[a] 20. Assume that the ice cream industry is perfectly competitive. Each firm producing ice cream must hire an operations manager. There are only 50 operations managers that display extraordinary talent for producing ice cream; there is a potentially unlimited supply of operations managers with average talent. Operations managers are all paid $200,000 per year.

- The long-run total cost (in thousands of dollars) faced by firms that hire operations managers with exceptional talent is given by $LTC_E = 200 + Q^2$, where Q is measured in thousands of gallon tubs of ice cream. The corresponding marginal cost function is given by $LMC_E = 2Q$, and the corresponding long-run average total cost is $LATC_E = 200/Q + Q$.
- The long-run total cost faced by firms that hire operations managers with average talent is given by $LTC_A = 200 + 2Q^2$. The associated marginal cost function is given by $LMC_A = 4Q$, and the corresponding long-run average total cost is $LATC_A = 200/Q + 2Q$.

a. Derive the firm supply curve for ice cream producers with extraordinary operations managers.

b. Derive the firm supply curve for ice cream producers with average operations managers.

c. The minimum $LATC_A$ (for firms with average operations managers) is $40, achieved when those firms produce 10 units of output. The minimum $LATC_E$ (for firms with exceptional operations managers) is $28.28, achieved when those firms produce 14 units of output. Explain why, given only that information, it is not possible to determine the long-run equilibrium price of 5-gallon tubs of ice cream.

d. Referring to part (c), suppose that you know that the market demand for ice cream is given by $Q^d = 8{,}000 - 100P$. Explain why, in the long run, that demand will not be filled solely by firms with extraordinary managers. (*Hint*: Derive the industry supply of extraordinary producers and then use the demand curve to determine the equilibrium price. Can that price persist in the long run?)

e. In part (d), you explained why the supply side of the market will consist of both firms with extraordinary managers and firms with average managers. What will the long-run equilibrium price of ice cream be?

f. At the price you determined in part (e), all 50 firms with extraordinary managers will find remaining in the industry worthwhile. How many firms with average managers will also remain in the industry?

g. At the price you determined in part (e), how much profit will a firm with an average manager earn?

h. At the price you determined in part (e), how much profit will a firm with an extraordinary manager earn? How much economic rent will that talented manager generate for her firm?

i. Use calculus to confirm that marginal costs for exceptional and average talent operations managers are as given in the problem.

j. Calculate producer surplus in the long-run equilibrium using calculus. (Hint: Remember how producer surplus is calculated in the Appendix to Chapter 3.)