Long run equilibrium with different technologies

Consider the market for electric scooters. There are two technologies used by firms in this industry: Technology 1, has a cost function $C^1(q) = q + 4q^2 + 32$ for $q > 0$. Technology 2, with a cost function $C^2(q) = q + 2q^2 + 32$ for $q > 0$. Assume that we are in the long run, so firms using both technologies can shut down and leave the market at 0 cost, so that $C(0) = 0$ for both technologies.

1. What are the marginal and average cost curves for each of these two technologies? In the long-run, assuming that firms can choose their technology, will any firms choose technology 1? Why or why not?

2. Find the individual supply curve of a firm operating with Technology 2.

3. Suppose that market demand is given by $D(p) = 820 - 40p$. What will be the long-run price in the market? How much will each firm produce at this price? What will the total number of firms be?

4. Now, suppose that the government offers renewable energy subsidies to manufacturers. These subsidies amount to $28 and the manufacturers receive these subsidies as long as they produce a positive quantity with the technology 1. What are the new average cost (AC), marginal cost (MC), and supply curves?

5. What will be the long-run price now that there are 10 manufacturers using technology 1 (assuming that there is still free entry for firms using technology 2)? What quantity will be produced by firms using technology 1 and 2? In equilibrium, how many firms using technology 2 will there be in the market?

Solutions

1. The MC and AC curves are:

$$MC^1(q) = 1 + 8q$$
$$MC^2(q) = 1 + 4q$$
$$AC^1(q) = 1 + 4q + \frac{32}{q}$$
$$AC^2(q) = 1 + 2q + \frac{32}{q}$$

No firms will choose first technology. Looking at the two cost functions, we can see that $AC^1(q) > AC^2(q)\ \forall q$. Therefore, firms will choose technology 2 regardless of their desired level of output.

2. Given price p, firms will choose q to maximize profits. They will do so by setting $p = MC$. For technology 2 this means $p = 1 + 4q$ so $q(p) = \frac{p-1}{4}$. We must also consider that the firm can exit the market (i.e., produce $q = 0$), so the supply curve will coincide with the marginal cost curve only when it is above the average cost curve. Hence, we have

$$q(p) = \begin{cases} \frac{p-1}{4} & \text{if } p \geq 17 \\ 0 & \text{if } p < 17 \end{cases}$$

3. With free entry, we know that firms will continue entering the market until profits are zero. Thus, in the long-run equilibrium, the price must be equal to the minimum average total cost, so $p^* = 17$. We can obtain this result by minimizing the average total cost:

$$\frac{\partial AC^2}{\partial q} = 2 - 32/q^2 = 0$$
$$q^2 = 16$$
$$q = 4$$

Then replacing in the supply curve:

$$4 = \frac{p-1}{4}$$
$$16 + 1 = 17 = p^*$$

To determine the equilibrium quantity and the total number of firms, we analyze the market demand at this price. We evaluate the demand function at this price, so we obtain $Q = 140$. To find the quantity produced by each individual firm, we evaluate the individual supply curve at the equilibrium price, so we obtain $q = \frac{17-1}{4} = 4$. Because each firm produces $q = 4$, the total number of firms, N, is $N = \frac{140}{4} = 35$.

4. Now the cost curve is:

$$C^1(q) = q + 4q^2 + 32 - 28 = q + 4q^2 + 4$$

The new MC, AC, and supply curves for Technology 1 with the subsidy are:

$$MC^1(q) = 1 + 8q$$
$$AC^1(q) = 1 + 4q + \frac{4}{q}$$

If we set $MC = p$, then $1 + 8q = p$ so $q = \dfrac{p-1}{8}$

$$q^1(p) = \begin{cases} \frac{p-1}{8} & \text{if } p \geq 9 \\ 0 & \text{if } p < 9 \end{cases}$$

5. At $p = 17$, the firms with technology 1 will each supply $q^1(p) = \frac{17-1}{8} = 2$ electric vehicles. Consequently, in total technology 1 firms will supply $10 \cdot 2 = 20$ electric vehicles, leaving technology 2 firms to supply the remaining demand when $p = 17$, this is $140 - 20 = 120$. Because the price is still 17, we know that each technology 2 firm will still produce 4 electric vehicles. Consequently, the total number of technology 2 firms will be $N^2 = \frac{120}{4} = 30$.