

#8.10

#24 ⑤ (a) Let K_C BE CHEMCO'S PROFIT WHEN $x=30$, AND LET K_B BE THE BREWERY'S PROFIT WHEN $x=0$. THUS, $\pi_C(x) = K_C - \frac{1}{2}(x-30)^2$ AND $\pi_B = K_B - \frac{2}{3}x^2$. EFFICIENCY REQUIRES THAT $\pi_C + \pi_B$ BE MAXIMIZED:

$$\pi(x) \triangleq \pi_C(x) + \pi_B(x) = K_C + K_B - \frac{1}{2}(x-30)^2 - x^2$$

$$\pi'(x) = 30 - x - 2x = 0 \iff \boxed{x=10}$$

$$\pi_C(10) = K_C - 200 \text{ AND } \pi_B(10) = K_B - 100;$$

$$\pi_C(30) = K_C \text{ AND } \pi_B(30) = K_B - 900.$$

IF t IS THE DOLLAR AMOUNT DE BEERS PAYS TO CHEMCO, THEN $t \geq 200$ ~~is~~ $= \pi_C(30) - \pi_C(10)$ AND $t \leq 800 = \pi_B(10) - \pi_B(30)$.

(b) $\pi_C(0) = K_C - 450$ AND $\pi_B(0) = K_B$. THUS, IF t IS THE AMOUNT PAID BY CHEMCO TO DE BEERS TO ALLOW CHEMCO TO SET $x=10$, THEN

$$t \geq 100 = \pi_B(0) - \pi_B(10) \text{ AND } t \leq 250 = \pi_C(10) - \pi_C(0).$$

THE PARETO LEVEL IS STILL $x=10$.

(c) WITH MANY FIRMS, IT WILL BE DIFFICULT TO ATTAIN THE EFFICIENT OUTCOME: EACH DOWNSTREAM FIRM HAS AN INCENTIVE TO BEHAVE AS IF ITS DAMAGE FROM POLLUTION IS MUCH GREATER THAN IT ACTUALLY IS — THERE IS A FREE-RIDER PROBLEM

