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**EXERCISE 14**


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**LONG TERM COSTS, ECONOMIES OF SCALE AND EQUIPMENT SELECTION**

*Several aspects of cost in microeconomics are presented in this exercise. In the first part the focus is on short-term analysis : in the second part the long-term aspects are explored.*

W.K. Lewis of Edmonton has just won a contract to build a road near Fort McMurray. The terrain in the area is very uneven and as a consequence filling up and blasting will have to be undertaken. John Arlington, roadworks division manager, has to decide whether to use Lewis' own trucks for the project or subcontract out to a local company, Cold Lake Transport (CLT). CLT would charge 17.5 cents per cubic meter. This price includes costs associated with the loading of the trucks.

Arlington figures out that, using Lewis' own fleet, 10 trucks of the same size would be necessary. Lewis has dump-trucks with carrying capacity of 20 m<sup>3</sup>, 30 m<sup>3</sup> and 40 m<sup>3</sup>. Loading the trucks will be done by mechanical shovels rented at a cost of 2500 dollars a week per unit. The maximum number of trips done varies with the number of shovels (table 1). Obviously, the bigger trucks can haul more, but they take longer to load, and are more difficult to handle especially in this difficult area of northern Alberta.

**TABLE 1**  
**Number of trips with a fleet of 10 trucks**

		With 20m <sup>3</sup> carrying capacity					
<b>Nb of shovels</b>		1	2	3	4	5	6
<b>Nb of trips</b>		360	500	600	670	720	750
		With 30m <sup>3</sup> carrying capacity					
<b>Nb of shovels</b>		2	3	4	5	6	7
<b>Nb of trips</b>		410	500	580	630	670	690
		With 40m <sup>3</sup> carrying capacity					
<b>Nb of shovels</b>		2	3	4	5	6	7
<b>Nb of trips</b>		350	440	510	560	590	610

Arlington estimates that the total cost of a dump-truck with a carrying capacity of  $20 \text{ m}^3$  is 1400 dollars a week. The same cost will be 2000 dollars for  $30 \text{ m}^3$  capacity and 2400 dollars for  $40 \text{ m}^3$ .

## **QUESTIONS**

### **A) Short-term analysis**

In Part A, suppose that Arlington considers only dump trucks with a  $30 \text{ m}^3$  carrying capacity.

#### **Question 1**

On a first graph, plot the total-cost curve.

#### **Question 2**

On a second graph, plot the average-cost curve.

#### **Question 3**

Calculate the marginal product of the «mechanical shovel» factor.

#### **Question 4**

Considering the results of question 3, what is the shape of the marginal-cost curve ?

#### **Question 5**

Calculate the marginal cost and plot it on the second graph.

#### **Question 6**

How could the information provided by the marginal cost could be used.

B) Long-term analysis

**Question 7**

On a new graph, plot the average cost associated with the three kind of trucks.

**Question 8**

In the present problem, what is the main source of economies or diseconomies of scales ?

**Question 9**

For which quantity should Arlington shift from 20 m<sup>3</sup> to 30 m<sup>3</sup> carrying capacity ?

**Question 10**

If Arlington could choose, what quantity would he select to haul per week ?

**Question 11**

When should Lewis subcontract out to CLT ?

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## ANSWERS

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### A) Short-term analysis

In the short-term only one factor varies, the others remain constant. In the present case, once the type of truck is selected, the only variable factor is the mechanical shovels.

### Question 1.

Total cost is divided in two parts : fixed cost (cost of 10 dump-trucks with carrying capacity of  $30\text{m}^3$ ) and variable cost (cost of renting the mechanical shovels).

The value of the total costs is given in table A.

Total cost is represented by a step-like graph ; each step is associated with renting an extra mechanical shovel (figure 14.1). Only at points A, B, C, D, E and F are the shovels used at their full capacity.

### Question 2.

If we assume that the variable "mechanical shovel" is a discrete variable (cannot rent a fraction of a mechanical shovel), the total cost is constant between two levels of full capacity. If total cost is constant, then the average cost is continuously decreasing between the two levels of full capacity. The average cost curve is in fact a series of hyperbolas. Discontinuity occurs every time a shovel is rented (figure 14.2).

**TABLE A**  
**Average and total cost table**

**Trucks with a carrying capacity of 20 m<sup>3</sup>**

<b>N</b>	<b>T</b>	<b>Q</b>	<b>TC</b>	<b>AC</b>
1	360	72,000	16,500	0.229
2	500	100,000	19,000	0.190
3	600	120,000	21,500	0.179
4	670	134,000	24,000	0.179
5	720	144,000	26,500	0.184
6	750	150,000	29,000	0.193

**Trucks with a carrying capacity of 30 m<sup>3</sup>**

<b>N</b>	<b>T</b>	<b>Q</b>	<b>TC</b>	<b>ACF</b>
2	410	123,000	25,000	0.203
3	500	150,000	27,500	0.183
4	580	174,000	30,000	0.172
5	630	189,000	32,500	0.172
6	670	201,000	35,000	0.174
7	690	207,000	37,500	0.181

**Trucks with a carrying capacity of 40 m<sup>3</sup>**

<b>N</b>	<b>T</b>	<b>Q</b>	<b>TC</b>	<b>ACF</b>
2	350	140,000	29,000	0.207
3	440	176,000	31,500	0.179
4	510	204,000	34,000	0.167
5	560	224,000	36,500	0.163
6	590	236,000	39,000	0.165
7	610	244,000	41,500	0.170

N is the number of mechanical shovels ; T is the maximum number of trips ; Q the quantity hauled, TC the total cost and ACF the average cost at full capacity.

**Question 3.**

The values of the marginal product of the «mechanical shovel» factor are as follows :

<b>Shovel</b>	<b>MP</b>
third	27,000 m <sup>3</sup>
fourth	24,000 m <sup>3</sup>
fifth	15,000 m <sup>3</sup>
sixth	12,000 m <sup>3</sup>
seventh	6,000 m <sup>3</sup>

**Question 4.**

As the marginal product function is decreasing, marginal cost is increasing.

**Question 5.**

As the «mechanical shovel» variable varies on a unit basis, the marginal cost, strictly speaking, is zero for every quantity other than the ones for which equipment is used at full capacity ; it is equal to \$2500 at full capacity. In fact it is more useful to use an «average» marginal cost between two full capacity utilizations.

$$\text{As } MC = \frac{P}{MP} \text{ (where P is the renting price)}$$

The marginal cost has the following values :

<b>Quantities</b>	<b>MC (in dollars)</b>
Between 123,000 and 150,000	0.092
Between 150,000 and 174,000	0.104
Between 174,000 and 189,000	0.167
Between 189,000 and 201,000	0.208
Between 201,000 and 207,000	0.417

**Question 6.**

Marginal cost can be used for pricing. If after agreeing on a price and a volume to haul we decide, a posteriori, to increase the quantity, marginal cost is the minimal price that must be charged for additional m<sup>3</sup> assuming that the initial conditions still prevail.

Assuming a carrying capacity of 30 m<sup>3</sup>, to haul 189 000 tonnes 0.172 dollar will have to be charged per m<sup>3</sup> (Refer to average and total cost table). If we decide a posteriori to haul an additional 12,000 m<sup>3</sup>, the marginal cost table indicates that we should charge 0.208 dollar per m<sup>3</sup>.

**B) Long-term analysis**

In the long-term all the factors of production vary. In the present context, this means that the size of the trucks could change.

**Question 7.**

The marginal cost curves are shown in figure 14.4.

**Question 8.**

Economies of scales are greater than diseconomies of scale, since the minimum average cost (short term) of 40 m<sup>3</sup> carrying capacity trucks is less than the minimum average cost (short term) of 30 m<sup>3</sup> capacity trucks, which in turn is less than the minimum average cost (short term) of trucks with 20 m<sup>3</sup> load capacity.

Economies are due mainly to the fact that the user cost of the trucks per m<sup>3</sup> decreases as the size increases. The user cost is 70 dollars per m<sup>3</sup> for trucks with carrying capacity of 20 m<sup>3</sup>, \$66.67 for 30 m<sup>3</sup> and \$60 for 40 m<sup>3</sup>.

As the bigger trucks are harder to handle and take longer to load and unload, diseconomies of scale occur. However, this disadvantage is not great enough to cancel out the advantage from the economies of scale.

**Question 9.**

Figure 14.4 confirms that up to 147,000 m<sup>3</sup>, trucks with a load capacity of 20 m<sup>3</sup> should be used. Between 147,000 m<sup>3</sup> and 191,000 m<sup>3</sup>, 30 m<sup>3</sup> should be used. For quantities greater than 191,000 m<sup>3</sup>, trucks with a carrying capacity of 40 m<sup>3</sup> should be selected.

**Question 10.**

If John Arlington has a choice, he will select the equipment having the lowest average cost. According to the cost table and to figure 14.4, a weekly quantity of 224,000 m<sup>3</sup> will produce the lowest cost per unit. Such cost will be obtained with 10 trucks, with a carrying capacity of 40 m<sup>3</sup> and 5 mechanical shovels.

**Question 11.**

For quantities less than 165,000 m<sup>3</sup>, the price proposed by CLT is more advantageous than the production cost of W.K. Lewis.