The variables are
$$p_i \in [0, p_i^{max}]$$

Q 4

Profit ~~function~~ of

The Bayesian equilibrium is a maximal point of expected payoff of firm 2.

$$EP_2 = u_2$$

$$\frac{\partial \hat{E}P_2}{\partial q_2}(q_1^*, q_2^*) = \theta_2 - q_1^* - 2q_2^* = 0$$

$$q_2^*(\theta_2) = (\theta_2 - q_1^*)/2 \quad (\theta_2 = \{3/4, 5/4\})$$

Expected pay off is as follows

$$EP_1 = \frac{1}{2} q_1 (\theta_1 - q_1 - q_2(3/4)) + \frac{1}{2} q_1 (\theta_1 - q_1 - q_2 (5/4))$$

$$\frac{\partial EP_1}{\partial q_1}(q_1^*, q_2^*) = 1 - 2q_1^* - \frac{1}{2}\{q_2^*(3/4) + q_2^*(5/4)\} = 0$$

$$q_1^* = \frac{2 - q_2^*(3/4) - q_2^*(5/4)}{4}$$

on solving Bayesian equilibrium we get

$$q_1^* = \frac{1}{3} \quad , \quad q_2^*(3/4) = \frac{11}{24} \quad , \quad q_2^*(5/4) = \frac{5}{24}$$