Announcements

- Tutorials
  - According to the syllabus, only your first presentation is graded, and none after.
  - It was announced that all your presentations would be graded, and the average taken.
  - We will follow what was stated in the syllabus.
  - If you have already presented and do not want that grade to be counted, then tell your tutor and your participation points will be based on your next presentation.

Announcements

- Homework #1
  - Has been posted on IVLE. Due in your TA's mailbox (5th floor AS2) on Monday, September 14th at 9 a.m. My mailbox is on 6th floor AS2.
  - If you are in tutorial W01, you can turn it in to me in class.

Quantity Tax Levied on a Monopolist

- Can a monopolist “pass” all of a \$t quantity tax to the consumers?
- Suppose price elasticity of demand is constant
- Suppose the marginal cost of production is constant at \$k/output unit.

Quantity Tax Levied on a Monopolist

- Recall that $MR(y) = p(y)\left[1 + \frac{1}{\epsilon}\right] = MC$

So, $p(y) = \frac{MC}{\left[1+\frac{1}{\epsilon}\right]} = \frac{\epsilon MC}{1+\epsilon}$

With no tax, the monopolist's price is

$$p(y^*) = \frac{k\epsilon}{1+\epsilon}$$

Quantity Tax Levied on a Monopolist

- The tax increases marginal cost to \$(k+t)/output unit, changing the profit-maximizing price to

$$p(y^t) = \frac{(k+t)\varepsilon}{1+\varepsilon}.$$

- The amount of the tax paid by buyers is

$$p(y^t) - p(y^*).$$

Quantity Tax Levied on a Monopolist

$$p(y^t) - p(y^*) = \frac{(k+t)\varepsilon}{1+\varepsilon} - \frac{k\varepsilon}{1+\varepsilon} = \frac{t\varepsilon}{1+\varepsilon}$$

is the amount of the tax passed on to buyers. E.g. if ϵ = -2, the amount of the tax passed on is 2t.

Because the monopolist always operates on the elastic portion of the demand curve, ϵ < -1.

This means that $\frac{\epsilon}{1+\epsilon} > 1$ and so the monopolist passes on to consumers more than the tax!

Quantity Tax Levied on a Monopolist

- The closer demand is to unit elastic, that is the less elastic demand is, the larger the difference in $p(y^t) - p(y^*)$.
- Example:

$$\epsilon = \text{-}2, \frac{\epsilon t}{1+\epsilon} = 2t$$

$$\epsilon = -4, \frac{\epsilon t}{1+\epsilon} = \frac{4}{3} t = 1.33t$$

$$\epsilon = -100, \frac{\epsilon t}{1+\epsilon} = \frac{100}{99} t = 1.01t$$

Chapter 28: Oligopoly

Good News

- Sections to ignore in the textbook:
  - Anything related to isoprofit lines
  - 28.3: Price leadership

Oligopoly

- You have seen two different market structures:
  - Perfect Competition
  - Monopoly

Oligopoly

	Perfectly Competitive Market	Monopoly Market
Industry Structure	Fragmented (no seller has significant market share)	Concentrated (one firm dominates the entire market
Pricing	Price takers	Price makers
Barriers to entry	None	Significant
Examples	Raw commodities (palm oil, soybeans, wheat)	Drugs with patents (Viagra until 2019)

Oligopoly

	Perfectly Competitive Market	Oligopoly	Monopoly Market
Industry Structure	Fragmented (no seller has significant market share)	A small number of firms dominate the market	Concentrated (one firm dominates the entire market
Pricing	Price takers	Depends	Price makers
Barriers to entry	None	Some	Significant
Examples	Raw commodities (palm oil, soybeans, wheat)	Cola, Airlines, Cellular Service Providers	Drugs with patents (Viagra until 2019)

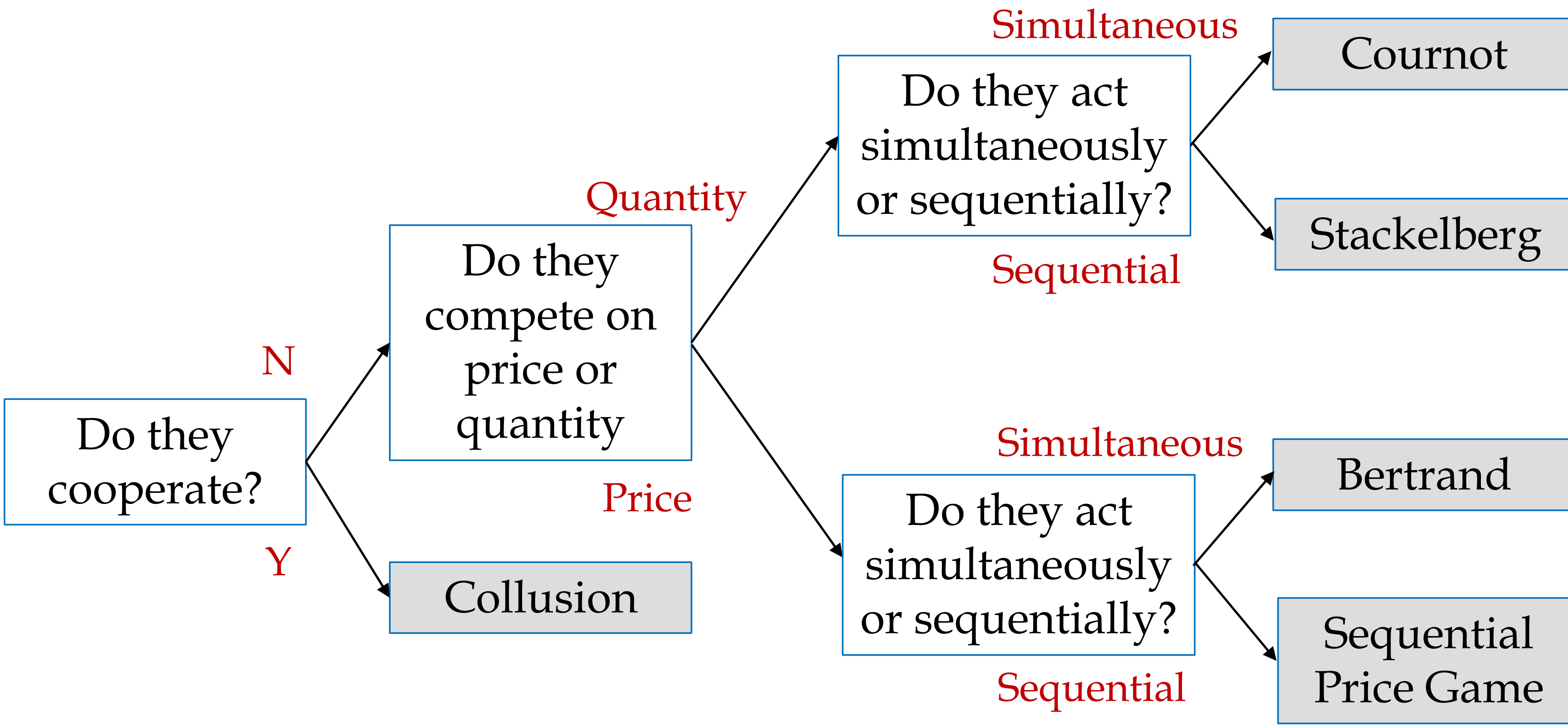
Oligopoly

	Perfectly Competitive Market	Oligopoly	Monopoly Market
Industry Structure	Fragmented (no seller has significant market share)	A small number of firms dominate the market	Concentrated (one firm dominates the entire market
Pricing	Price takers	Depends	Price makers
Product	Homogenous	Could vary	Only one
Barriers to entry	None	Some	Significant
Examples	Raw commodities (palm oil, soybeans, wheat)	Cola, Airlines, Cellular Service Providers	Drugs with patents (Viagra until 2019)

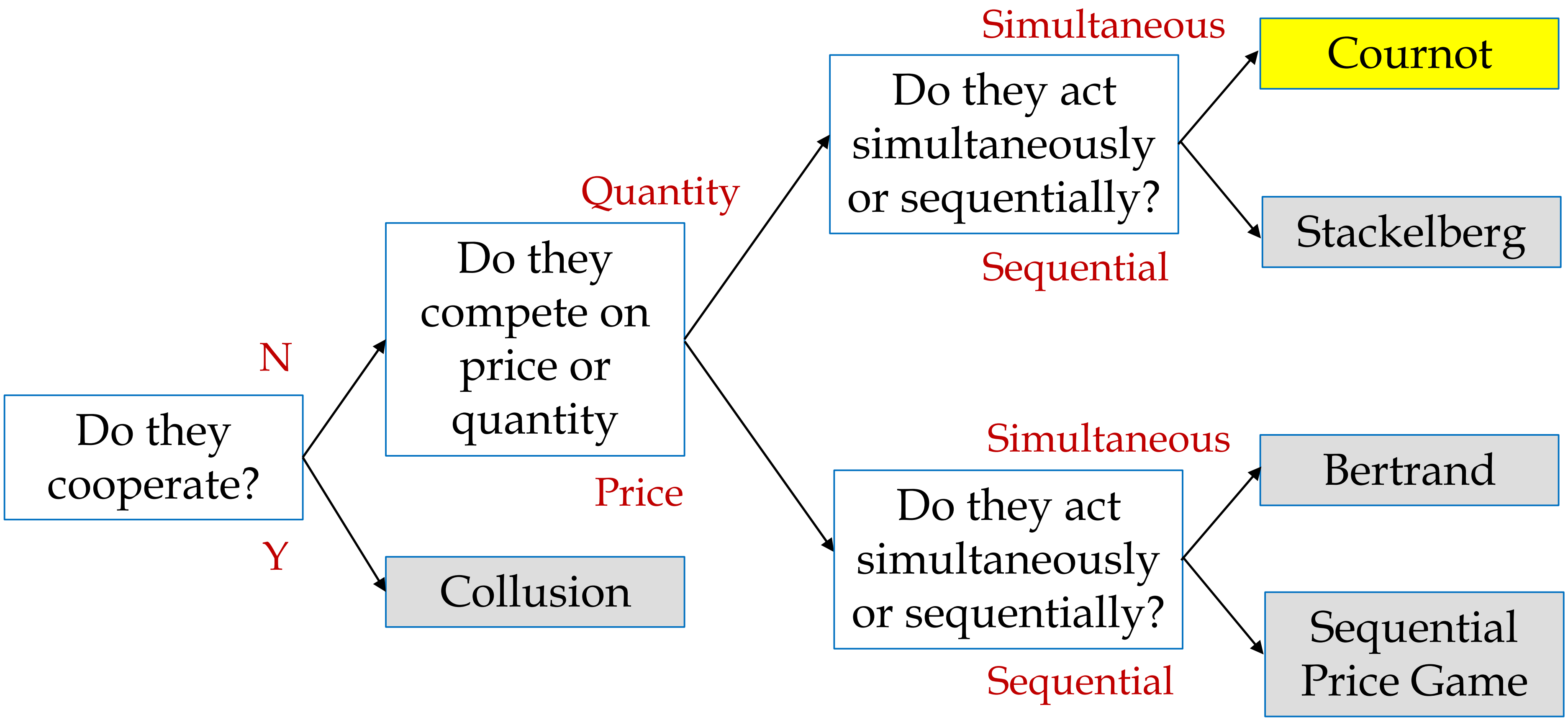
Oligopoly

- It is not always easy to define Oligopoly markets
- For example, when Coca-Cola wanted to acquire Dr. Pepper it defined its relevant market as the market for all beverages, while the US Federal Trade Commission defined the relevant market as the market for carbonated beverages.

Types of Oligopoly Markets



Types of Oligopoly Markets



Cournot Competition

- Firms produce identical products
- Firms compete by independently and simultaneously choosing output levels.

Cournot Competition: An Example

- In the 1990s and 2000s, Singapore Airlines (SQ) and Malaysia Airlines (MH) were the only producers of an identical good:
  - flights between Singapore Changi Airport and Subang International Airport (followed by Kuala Lumpur International Airport)
- Let's assume both airlines chose their quantities independently and simultaneously.

Cournot Competition: An Example

- Suppose that the market inverse demand function is

$$P = 100 - X - Y$$

where X is the quantity produced by SQ and Y is the quantity produced by MH.

- Both airlines have the same marginal cost: $MC = 10$

Cournot Competition: An Example

- Although neither firm directly chooses price (remember, in this model, they choose quantity) the quantity decisions each makes affects the market price and profitability of the other firm.
  - If SQ produces 30 and MH produces 30,
  $$P = 100 - 30 - 30 = 40$$
  - If SQ increases production to 40,
  $$P = 100 - 40 - 30 = 30$$
- This will definitely decrease MH’s profits

Cournot Competition: An Example

- In this example, what are we interested in knowing?
    - What quantities will each airline choose?

Cournot Competition: An Example

- Since both airlines make their quantity decisions simultaneously, they have to form expectations about what the other airline will do.
  - SQ will choose a quantity that maximizes its profits given what it expects MH to do.
  - MH will choose a quantity that maximizes its profits given what it expects SQ to do.

Cournot Competition: An Example

- Suppose SQ believes MH will produce Y=50
- Then the residual demand that SQ faces is

$$
\begin{aligned}
P &= 100 - X - 50 \\
&= 50 - X
\end{aligned}
$$

- Residual demand is the remaining demand left for SQ after MH has taken its share. SQ can behave as a monopolist with regard to its residual demand

Cournot Competition: An Example

- Since Residual Demand, $P = 50 - X$

$$\text{Revenue} = (50 - X)X$$

$$\text{Marginal Revenue, MR} = \frac{\partial Rev}{\partial X} = 50 - 2X$$

Setting MR=MC

$$50 - 2X = 10$$

$$\underline{X = 20}$$

Cournot Competition: An Example

- Suppose SQ believes MH will produce Y=40
- Then the residual demand that SQ faces is

$$P = 100 - X - 40$$
$$= 60 - X$$

$$\text{Revenue} = (60 - X)X$$

$$\text{Marginal Revenue, MR} = \frac{\partial Rev}{\partial X} = 60 - 2X$$

Setting MR=MC

$$60 - 2X = 10$$
$$\underline{X = 25}$$

Cournot Competition: An Example

- We can uncover the quantity maximizes SQ's profit given any possible quantity produced by MH.
- SQ's best response function describes SQ's best response to each possible move made by MH.
- SQ's best response function is a function of MH's choice, Y. Let's call this $B_{SQ}(Y)$

Cournot Competition: An Example

- Let’s derive SQ’s best response function:

Residual demand $P = (100 - Y) - X$

SQ acts as a monopolist with respect to residual demand:

$$Revenue = [(100 - Y) - X]X$$

$$MR = 100 - Y - 2X \qquad\qquad MC = 10$$

Setting $MR = MC$,

$$100 - Y - 2X = 10$$

$$X = \frac{90 - Y}{2}$$

Cournot Competition: An Example

- That is, SQ's best response function,

$$B_{SQ}(Y) = \frac{90 - Y}{2}$$

Cournot Competition: An Example

- We do the same thing to derive MH's best response function:

Residual demand $P = (100 - X) - Y$

MH acts as a monopolist with respect to residual demand:

$$Revenue = [(100 - X) - Y]Y$$

$$MR = 100 - X - 2Y \qquad\qquad MC = 10$$

Setting $MR = MC,$

$$100 - Y - 2Y = 10$$

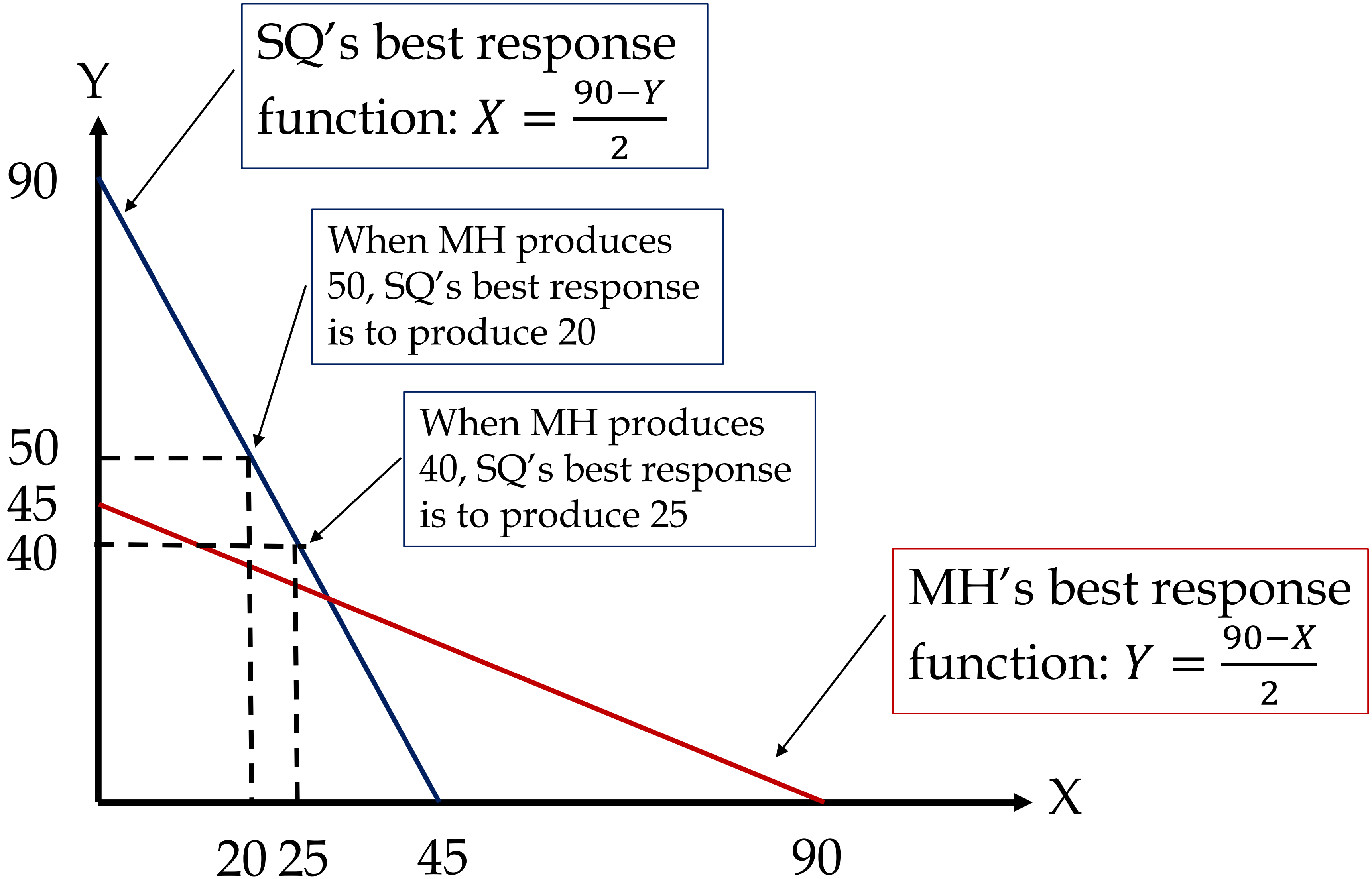
$$Y = \frac{90 - X}{2}$$

Cournot Competition: An Example

- That is, MH's reaction function,

$$B_{MH}(X) = \frac{90 - X}{2}$$

Cournot Competition: An Example



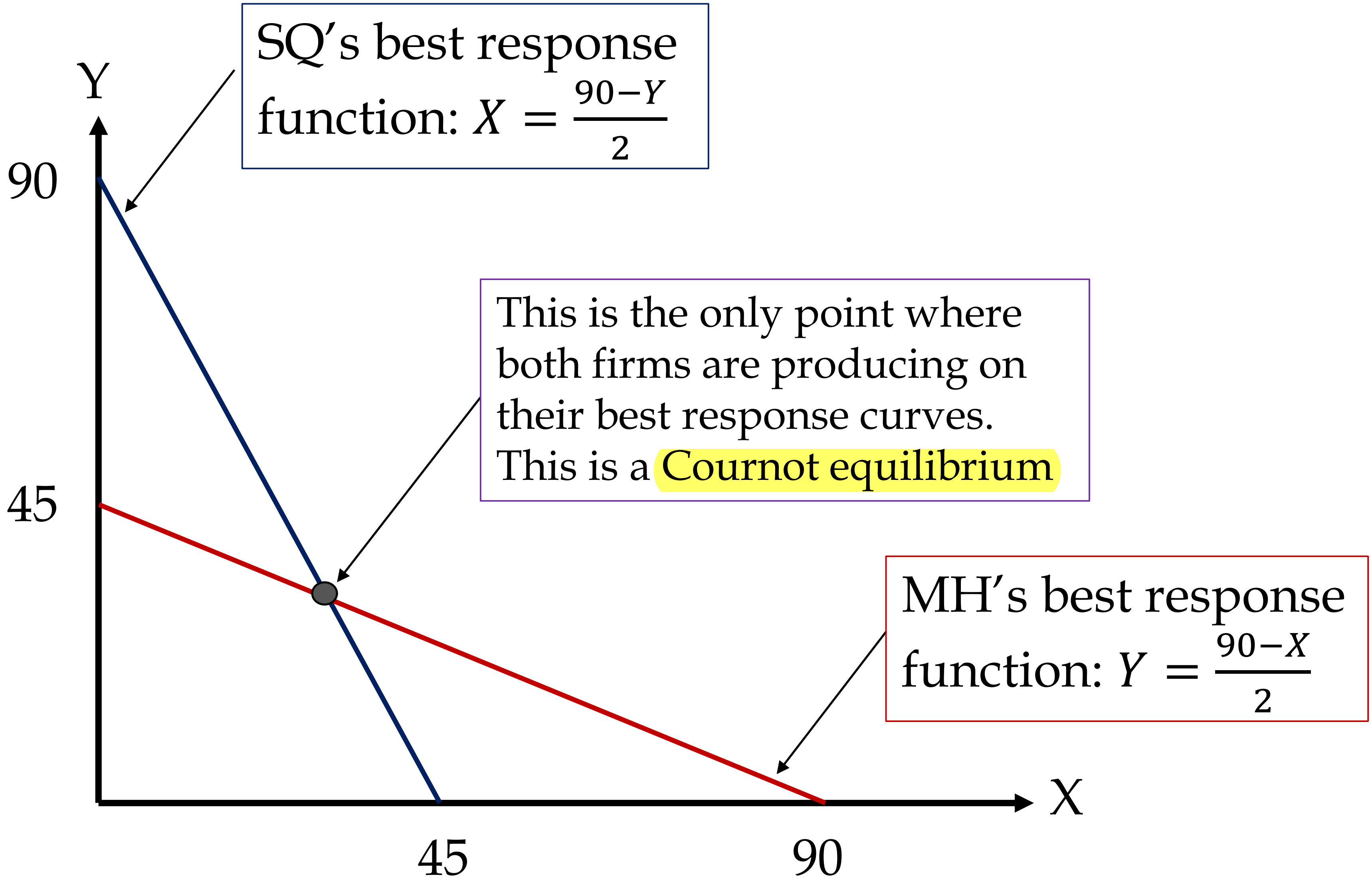
Cournot Competition: An Example

- Cournot Equilibrium:
  - In a Cournot equilibrium,
  - SQ is maximizing its profits given its beliefs of what MH will do, AND
  - MH is maximizing its profits given its beliefs of what SQ will do.

Cournot Competition: An Example

- This means SQ is producing at a point on its best response function, and MH is producing at a point on its best response function

Cournot Competition: An Example



Cournot Competition: An Example

- Mathematically, we have to solve:

$$X = \frac{90-Y}{2} \text{ and } Y = \frac{90-X}{2}$$

- Plugging one into the other,

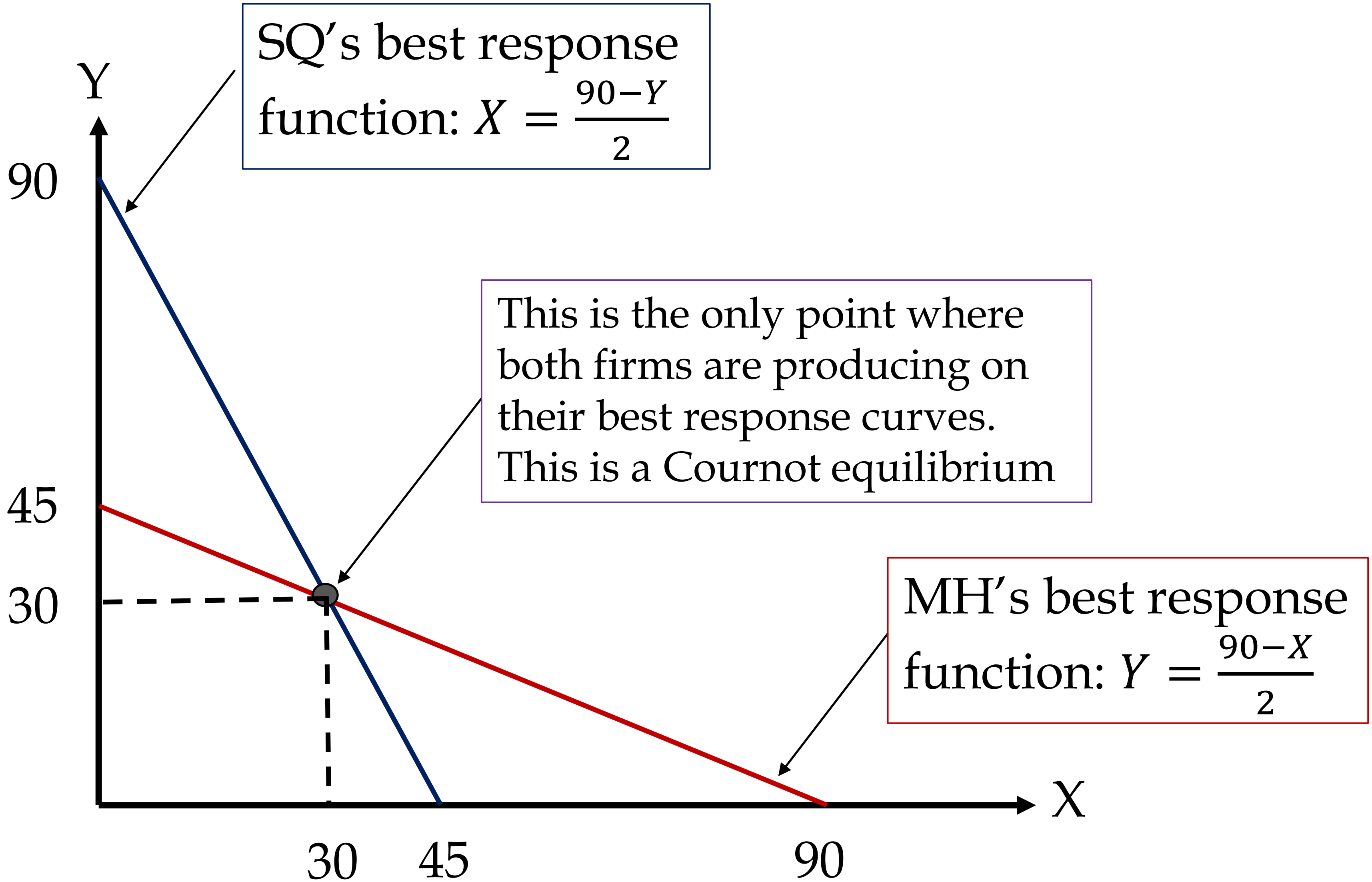
$$X = \frac{90-\left(\frac{90-X}{2}\right)}{2}$$

$$= \frac{180-90+X}{4}$$

$$\frac{3}{4}X = \frac{90}{4}$$

$$\underline{X = 30, Y = 30}$$

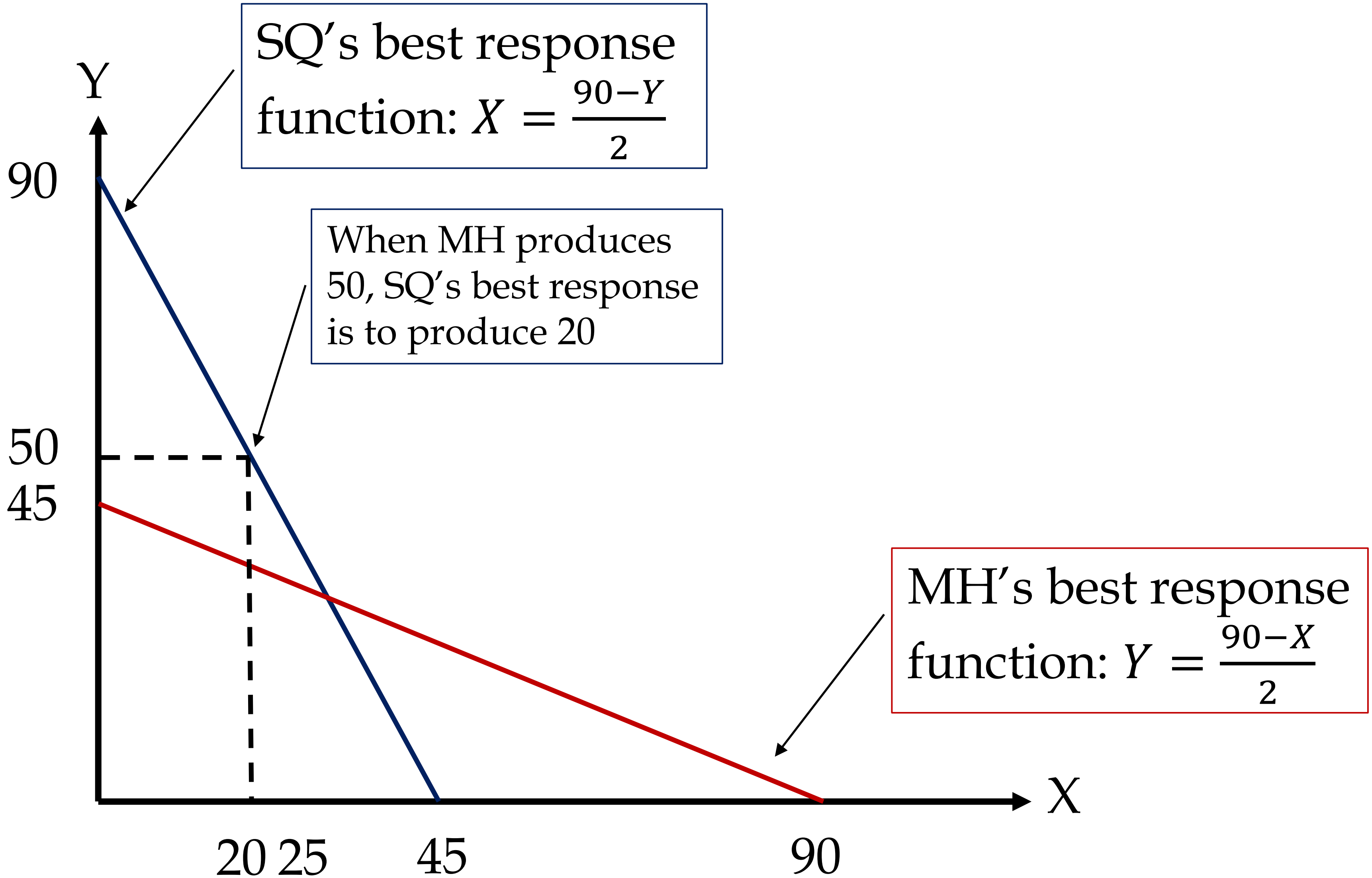
Cournot Competition: An Example



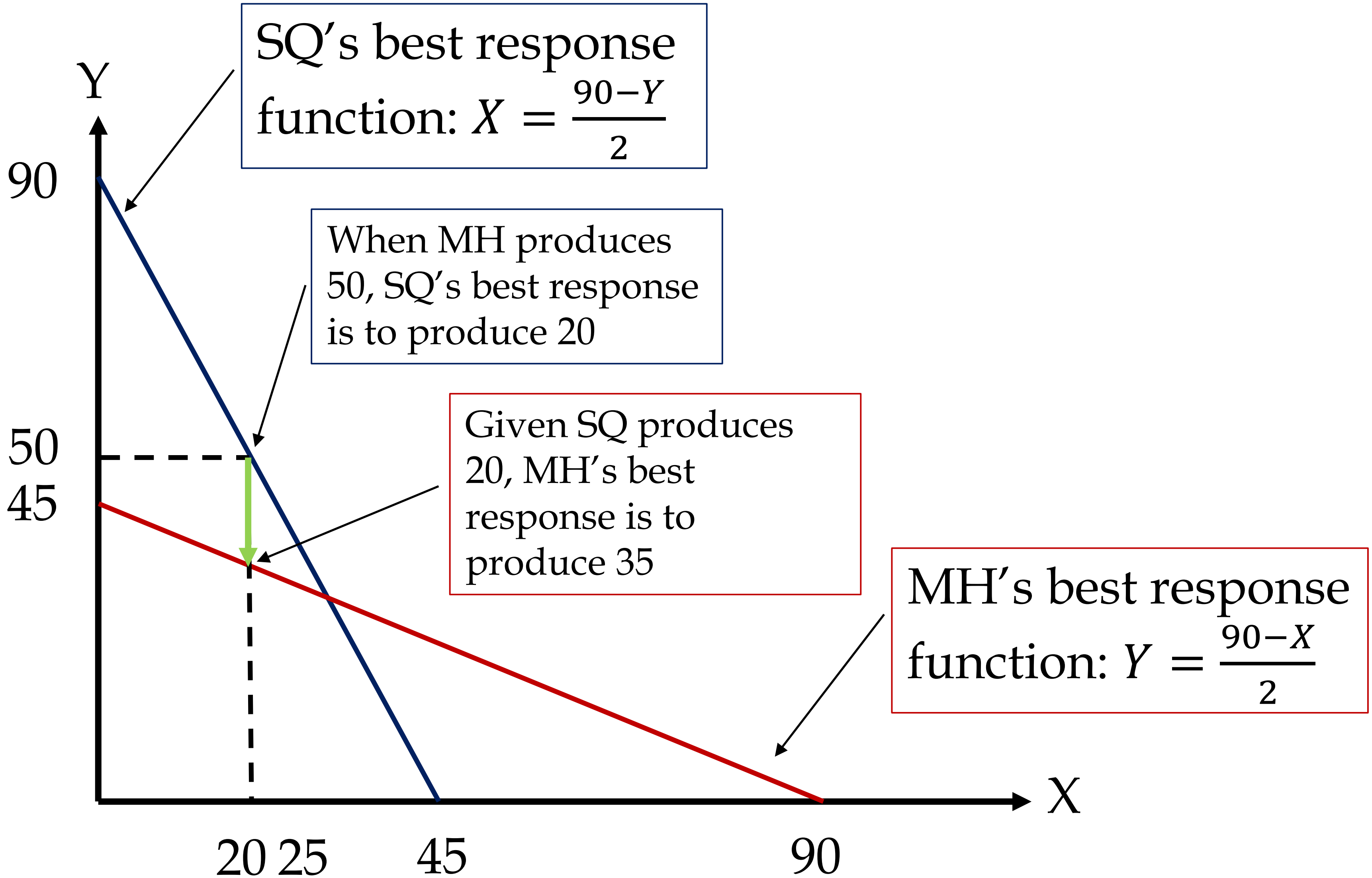
Cournot Competition: An Example

- In this equilibrium, neither firm has an incentive to deviate. SQ has no incentive to change its output from 30. MH has no incentive to change its output from 30.
- What's an example of a point where firms DO have an incentive to deviate?

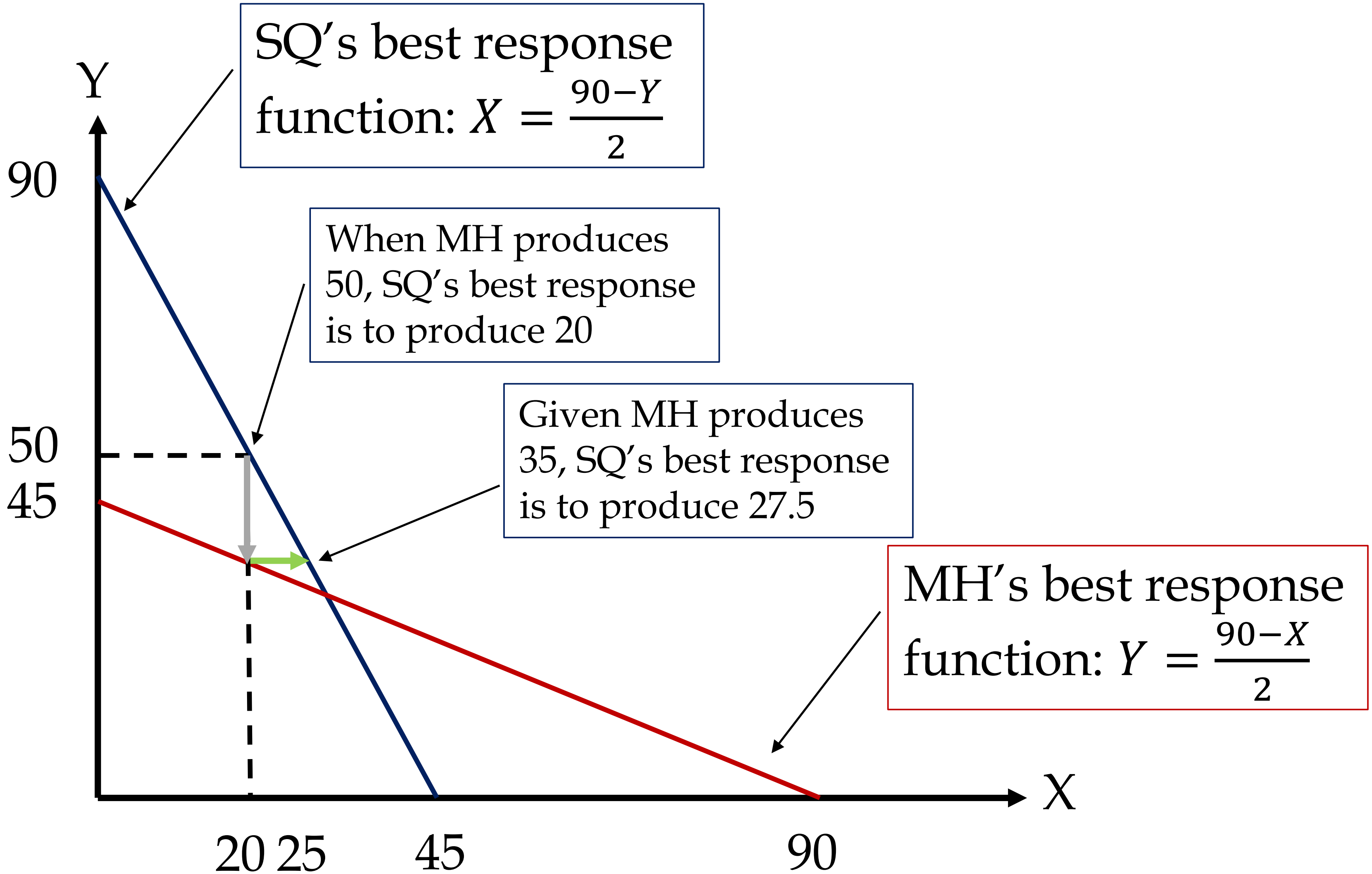
Cournot Competition: An Example



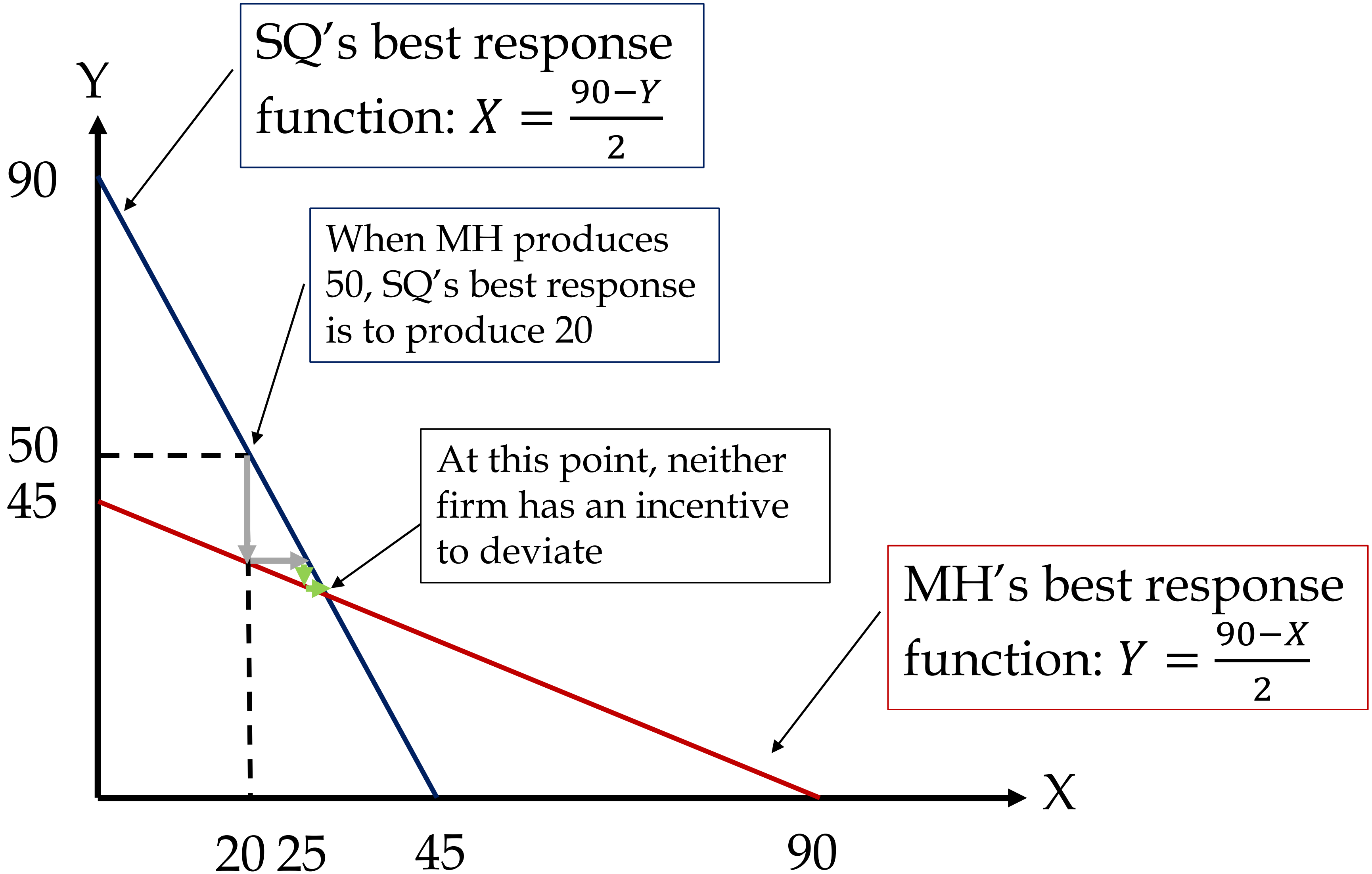
Cournot Competition: An Example



Cournot Competition: An Example



Cournot Competition: An Example



Cournot Competition: An Example

- Total quantity produced is $30 + 30 = 60$.
- Therefore, $P = 100 - 30 - 30 = 40$.
- Assume fixed cost is zero.
- SQ's profit is $Total\ Revenue - Total\ Cost$

$$= (\$40 \times 30) - (\$10 \times 30)$$
$$= \$900$$

- Since MH has the same costs and quantities, MH's profit is also $900.

Cournot Competition: An Example

- What if the marginal costs are different?
- Let's assume:
  - SQ's marginal cost, $MC_s = 5$, and
  - MH's marginal cost, $MC_M = 10$
- What is SQ's best response function?

$$MR = 100 - Y - 2X = 5$$

$$X = \frac{95 - Y}{2} = B_{SQ}\ (Y)$$

Cournot Competition: An Example

- What is MH's best response function?

$$MR = 100 - X - 2Y = 10$$

$$Y = \frac{90 - X}{2} = B_{MH}\ (X)$$

Cournot Competition: An Example

- What is the Cournot Equilibrium?

$$X = \frac{95 - \left(\frac{90 - X}{2}\right)}{2}$$

$$= \frac{190 - 90 + X}{4}$$

$$\frac{3}{4}X = \frac{100}{4}$$

$$X = \frac{100}{3} \approx 33.33$$

Cournot Competition: An Example

- What is the Cournot Equilibrium?

$$Y = \frac{90 - \left(\frac{100}{3}\right)}{2}$$

$$= \frac{170}{6} \approx 28.33$$

- SQ produces 33.33 and MH produces 28.33

lower cost so produce more

Cournot Competition: An Example

- What is the Cournot Equilibrium?

$$P = 100 - X - Y$$
$$= 100 - \frac{200}{6} - \frac{170}{6}$$
$$= 38.33$$

Cournot Competition: An Example

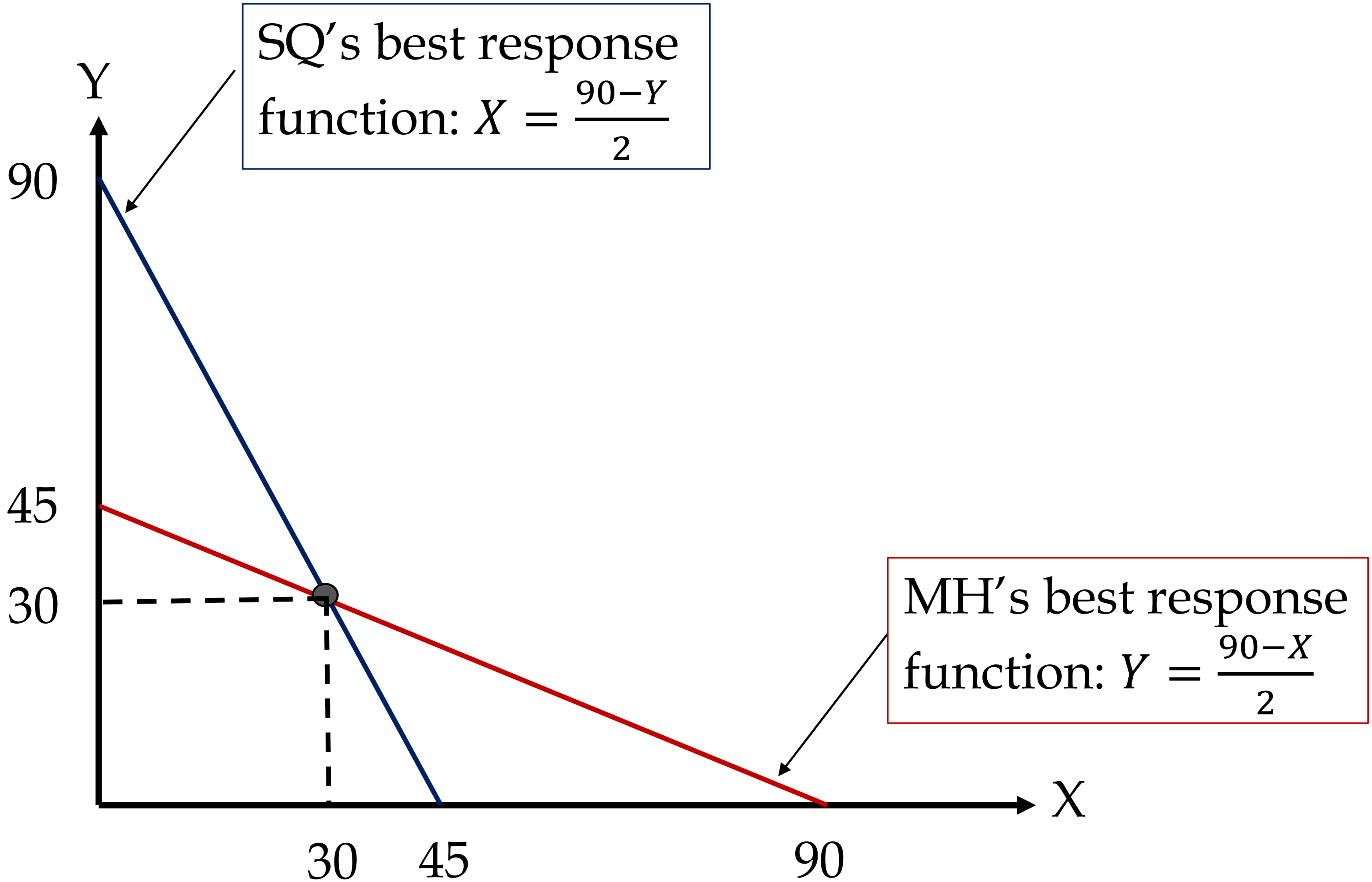
- What are profits at the equilibrium?

$$\text{SQ: } (\underset{\substack{\uparrow \\ \text{Price}}}{38.33} - \underset{\substack{\uparrow \\ \text{Marginal} \\ \text{Cost}}}{5}) \times \underset{\substack{\uparrow \\ \text{Quantity}}}{33.33} = \ 1110.89$$

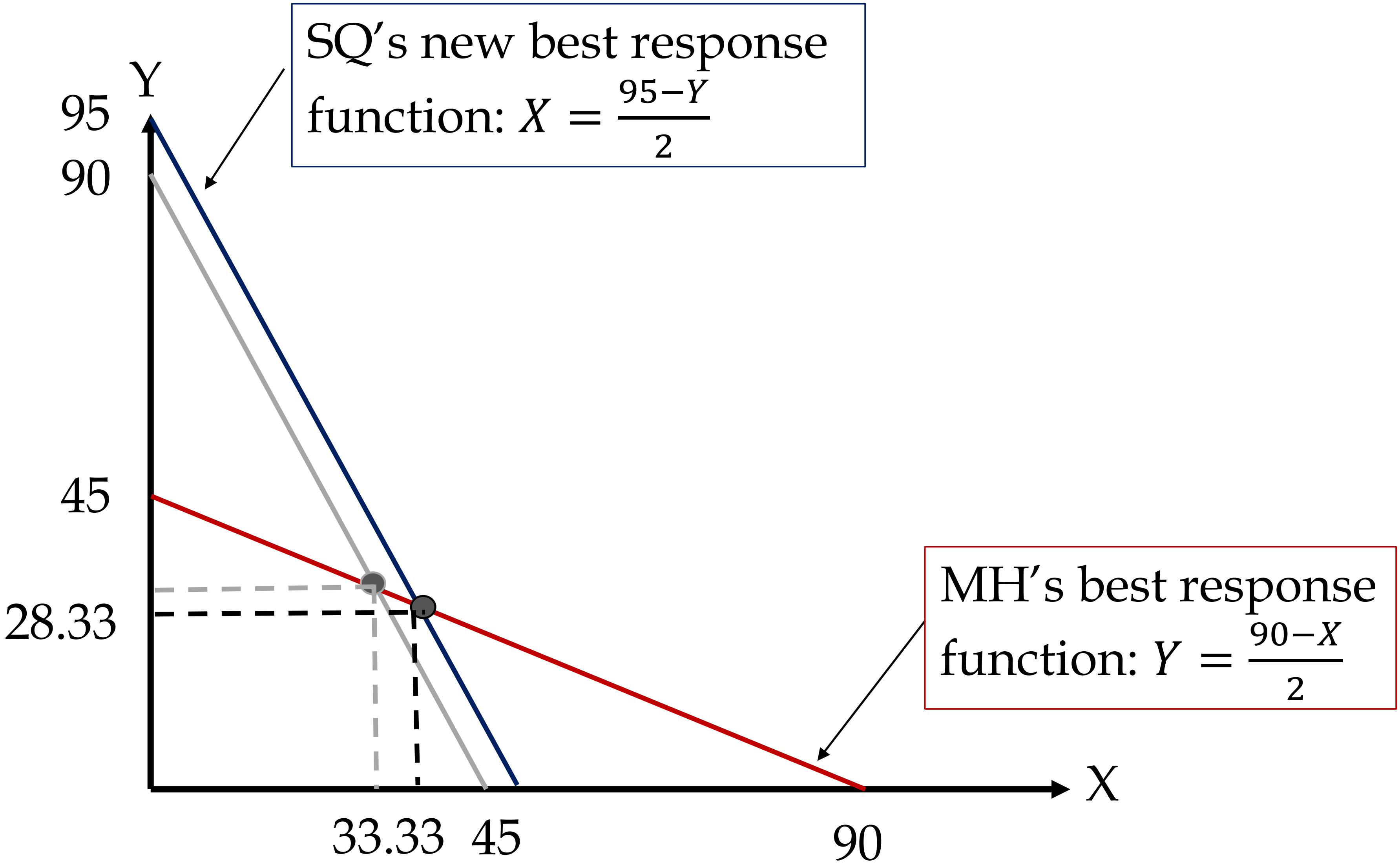
$$\text{MH: } (38.33 - 10) \times 28.33 = 802.59$$

Only place which the fixed cost matters

Cournot Competition: An Example



Cournot Competition: An Example



Cournot Competition: An Example

- Because SQ has a lower marginal cost, it can “afford” or be profitable at a lower price. Thus it builds capacity more aggressively than MH.
- This results in a larger market share for SQ and higher profits.

Cournot Competition: An Example

- What if demand increases, and marginal costs are the same?

$$P = 140 - X - Y$$

$$MR = 140 - Y - 2X, \qquad MC = 10$$

$$140 - Y - 2X = 10$$

$$B_{SQ}(Y) = \frac{130 - Y}{2}$$

$$B_{MH}(X) = \frac{130 - X}{2}$$

Cournot Competition: An Example

$$B_{SQ}(Y) = \frac{130-Y}{2}$$

$$B_{MH}(X) = \frac{130-X}{2}$$

- Equilibrium:

$$X = \frac{130-\left[\frac{130-X}{2}\right]}{2}$$

$$X = \frac{130}{3} = 43.33$$

$$Y = 43.33$$

Cournot Competition: An Example

$$B_{SQ}(Y) = \frac{130-Y}{2}$$

$$B_{MH}(X) = \frac{130-X}{2}$$

- Equilibrium:

$$X = \frac{130-\left[\frac{130-X}{2}\right]}{2}$$

$$X = \frac{130}{3} = 43.33$$

$$Y = 43.33$$

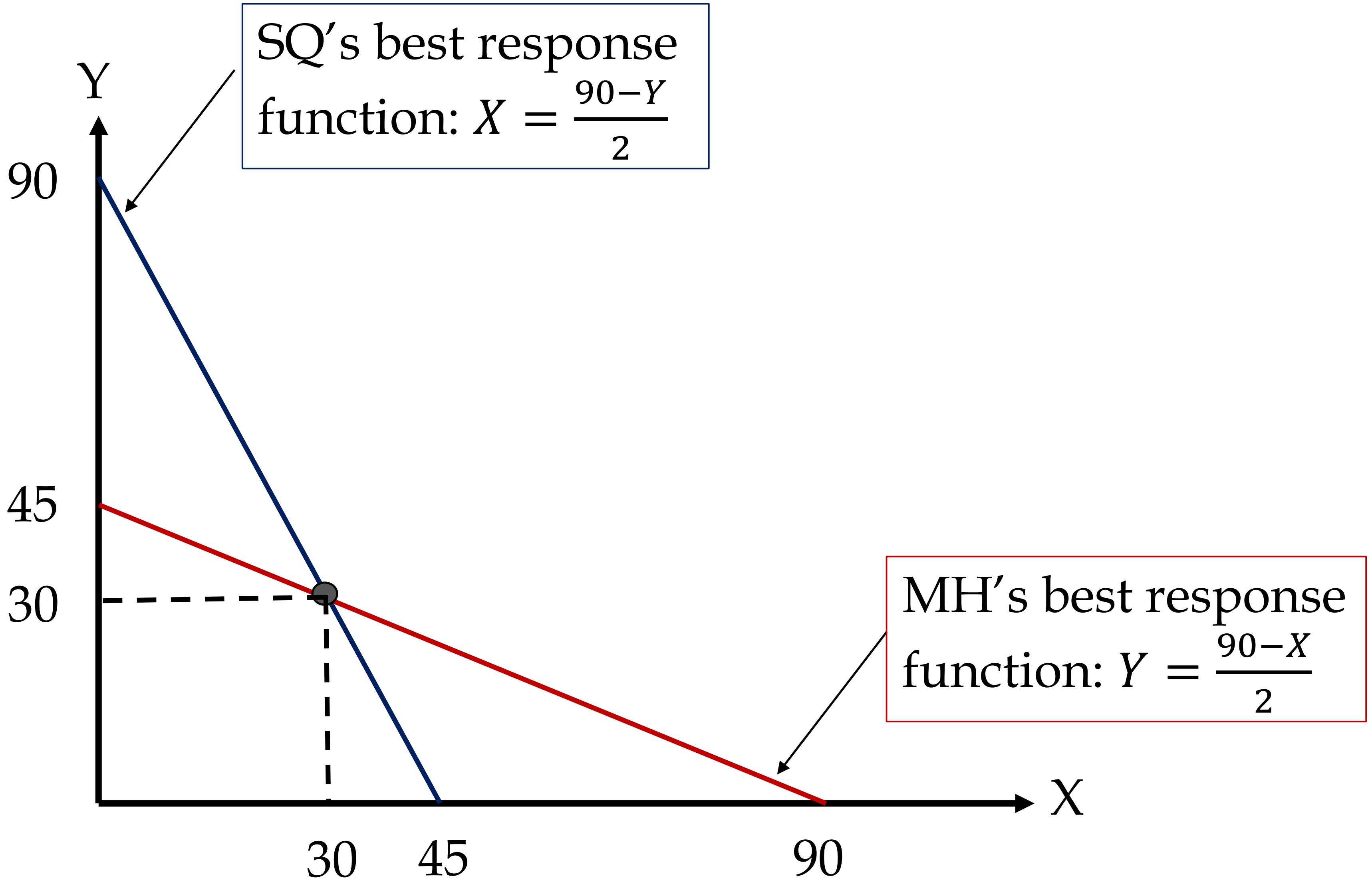
$$P = 140 - 86.66 = 53.34$$

$$\pi_{SQ} = (53.34 - 10) \times 43.33$$

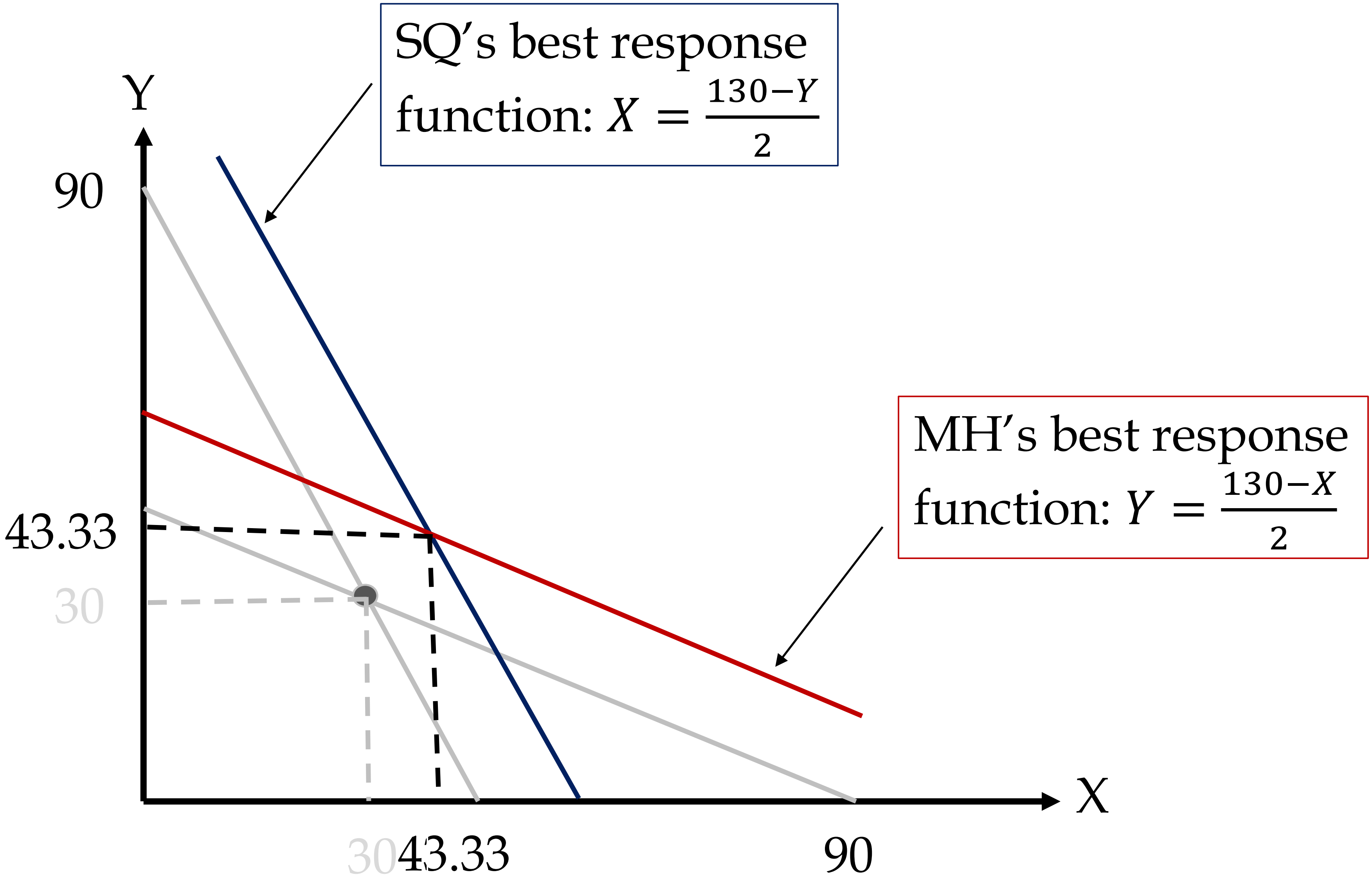
$$= 1877.92$$

$$\pi_{MH} = 1877.92$$

Cournot Competition: An Example



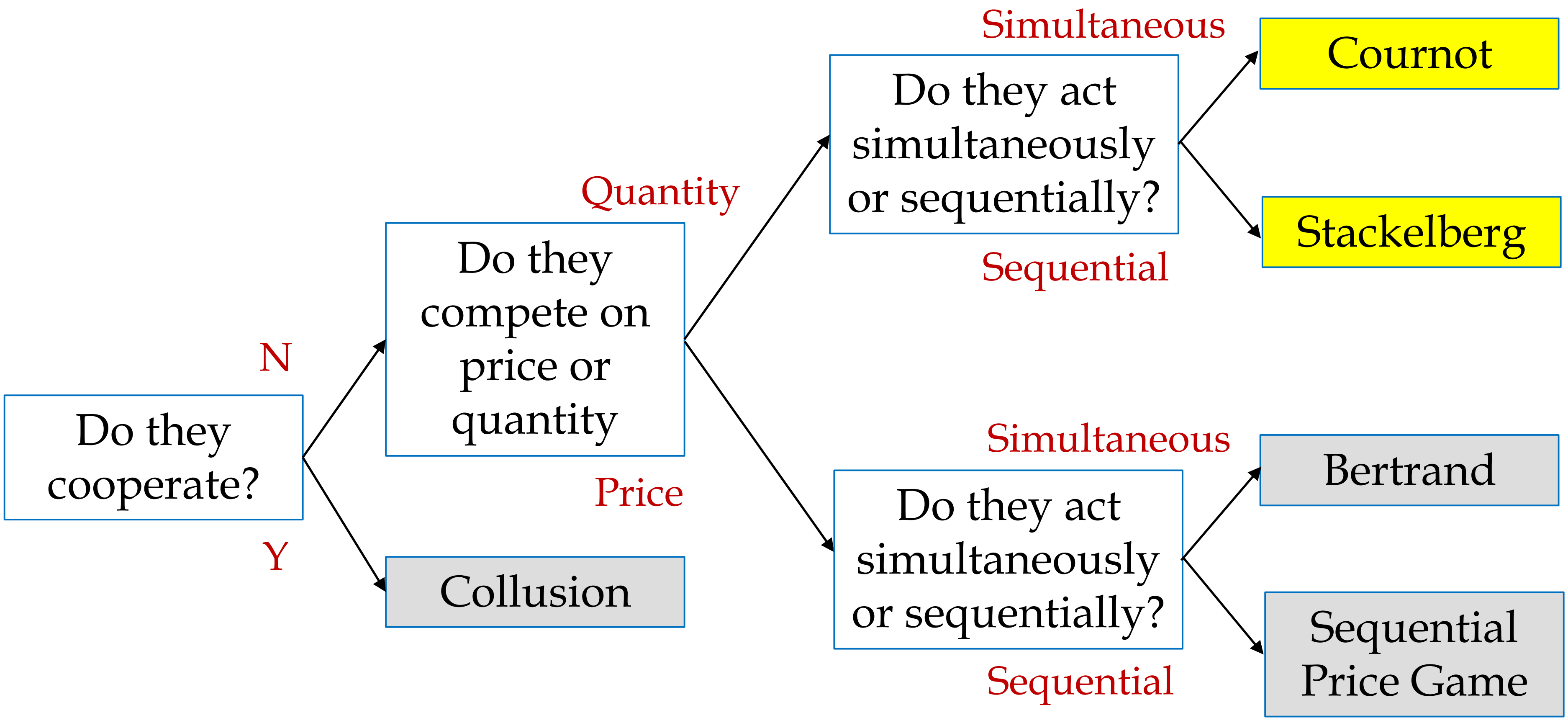
Cournot Competition: An Example



Cournot Competition: An example

- An increase in demand raises all boats!
- It increases the quantities produced by both firms.
- Recall that profits with the old demand curve were $900 for each firm. Now they are $1877.92 per firm!

Types of Oligopoly Markets



Stackelberg: An Example

- Stage 1
  - SQ sets its quantity. SQ is the *Stackelberg leader*.

- Stage 2
  - MH observes SQ's quantity and sets its own quantity. MH is the *Stackelberg follower*.

Stackelberg: An Example

- MH maximizes profit based on the given SQ's quantity decision. This means MH's decision is the same as in the Cournot competition case!
- Recall that MH's best response function is: $B_{MH}(X) = \frac{90-X}{2}$

Stackelberg: An Example

- SQ knows what MH will do given SQ's decision.
  - If SQ chooses to produce 30 units, it knows MH will choose to produce 30 units.
  - If SQ chooses to produce 40 units, it knows MH's best response will be to produce $\frac{90-40}{2} = 25$ units.

Stackelberg: An Example

- In effect, SQ gets to determine MH’s output level.
- What is SQ’s profit maximizing choice in this situation?

Stackelberg: An Example

- How do we solve the Stackelberg problem?
- Step 1: Find the follower's best response function (just as is done in the Cournot case)

$$B_{MH}(X) = \frac{90 - X}{2}$$

Stackelberg: An Example

- How do we solve the Stackelberg problem?
- Step 2: Find the leader's profit maximizing quantity:

$$P = 100 - \left[\frac{90 - X}{2}\right] - X$$

$$= 100 - 45 - \frac{X}{2}$$

$$= 55 - \frac{X}{2}$$

$$Revenue_{SQ} = \left[55 - \frac{X}{2}\right] X$$

$$MR_{SQ} = 55 - X$$

Stackelberg: An Example

- How do we solve the Stackelberg problem?
- Step 2: Find the leader's profit maximizing quantity:

$$Revenue_{SQ} = \left[55 - \frac{X}{2}\right]X$$

$$MR_{SQ} = 55 - X$$

SQ sets $MR_{SQ} = MC_{SQ}$

$$55 - X = 10$$

$$\underline{X = 45}$$

Stackelberg: An Example

- How do we solve the Stackelberg problem?
- Step 3: Find the follower's profit maximizing quantity:

$$B_{MH}(X) = \frac{90 - X}{2}$$

$$B_{MH}(45) = \frac{90 - 45}{2}$$

$$= 22.5$$

Stackelberg: An Example

- How do we solve the Stackelberg problem?
- Step 4: Find the market price:

$$\begin{aligned} P &= 100 - 45 - 22.5 \\ &= 32.5 \end{aligned}$$

Stackelberg: An Example

- SQ's profit:

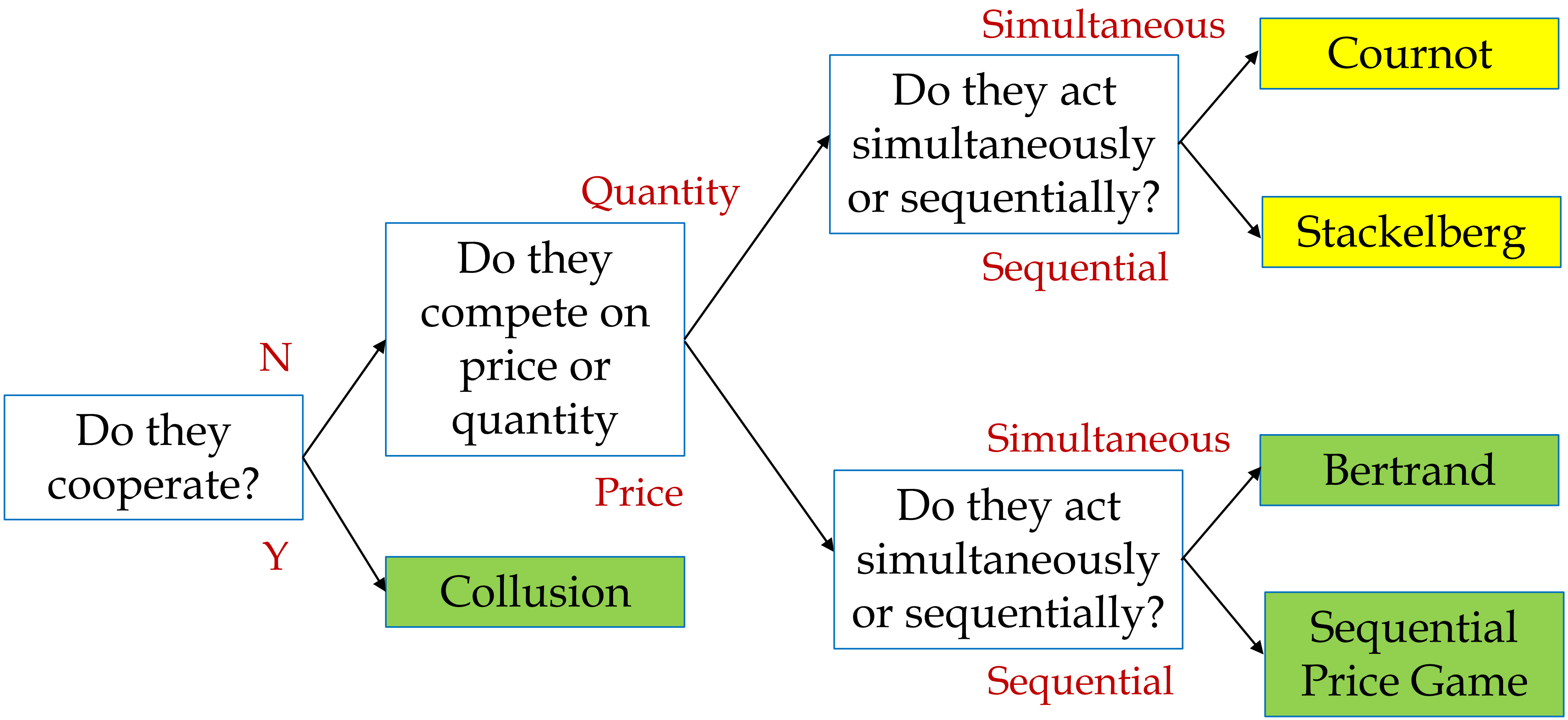
$$\pi_{SQ} = (\underset{\substack{\uparrow \\ \text{Price}}}{32.5} - \underset{\substack{\uparrow \\ \text{Marginal} \\ \text{Cost}}}{10}) \times \underset{\substack{\uparrow \\ \text{Quantity}}}{45} = 1012.5$$

$$\pi_{MH} = (32.5 - 10) \times 22.5 = 506.25$$

Stackelberg: An Example

- SQ produces more output and has higher profit than MH even though both have the same cost structure.
- There is an advantage from being the Stackelberg leader.

Types of Oligopoly Markets



Product Differentiation

- What if the products are not identical?
- The Cournot and Stackelber model can still apply.
- What changes?
  - Instead of a single demand curve, each firm as an individual demand curve for their product.
  - However, unlike a monopoly, their demand is a function of not just their own prices but their competitors prices as well

Product Differentiation

- Example:

$$Q_A = 100 - P_A + 2P_B$$
$$Q_B = 200 - 3P_B + P_A$$

Firm A benefits from a small change in the price of good B.

Firm B has to be careful because if it decreases its price, Firm A stands to gain a lot from it.

Product Differentiation

- If we have marginal cost, we can still form profit functions to derive best response functions.
- The we can estimate Cournot and Stackelberg outcomes as before.

Summary

- Cournot:
  - Firms act simultaneously.
    - We solve for each firm's best response function, and solve them as a system of equations
  - Stackelberg
    - Firms act sequentially.
      - We solve for the follower's best response function and plug it into the leader's profit function.