate the following statement: "All constraints on behaviour are costly, which explains why the short-run total cost curve lies above the long-run total cost curve."

Exercise (3)

Fuel costs are important inputs to any transportation activity. Suppose that real energy prices fall. Graphically depict the impact that this would have upon a firm's total short-run and long-run cost structure. Would you expect a firm's long-run response to a fall in energy to be greater, less, or equal to its short-run response to a fall in energy prices? What does this suggest about the firm's short-run input price elasticity of fuel relative to its long-run input price elasticity of fuel?

Exercise (4)

Suppose that you are given the following information on All Around Airlines:

- The average variable cost of producing airline trips varies between 11.5 cents a mile when 50,000 trips per year are produced and 16.7 cents per mile when 500,000 trips per year are produced. Its lowest value is 11.5 cents a mile when 250,000 trips are produced.
- The average total cost of producing trips varies between 15.3 cents per mile when 250,000 trips are produced and 17.3 cents per mile when 500,000 trips are produced. The minimum short-run average total cost is 13.0 cents when 300,000 trips are produced.

Questions:

- Approximately, how many trips will be produced in the short run if the fare is 15.4 cents per mile?
- Will any trips be produced if the fare is 12.1 cents per mile? If so, why; and if not, why not?
- Will any trips be produced if the fare is 10 cents per mile? If so, why; and if not, why not?

Exercise (5)

The July 7, 1993 *Wall Street Journal* provides the following information: “Northwest Airlines averted – at least for now – a threatened federal bankruptcy-law filling after its pilots’ union agreed to a last-minute pact to save the carrier $365 million over three years.” Using Northwest’s short-run cost curves, depict where Northwest was operating before and after the agreement with the pilots’ union.

Exercise (6)

Economies of scale in railway operations

- List what you believe to be the main sources of economies of scale in the rail industry. Once you have produced this list, indicate which arise as a result of returns to scale and which are cost savings.
- What on the other hand do you believe are the main sources of diseconomies of scale in larger integrated railways?
- If you were a rail industry regulator in Britain today, what other factors apart from economies of scale would you take into account when deciding on the number of operators to have in the market?

Exercise (7)

In 1968, Keeler (1971) identified the per seat-mile costs (shown in table 5.14) associated with four major intercity modes of travel: rail, air, automobile, and intercity bus.

Table 5.14 Intercity modal costs, 1968

Mode	Cost Per Seat-Mile (cents)
Intercity Bus (200-mile trip)	1.44
Air (Lockheed 1,011, 256-seat configuration, 250-mile trip)	3.00
Automobile (two occupants)	4.5
Rail (three-car train seating 240 passengers)	1.5

Source: Reprinted from Keeler (1971), table 7, p. 160,

What does this table tell us about the cost competitiveness of rail in comparison with the other three intercity modes?

Exercise (8)

Consider the following sets of statistics for 1990:

Intercity modal costs

Mode	Per-Mile Cost	Average Length of Trip
Certificated Air Carrier	13.02	803
Rail	12.85	274
Intercity Bus	11.55	141
Automobile	13.33*	115*

* Per mile costs of operating vehicle occupant: assumes 1.62 occupants per vehicle in 1990. Average Length of Trip for automobile is based upon intercity vacation trips.

Based upon this information, can you conclude that rail trips are competitive with air trips? How about intercity bus and automobile trips? Use the concept of economies of distance to argue that rail trips *will be more competitive* with shorter-haul air trips, but *will be less competitive* with longer-haul intercity bus and auto trips.

4.2 Applications

Case: Mode cost comparison

Operating Cost	*Airline*		*Ferry Operator*		*Bus Company*		*Railway Company*		*Parcels*	
	British Airways		*Caledonian Mac.*		*First Glasgow*		*Virgin West Coast*		*Parcelforce*	
	2005/6		*2005/6*		*2005/6*		*Value 2005/6*		*Value 2005/6*	
	Value	*%*	*Value*	*%*	*Value*	*%*	*Value*	*%*	*Value*	*%*
Labour Costs:	2346	30.0%	45.0	51.7%	45.4	69.2%	102.2	17.7%	5968	71.8%
Vehicle Costs:	1302	16.6%	18.0	20.7%	5.8	8.8%	171.7	29.8%	1392	16.7%
Infrastructure Costs:	0	0.0%	0.0	0.0%	0.0	0.0%	141.4	24.5%	0	0.0%
Fuel Costs:	1632	20.8%	9.5	10.9%	10.0	15.2%	15.6	2.7%	0	0.0%
Terminal Costs:	1514	19.3%	12.6	14.5%	0.0	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%**	**87.0**	**100%**	**65.5**	**100%**	**576.9**	**100%**	**8316**	**100%**
Fixed Inputs:	2816	36.0%	29.0	37.7%	5.8	8.8%	330.5	57.3%	1922	23.1%
Variable Inputs:	5012	64.0%	48.0	62.3%	59.7	91.2%	246.4	42.7%	6394	76.9%

Sources: Compiled from Company Annual Reports, 2005/6

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

Airline:	*British Airways*		*easyJet*		*Ryanair*	
	Actual	*%*	*Actual*	*%*	*Actual*	*%*
Staff costs	2346.0	30%	75.2	11%	171.4	13%
Selling costs	449.0	6%	26.0	4%	13.9	1%
Aircraft costs	2446.0	31%	366.8	54%	590.1	45%
Fuel costs	1632.0	21%	165.9	25%	462.5	35%
Other costs	955.0	12%	42.2	6%	85.6	6%

Source: Adapted from the respective company accounts

Costs at privatized British railways

Table 1: Rail Industry Costs in Britain (Infrastructure and Passenger Train Operations): 1997 to 2012

Costs (£b2011/12 prices)	1996/97	2005/6	2011/12
Infrastructure expenditure			
Maintenance	1.1	1.4	1
Renewals and enhancements	1.5	3.7	4.6
Other operating costs	1	1.4	1.5
	3.5	6.5	7.1
TOC costs less access charge payments	**4.2**	**5.8**	**5.9**
Total passenger rail costs	**7.7**	**12.3**	**13**
Unit cost measures (£)			
Total passenger rail costs per passenger train km	20.2	27	25.4
Infrastructure costs per passenger train km	9.2	14.4	13.9
TOC costs (excluding access charges) per passenger train km	11	12.6	11.5

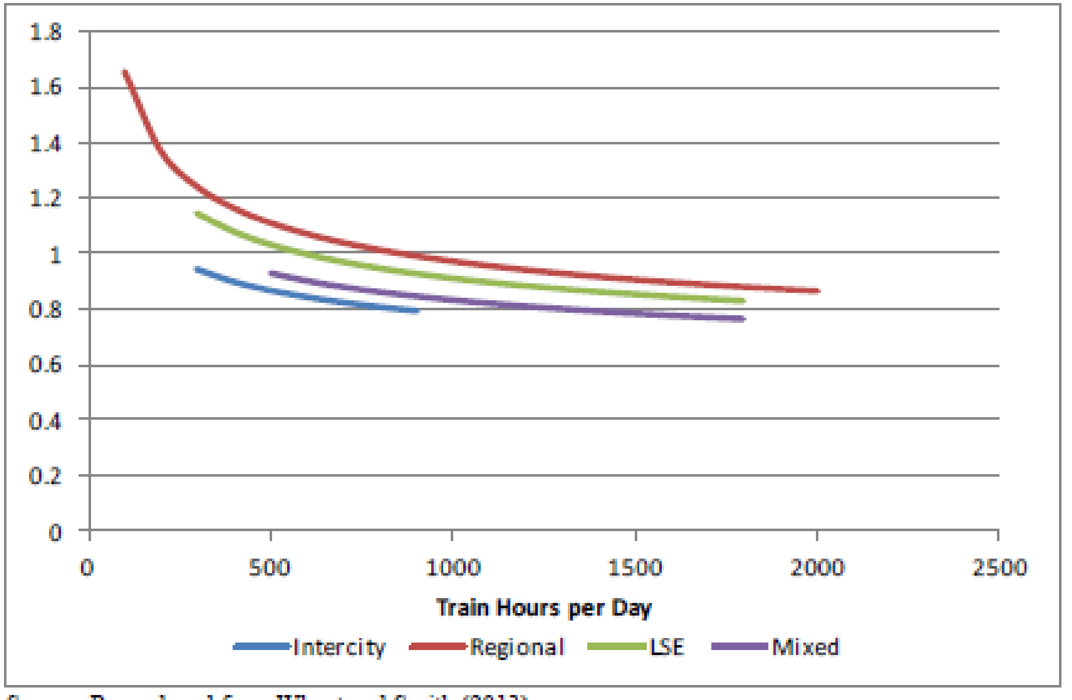
Economies of scale, scope and density

- If an equal proportionate increase in all outputs and route kilometers leads to the same proportionate increase in costs → **constant returns to scale**
- If an equal proportionate increase in all outputs holding route kilometers constant leads to the same proportionate increase in costs → **constant returns to density**
- If splitting the production of passenger and freight outputs and of infrastructure leads to increased costs → the railway is said to experience **economies of scope**

Nash, C. (2011). Competition and regulation in rail transport. *Handbook of Transport Economics.*

Economies of scale

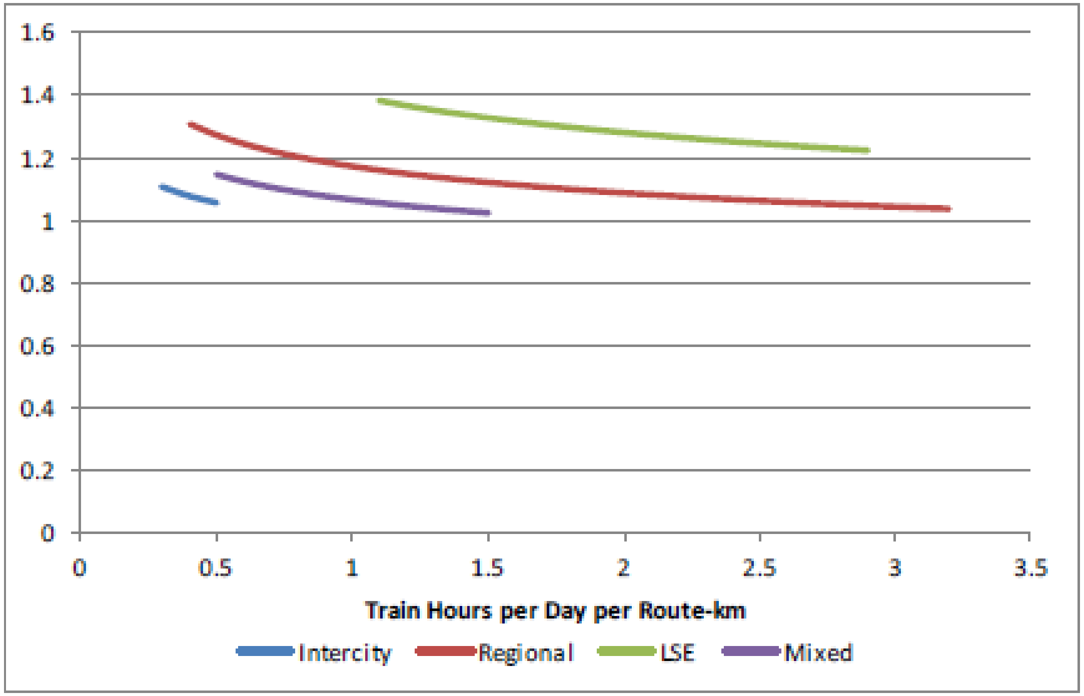
Figure 3. Returns to scale for different TOC types holding other variables constant



Source: Reproduced from Wheat and Smith (2013).

Economies of density

Figure 2. **Returns to density for different TOC types holding other variables constant**



Source: Reproduced from Wheat and Smith (2013).

Fixed costs issue

- When fixed costs are present and there is a competitive supply, then competition will push prices down to marginal costs, but they will be insufficient for capital cost recovery
- The challenge confronting the transport supplier is thus how to ensure sufficient revenue
- Empty core problem

Button, K. (2005). The economics of cost recovery in transport: introduction. *Journal of Transport Economics and Policy*, *39*(3), 241-257.

Methods of capital recovery

1. Subsidies
2. Monopolies
3. Internal coalitions
4. Long term contracts between supplier and customer
5. Advance revenue
6. Vertical integration
7. Discriminate pricing
8. Two part tariff

Decline of transport costs

- The theoretical framework of urban and regional economics is built on transportation costs for manufactured goods. But over the twentieth century, the costs of moving these goods have declined by over 90% in real terms, and there is little reason to doubt that this decline will continue.
- Moreover, technological change has eliminated the importance of fixed infrastructure transport (rail and water) that played a critical role in creating natural urban centres. In this article, we document this decline and explore several simple implications of a world where it is essentially free to move goods, but expensive to move people.
- We find empirical support for these implications.

Glaeser, E. L., & Kohlhase, J. E. (2004). Cities, regions and the decline of transport costs. *Papers in regional Science*, *83*(1), 197-228.

Transportation costs

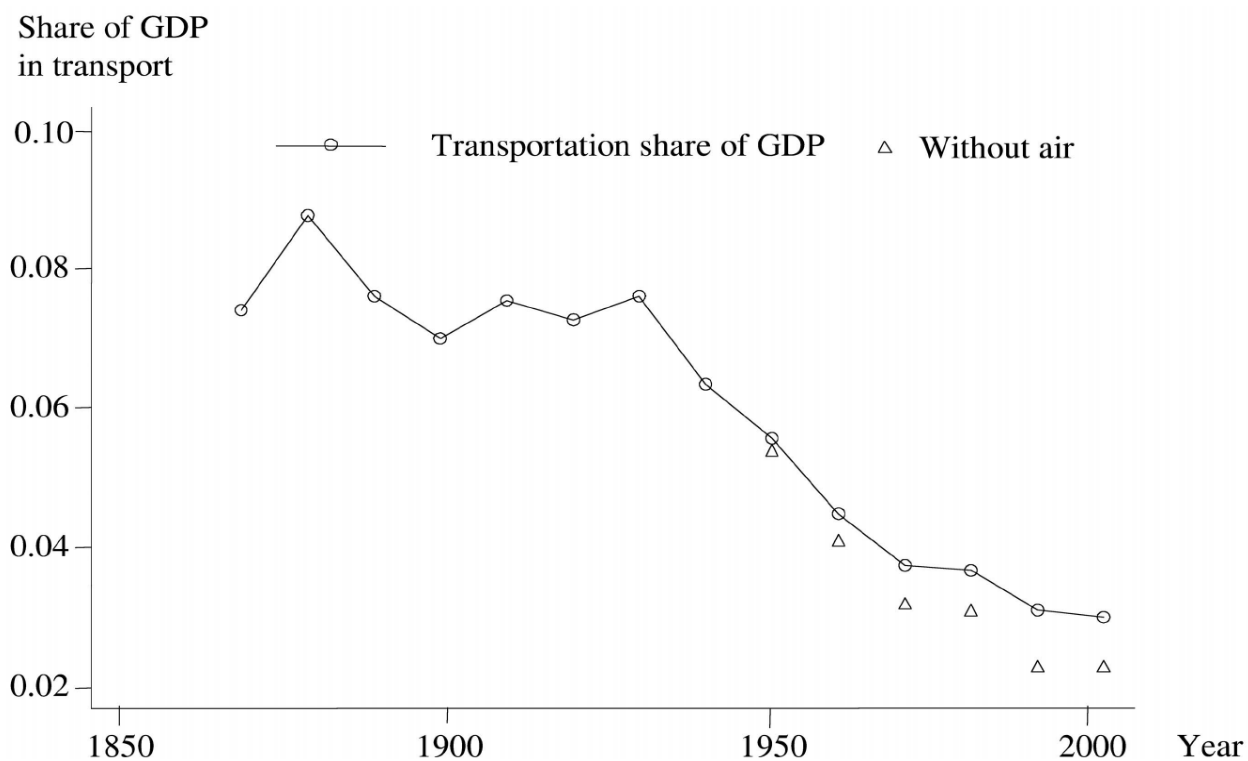


Fig. 1. The share of GDP in transportation industries. *Source:* Department of Commerce (since 1929), and Historical Statistics of the U.S. (Martin Series) before then

Railroad costs

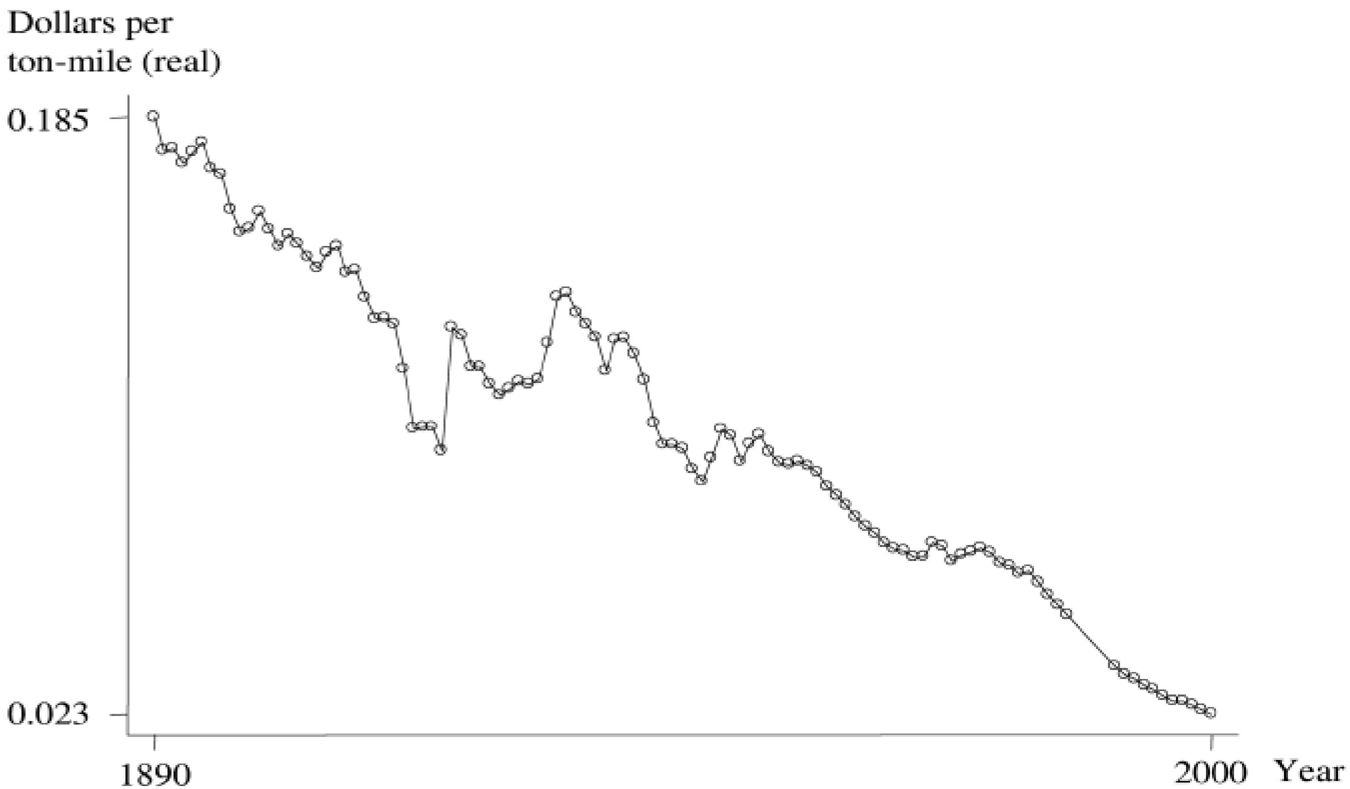


Fig. 3. The costs of railroad transportation over time. *Source:* Historical Statistics of the US (until 1970), 1994, Bureau of Transportation Statistics Annual Reports 1994 and 2002

Implications (1)

1. People are no longer tied to natural resources
2. Consumer-related natural advantages are becoming more important
3. Population is increasingly centralised in a few metropolitan regions
4. People are increasingly decentralised within those regions

Implications (2)

5. High density housing and public transportation are becoming increasingly irrelevant
6. Services are in dense areas; manufacturing is not
7. The location of manufacturing firm is not driven by proximity to customers or suppliers, the location of service firms is determined by proximity
8. Density and education go together

4.3. Urban bus transportation cost and production

Introduction

- An often stated economic argument for the justification of a single bus system, a market structure that chracterizes most urban mass transit systems in the USA, is the presence of large economies of scale.
- Source of scale economies: costs of administrative staff, economies of capital stock utilization, traffic density and generalized economies of scale.
- Viton (1981) analyzed the cost and production structure of bus systems operating in the United States and Canada

Specification

Viton specified a translog empirical cost model in which short-run total variable cost was assumed to depend upon a bus system's produced output, defined as vehicle/miles (millions), input prices for labor (p_l) and fuel (p_f) and a fixed factor of production (buses), which is defined as the number of buses in the bus system. Specifically, the empirical cost model is:

$$
\begin{aligned}
&\ln STVC(T; p, o, k) \\
&= \alpha_0 + \alpha_1(\ln T - \ln \bar{T}) + \alpha_2(\ln p_{\mathrm{l}} - \ln \bar{p}_{\mathrm{l}}) \\
&+\alpha_3(\ln p_{\mathrm{f}} - \ln \bar{p}_{\mathrm{f}}) + \alpha_4\left(\ln \mathrm{buses} - \ln \overline{\mathrm{buses}}\right) \\
&+\text{“second– order and interaction terms”} + \varepsilon
\end{aligned}
$$

Hypotheses

1. Bus transit systems operate under increasing returns to capital utilization → $\alpha_1 < 1$.
2. $\alpha_2 > 0$, $\alpha_3 > 0$ $\alpha_2 + \alpha_3 = 1$
3. An increase in a bus system rolling stock is expected to decrease short-run total variable costs: $\alpha_4 < 0$.

Estimation results

Regressor	Coefficient Estimate (t-statistic)	Interpretation
Constant term	2.63 (9.8)	Logarithm of short-run total variable cost, at the simple mean
Vehicle-Miles (millions)	0.561 (3.6)	Elasticity of short-run total cost with respect to output T at the sample mean
Price of Labor	0.777 (18.4)	Share of labor in short-run total costs, evaluated at the sample mean
Price of Fuel	0.223 (18.4)	Share of fuel in short-run costs, evaluated at the simple mean
Number of Buses	0.566 (3.7)	Elasticity of short- run total cost with respect to buses, at the simple mean
$R^2 = 0.62$		

Note: The estimated translog cost function has the following form:

$$\ln STVC(T;p,k) = \alpha_0 + \alpha_1(\ln T - \ln \bar{T}) + \sum_{i=2}^{1} \alpha_1(\ln p_1 - \ln \bar{p}_1) + \alpha_5\big(\ln buses_1 - \ln \overline{buses}\big)$$
$$+\text{"second-order and interaction terms"} + \varepsilon$$

Source: Viton (1981). Table I. p. 294

Utilization economies

Location	1975 Output[a]	Economies of Capital Stock Utilization[b]	Short-Run Average Variable Cost ($)[c]	Short-Run Marginal Cost ($)[d]
Chicago, Illinois	88.5	1.96 (1.6)	2.18	1.11 (1.7)
Ottawa, Ontario	20.0	1.67 (1.9)	1.26	0.76 (3.0)
Albany, New York	5.5	1.78 (3.1)	1.1	0.62 (5.3)
Huntington, West Virginia	0.9	1.67 (3.5)	0.91	0.54 (5.1)
Greenfield, Massachusetts	0.2	1.96 (1.8)	0.94	0.48 (1.9)

[a] Output is defined in million vehicle-miles.

[b] Economies of utilization ($\varepsilon_{0|k}$) can be estimated in either of two two ways: (1) by taking the ratio of short-run average variable cost in column 3 and the short-run marginal cost in column 4: (2) the inverse of the cost elasticity with respect to ouput, which equals the reciprocal of the output coefficient reported in table 6.4. The measures reported here use the first method where the t-statistic in parentheses tests the null hypothesis that there are no economies of capital stock utilization. Using the alternative approach, capital stock utilization at the sample mean is 1/0.561 = 1.78.

[c] Short-run average variable cost (SRAVC) gives the cost per vehicle-mile and is based on actual data.

[d] Short-run marginal cost gives the cost per vehicle-mile and is defined as $((1/\varepsilon_{0|k}))$SRAVC. The t-statistic in parentheses tests the null hypothesis that the short-run marginal cost is zero.

Source: Adapted from Viton (1981). Table II. p. 296

Optimal bus fleet size

Location	Observed Fleet	Optimal Fleet*
Chicago, Illinois	2.777	1.181
Ottawa, Ontario	629	333
Albany, New York	205	111
Huntington, West Virginia	36	23
Greenfield, Massachusetts	9	6

*Based upon $3.000 renovation costs. 6.75% rate of interest, and five-year extended bus life.
Source: Viton (1981). Table IV. p. 299

Long run economies

Location	Economies of Scale*	Long-Run Average Cost ($)	Long-Run Marginal Cost ($)
Chicago, Illinois	0.87	1.48	1.70
Ottawa, Ontario	0.92	1.17	1.26
Albany, New York	0.98	0.87	0.89
Huntington, West Virginia	1.06	0.90	0.85
Greenfield, Massachusetts	1.15	0.92	0.80

Note: Based upon optimal fleet size in table 6.6 and a replacement cost of $3.000.
* Economies of scale are given by the reciprocal of the cost elasticity with respect to output. $1/(E_{Cost.T})$, which equals long-run average cost (LRAC) divided by long-run marginal cost (LRMC). The ratio of LRAC in column 2 and LRMC in column 3 is the economies of scale measure reported in column 2.
Source: Viton (1981). Table V. p. 300

Comments

1. In the short run bus companies will have trouble covering their variable costs of service.
2. Bus systems in general appear to be overcapitalized.
3. Even with optimal fleets, smaller bus systems require subsidies.

Short-run and long-run cost curves

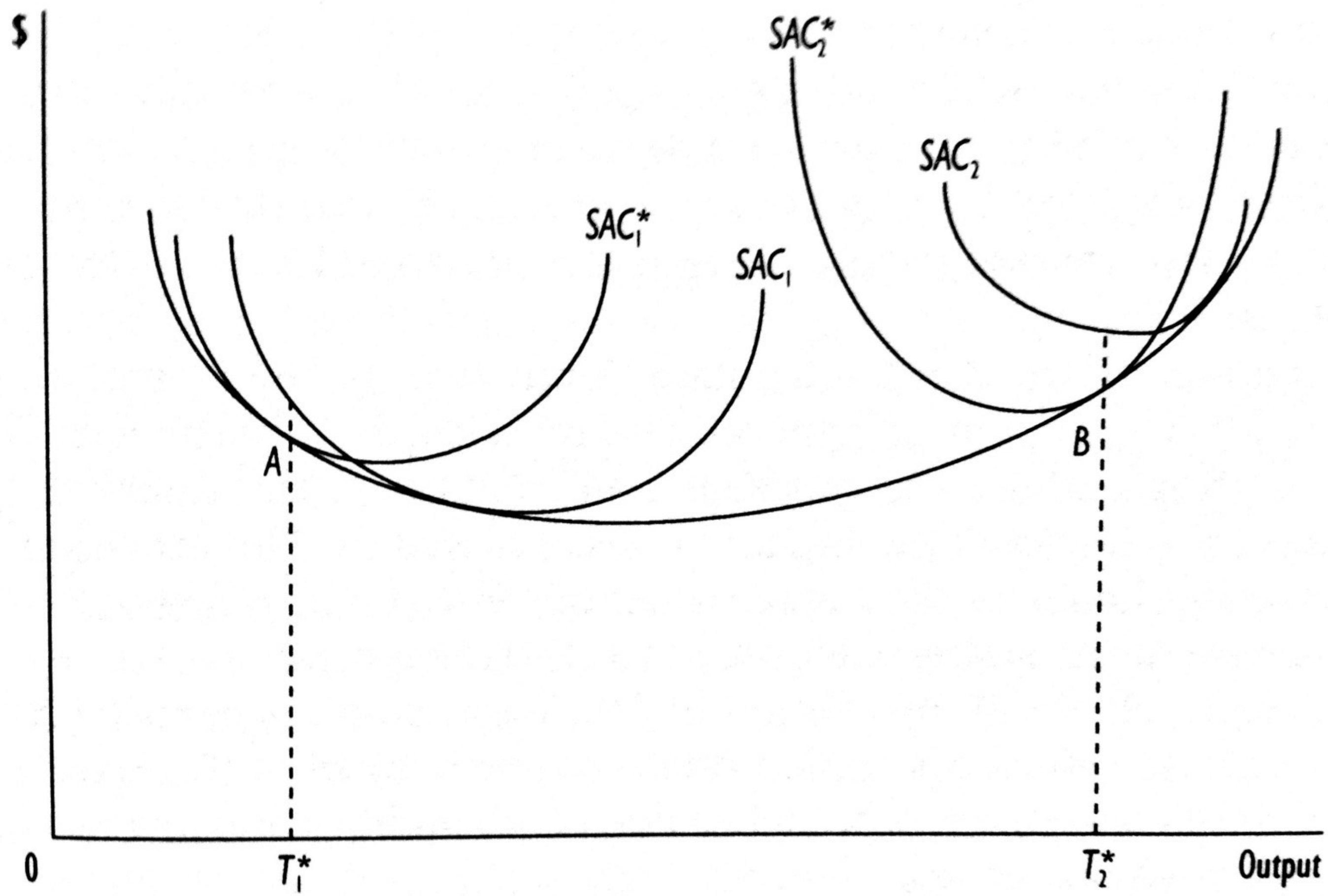


Figure 6.5 A cost and output structure consistent with Viton's study.

Review questions

1. Viton's 1981 study of urban transit costs found that urban transit firms operating in small cities (where fewer than 1 million vehicle-miles are produced annually) operate under increasing returns to scale, in medium-sized cities (which produce between 1 million and 5.5 million vehicle-miles annually) they operate under decreasing returns to scale.
2. Assuming that fares are set at marginal cost, what do these results imply about the possibility of small-scale profitable entry in small, medium, and large cities?
3. Based upon Viton's results, are there any benefits to decentralizing urban transit systems in the largest cities?

4.4 Summary

Summary

- Both short and long average costs curves are U shaped
- In the short run it is due to the law of diminishing returns, in the long run due to economies/diseconomies of scale

Readings for Lecture 5

- Nash, C., Crozet, Y., Nilsson, J. E., & Link, H. (2016). Liberalisation of passenger rail services. *CERRE Report*.