

OLIGOPOLY

PART I : QUANTITY COMPETITION

Weeks 4–5
(Chapter 28 optional reading)

We have seen two extremes

- Perfect competition
 - A large number of firms producing homogeneous product
 - Firms have no market power
- Monopoly
 - Only one firm in the market
 - Monopolist has no competitor
- But most industries in the real world are in between

Oligopoly

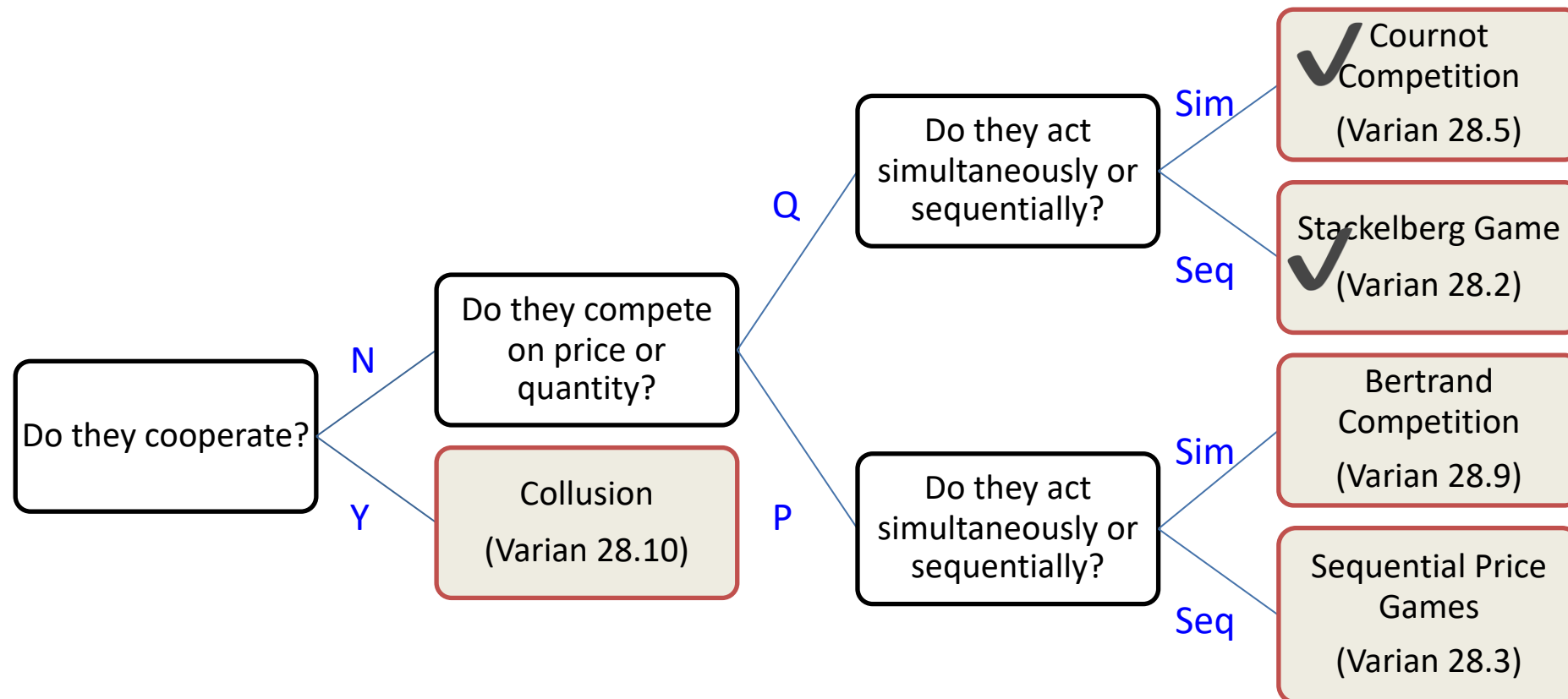
	Perfect Competition	Oligopolistic Competition	Monopoly
Industry structure	Fragmented; No dominant firm	Small number of firms dominate market	Concentrated; One firm dominates
Pricing	Price takers	Some power	Price maker
Barriers to entry	No	Quite Significant	Significant
Product	Homogenous	Homogenous or Heterogenous	One
H-index	0	$0 < H < 1$	1

Simultaneous and Sequential Games

- Consider market with n firms, if n is small, action taken by a single firm has consequences on others \implies strategies become important
- Game theory: study of strategic decision making
- Simultaneous Games
 - Scissors, Paper, Stone
- Sequential Games
 - Monopoly (The Board Game)
 - Mahjong

The Big Picture

Nature of competition among oligopolistic firms depends on how they interact



Types of Competition

	Simultaneous	Sequential
Quantity	Cournot	Stackelberg
Price	Bertrand	-

Cournot Model

Developed by the French
mathematician-economist
Antoine Cournot in 1838



Our Analytical Framework

For simplicity

- Suppose the market is a *duopoly*, e.g., suppose there are only two cola firms in the market, Coke and Pepsi
- Product is *homogeneous*
 - Cola drinks produced by Coke and Pepsi are identical in the eyes of the consumers
- Quantity competition
 - Coke and Pepsi independently and simultaneously decide the quantity of Cola drinks to supply the market

Market Demand and Marginal Costs

- Suppose the inverse market demand curve for cola is

$$P = 100 - X - Y$$

- X : quantity produced by Coke
- Y : quantity produced by Pepsi

- Coke and Pepsi has the same marginal cost

$$MC = 10$$

Coke and Pepsi have market power

$$P = 100 - X - Y$$

- Although Coke and Pepsi do not set price directly, they can control market price through their quantity decisions

- If Coke's quantity is 40 and Pepsi's quantity is 20, market price is

$$100 - 40 - 20 = 40$$

- If Pepsi increases its quantity to 40, then market price is

$$100 - 40 - 40 = 20$$

Questions We Want to Answer

- What are the optimal quantity choices for Coke and Pepsi?
- What will happen to these choices if Pepsi's marginal cost becomes higher?
- What will happen to these choices if the demand for cola drinks increases?

Coke and Pepsi's Decisions

- Coke and Pepsi choose quantity (capacity) **simultaneously**
 - When Coke decides, it does not know Pepsi's choice of quantity
 - When Pepsi decides, it does not know Coke's choice of quantity
- Coke and Pepsi have expectations about each other's choice
 - Coke will choose the quantity that maximizes its profit given what it thinks Pepsi's choice will be
 - Pepsi will choose the quantity that maximizes its profit given what it thinks Coke's choice will be

If Coke believes $Y=50$

- The *residual demand* Coke faces is

$$P = 100 - 50 - X = 50 - X$$

- Since Pepsi has produced 50 units, with respect to “the rest of the market”, Coke is a monopolist, so Coke will set $MR=MC$ to maximize profit

$$MR = 50 - 2X = MC = 10 \implies X = 20$$

- If Pepsi produces 50 units, Coke's best response is to produce 20 units

If Coke believes $Y=40$

- The *residual demand* Coke faces is

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

- Since Pepsi has produced 40 units, with respect to “the rest of the market”, Coke is a monopolist, so Coke will set $MR=MC$ to maximize profit

$$MR = 60 - 2X = MC = 10 \implies X = 25$$

- If Pepsi produces 40 units, Coke’s best response is to produce 25 units

Reaction Function

- Coke's Optimal Choice Depends on Pepsi's Choice
- For any quantity Pepsi chooses, Coke chooses a quantity that maximizes its profit (i.e. Coke picks its best response)
- Coke's *reaction function* describes Coke's *best response* (i.e., profit-maximizing quantity) for each possible move of Pepsi
- Mathematically, Coke's reaction function is X as a function of Y
- Note:
 - In the textbook, the concept of best response is not introduced in Chapter 28, but you are expected to know it
 - You will not be tested on the concept of isoprofit lines in Chapter 28

Deriving Coke's reaction function

- For any output level that Pepsi chooses (Y), Coke's residual demand is

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

- Coke acts like a monopolist facing the residual demand, and its MR is

$$MR = (100 - Y) - 2X$$

- Setting $MR=MC$

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

- Coke's reaction function is

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

Deriving Pepsi's reaction function

- For any output level that Coke chooses (X), Pepsi's residual demand is

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

- Pepsi acts as a monopolist facing the residual demand, and its MR is

$$MR = (100 - X) - 2Y$$

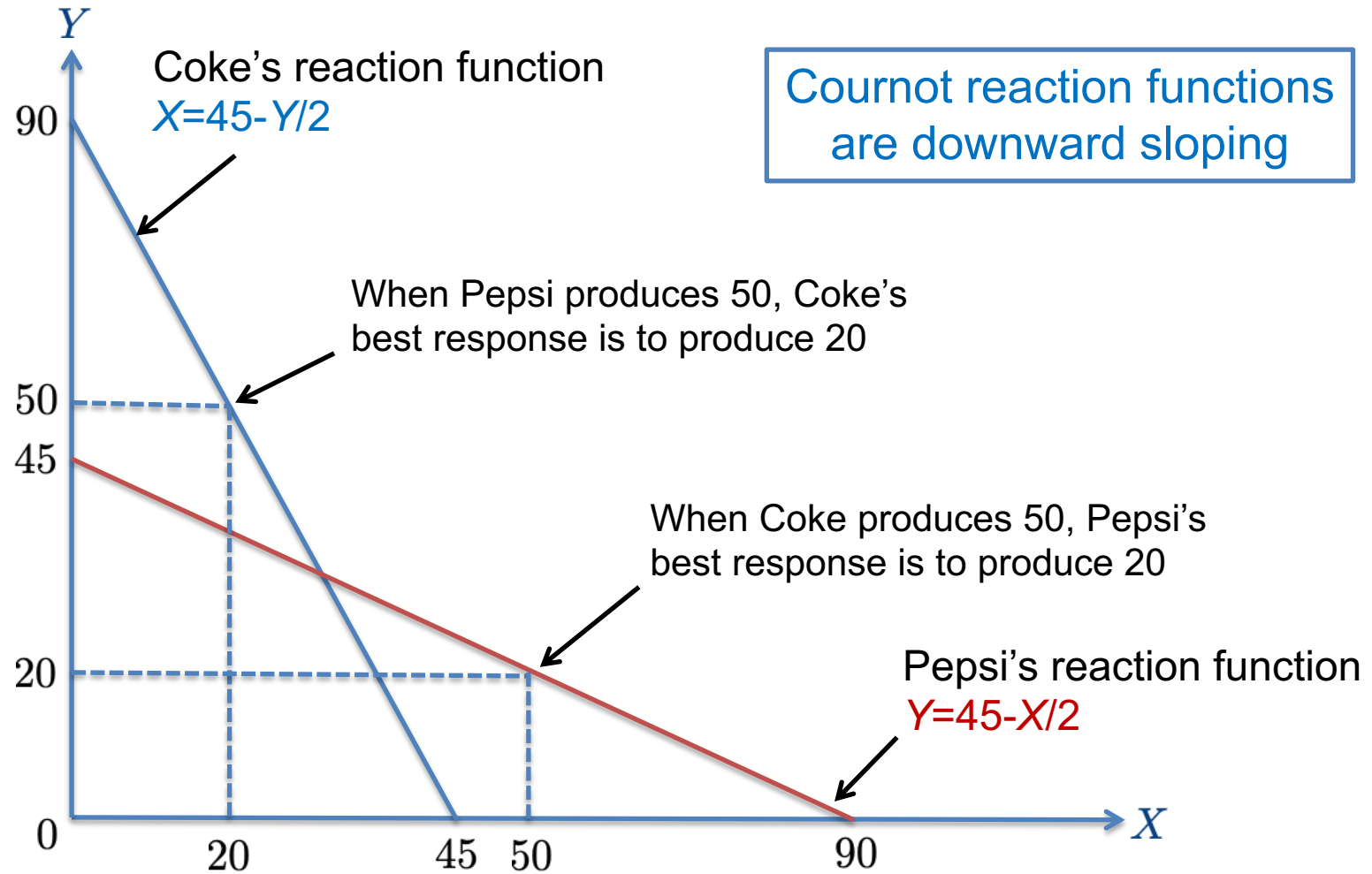
- Setting $MR=MC$

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

- Pepsi's reaction function is

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

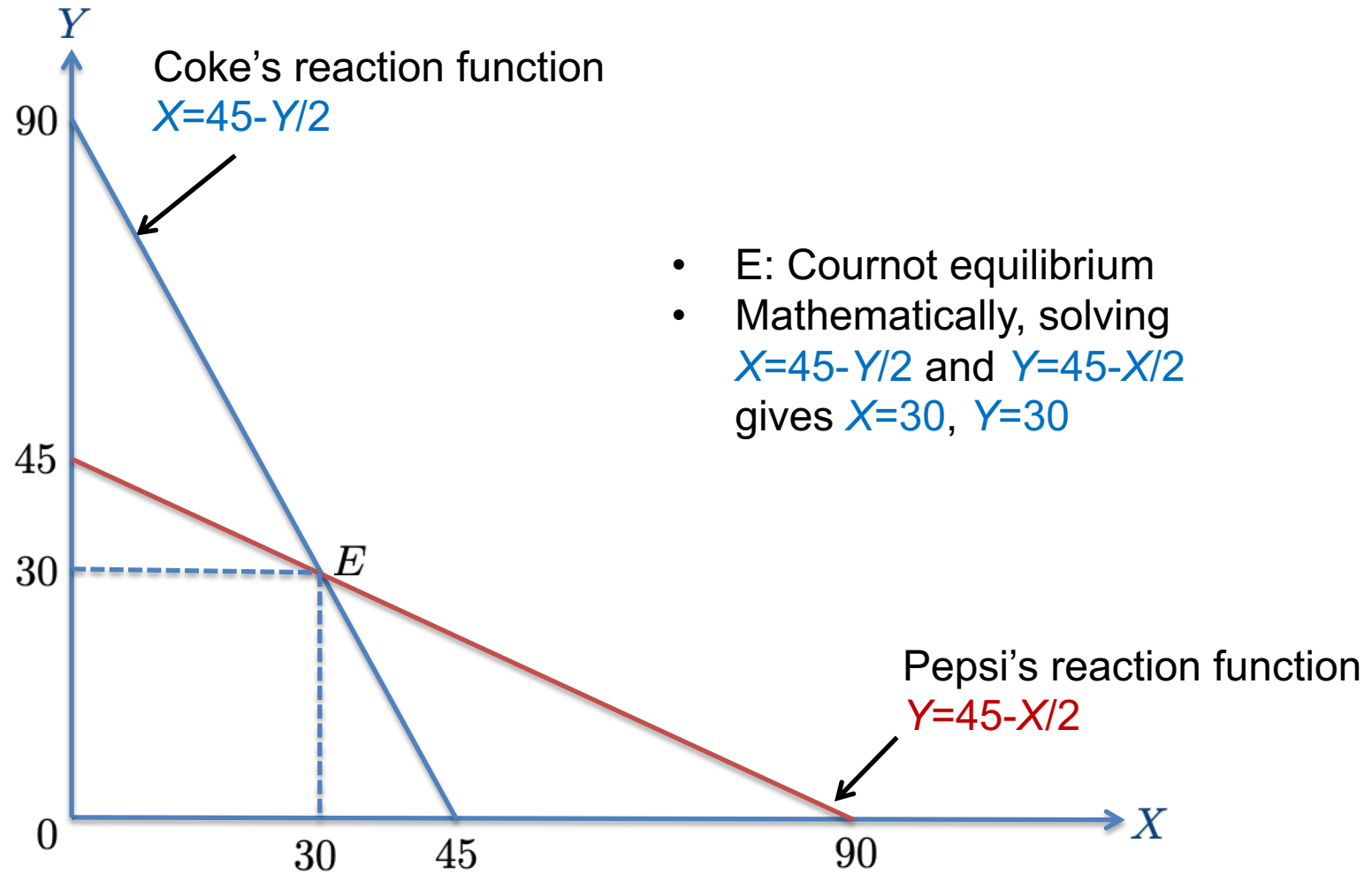
Reaction Functions in Graph



Cournot Equilibrium

- Coke chooses the quantity X that maximizes its profit given the quantity choice Y of Pepsi, and
- Pepsi chooses the quantity Y that maximizes its profit given the quantity choice X of Coke
- (No one has the incentive to deviate given the choice of others)

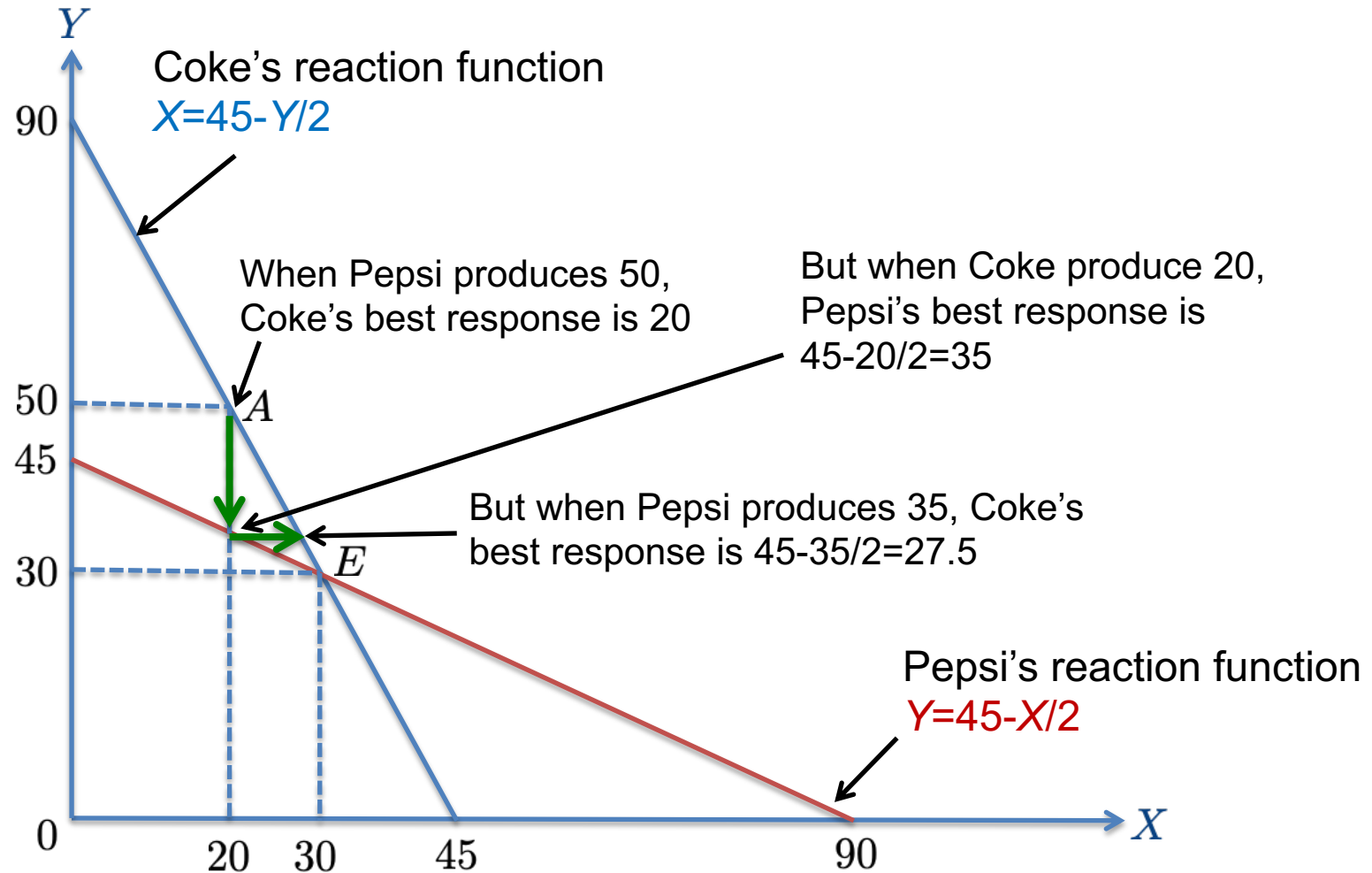
Equilibrium at intersection of reaction functions



Equilibrium as mutual best responses

- (Cournot equilibrium: $X=30$ and $Y=30$)
- In equilibrium, no one has the incentive to deviate
- When Pepsi produces 30 units, Coke's best response is to produce 30 units (Coke has no incentive to change its output to something other than 30)
- When Coke produces 30 units, Pepsi's best response is to produce 30 units (Pepsi has no incentive to change its output to something other than 30)

Why is point A not an equilibrium?



The Cournot Equilibrium Price

- In equilibrium both Coke and Pepsi will produce 30 units

- Thus the Cournot equilibrium market price is

$$P = 100 - 30 - 30 = 40$$

- Recall that $MC=10$, in Cournot equilibrium, equilibrium price is above marginal cost

- Suppose Coke and Pepsi have 0 fixed cost, then each of them earns profit

$$TR - TC = 40 \times 30 - 10 \times 30 = 900$$

What if Pepsi's MC is higher?

- Suppose now Coke's $MC=10$ but Pepsi's $MC=20$

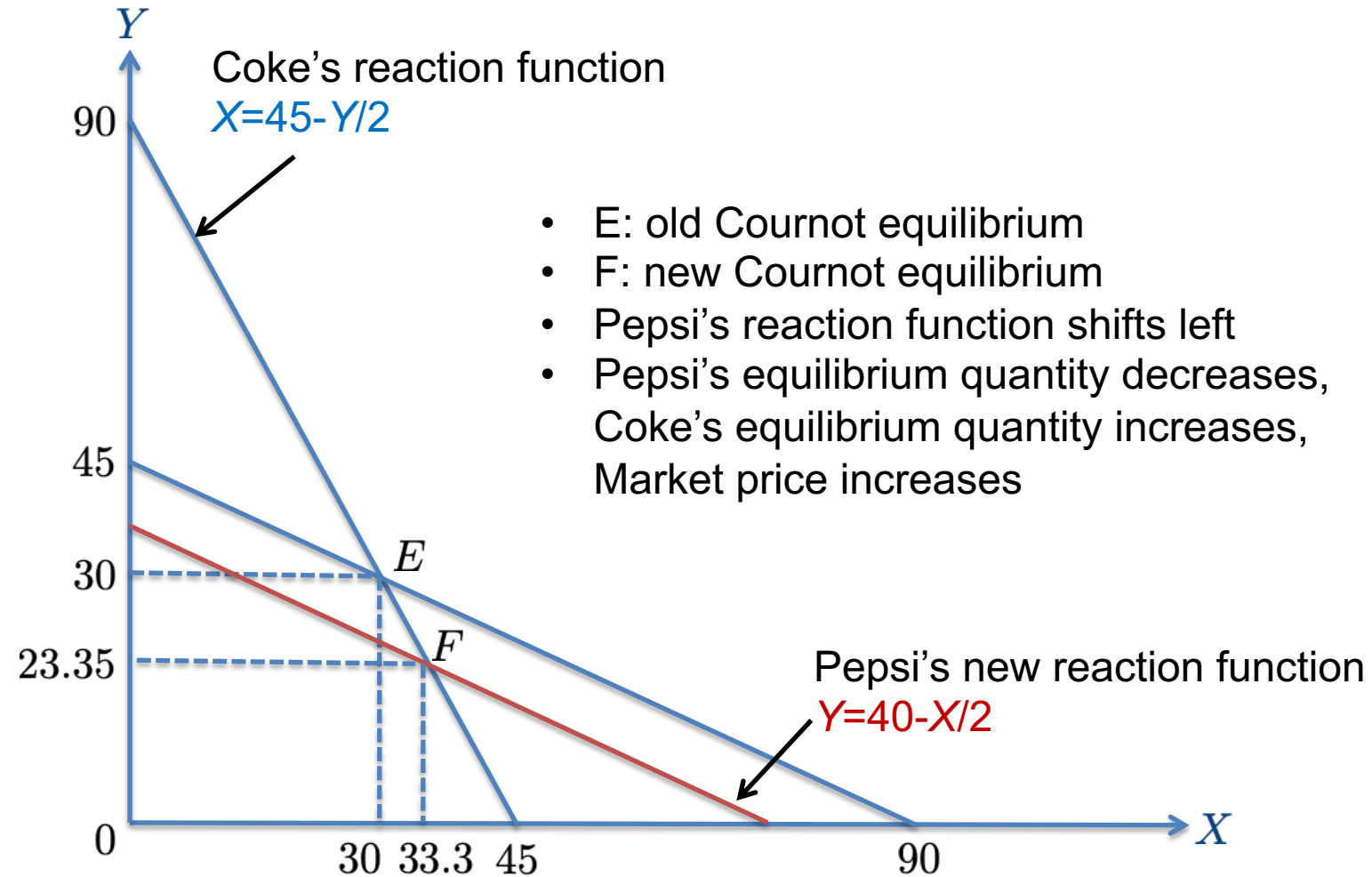
- Pepsi's reaction function is now

$$MR = (100 - X) - 2Y = 20 \implies Y = 40 - \frac{X}{2}$$

- Coke's reaction function remains as $X = 45 - \frac{Y}{2}$

- New Cournot equilibrium is $X=33.3$, $Y=23.35$, equilibrium price is $P=43.35$

Cournot Equilibrium if Pepsi has higher MC

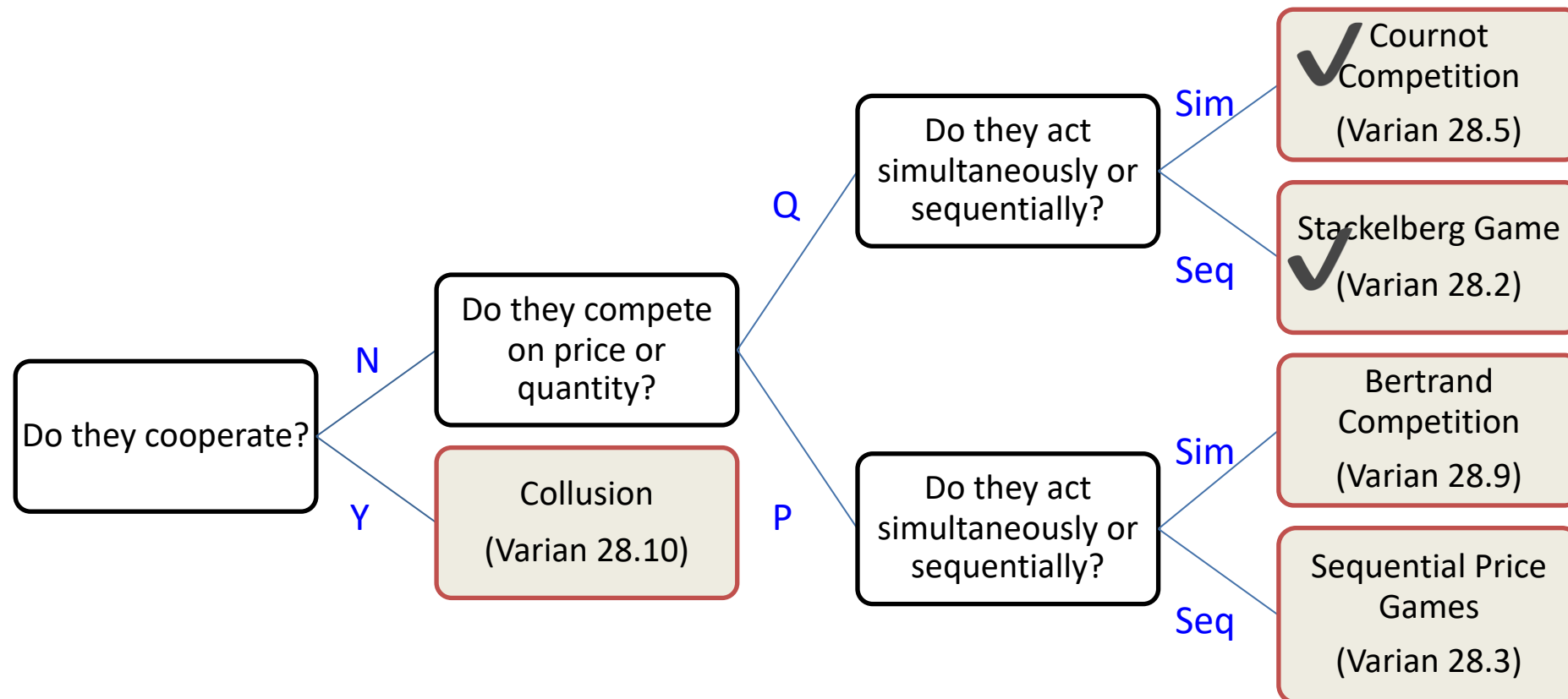


Cost Advantage

- In Cournot competition, Coke will gain higher market share and earn more profit than Pepsi if its marginal cost is lower than Pepsi
- With lower marginal cost, Coke can “afford” lower market price, thus Coke will build capacity more aggressively than Pepsi

The Big Picture

Nature of competition among oligopolistic firms depends on how they interact



Types of Competition

	Simultaneous	Sequential
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Stackelberg Competition: Coke and Pepsi

- Period 1
 - Suppose Coke makes its quantity/capacity decision *before* Pepsi
 - Coke is the *Stackelberg leader*
- Period 2
 - After Coke has made its decision, Pepsi observes Coke's choice of quantity and makes its own decision
 - Pepsi is the *Stackelberg follower*

What should Pepsi do? (after observing Coke's choice)

- Pepsi should choose a capacity that maximizes its profit given Coke's capacity choice
- Pepsi's thought process is the same as in Cournot competition!
- Pepsi should act according to its reaction function

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

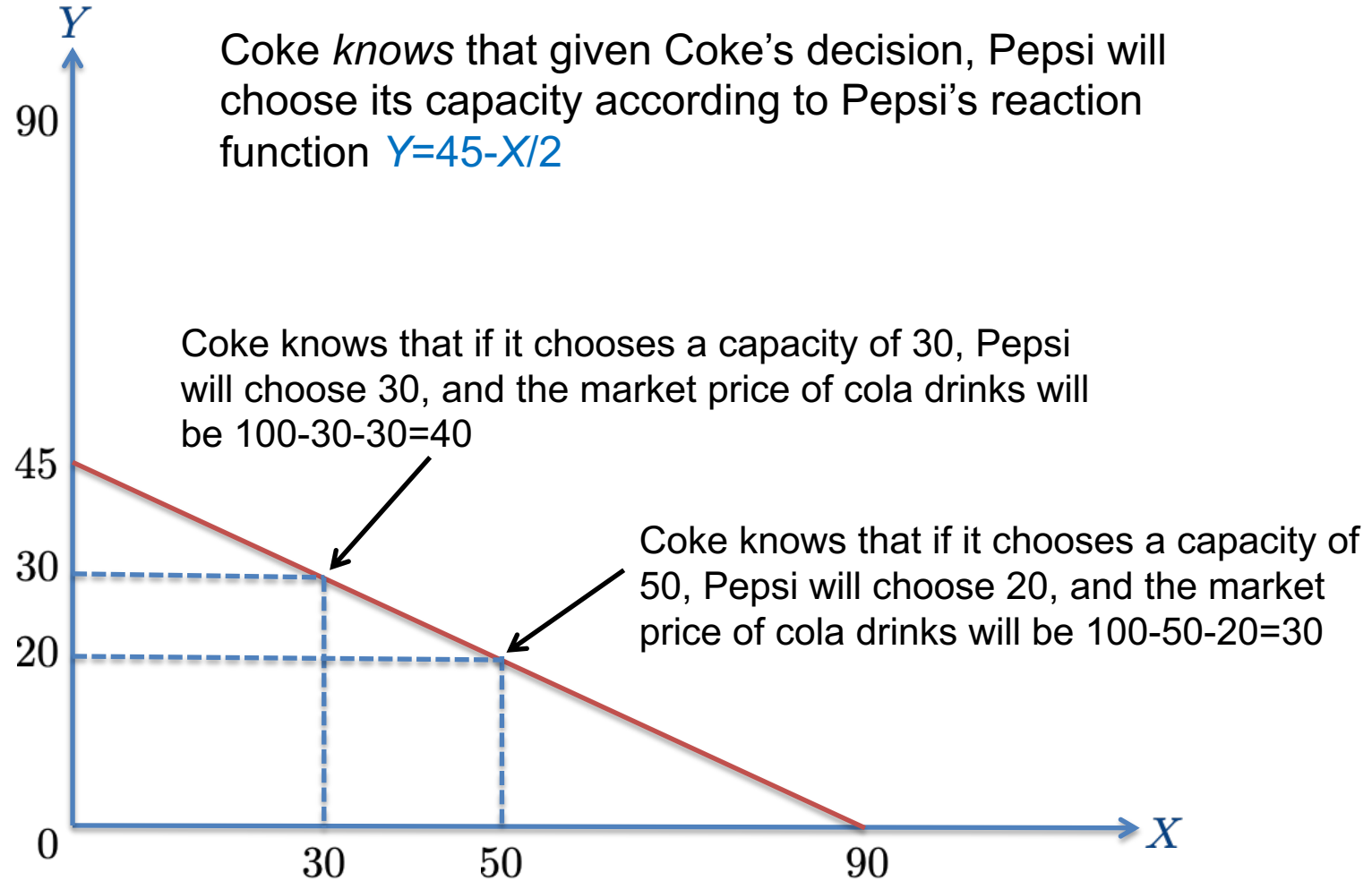
- If Coke chooses a capacity of 50, Pepsi's best response is to choose a capacity of

$$45 - 50/2 = 20$$

- If Coke chooses a capacity of 30, Pepsi's best response is to choose a capacity of

$$45 - 30/2 = 30$$

What should Coke do?



Coke determines everything!

- In effect, Coke “chooses” Pepsi’s output and the market price
- What is Coke’s profit-maximizing output?
- For any capacity level X , Coke’s manager knows that Pepsi will choose
$$Y = 45 - X/2$$
- It is as if Coke is a monopolist trying to maximize its profit by choosing an optimal X given that Pepsi’s quantity is

$$45 - X/2$$

Solving Stackelberg Model

(Backward Induction)

- Step 1: consider the follower's profit-maximizing problem
 - Pepsi takes Coke's capacity as given and chooses its own capacity to maximize profit
 - Pepsi's reaction function is the same as in Cournot:

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

- Step 2: incorporate the follower's reaction function into the leader's profit-maximizing problem
 - Market demand can be written as

$$P = 100 - X - Y = 100 - X - \left(45 - \frac{X}{2}\right) = 55 - \frac{X}{2}$$

Solving Stackelberg Model

- Coke's marginal revenue is $MR = 55 - X$

- Coke sets $MR=MC$

$$55 - X = 10 \implies X = 45$$

$$\implies Y = 45 - \frac{45}{2} = 22.5$$

$$\implies P = 100 - X - Y = 100 - 45 - 22.5 = 32.5$$

Profits in Stackelberg Equilibrium

- Coke's profit is $TR - TC = 32.5 \times 45 - 10 \times 45 = 1012.5$
- Pepsi's profit is $TR - TC = 32.5 \times 22.5 - 10 \times 22.5 = 506.25$
- Coke has higher output and higher profit

Cournot vs. Stackelberg

	Cournot Equilibrium	Stackelberg Equilibrium
Price	40	32.5
Quantity	30 each	45 (Coke) 22.5 (Pepsi)
Profit	900 each	1012.5 (Coke) 506.25 (Pepsi)

The Value of Strategic Commitment

- Coke *committed* in advance to supply a large output while Pepsi has the flexibility to respond to Coke
- By committing to supply a large output, Coke “forces” Pepsi to choose small output
- Coke earns higher profit if it can make a credible commitment

How to make commitment work?

- Commitment must be credible
 - Pepsi must believe that Coke will indeed supply a large output
 - If Pepsi knows that Coke is bluffing, Pepsi will supply a large output too
- Ways to improve credibility
 - Public announcement
 - Contract
 - Irreversible investment

Burn your own bridges, to ensure that there is no turning back for you.

— Sun Tzu, *The Art of War*

Example: Airbus vs. Boeing

- In 2000, Airbus announced plans to launch A380
- Boeing announced it would abandon its plan to build 747X a few months later
- Airbus's commitment is credible
 - Airbus has secured over 60 early orders for A380
- Airbus's commitment has preempted Boeing from competing