3.2 — Stackelberg Competition

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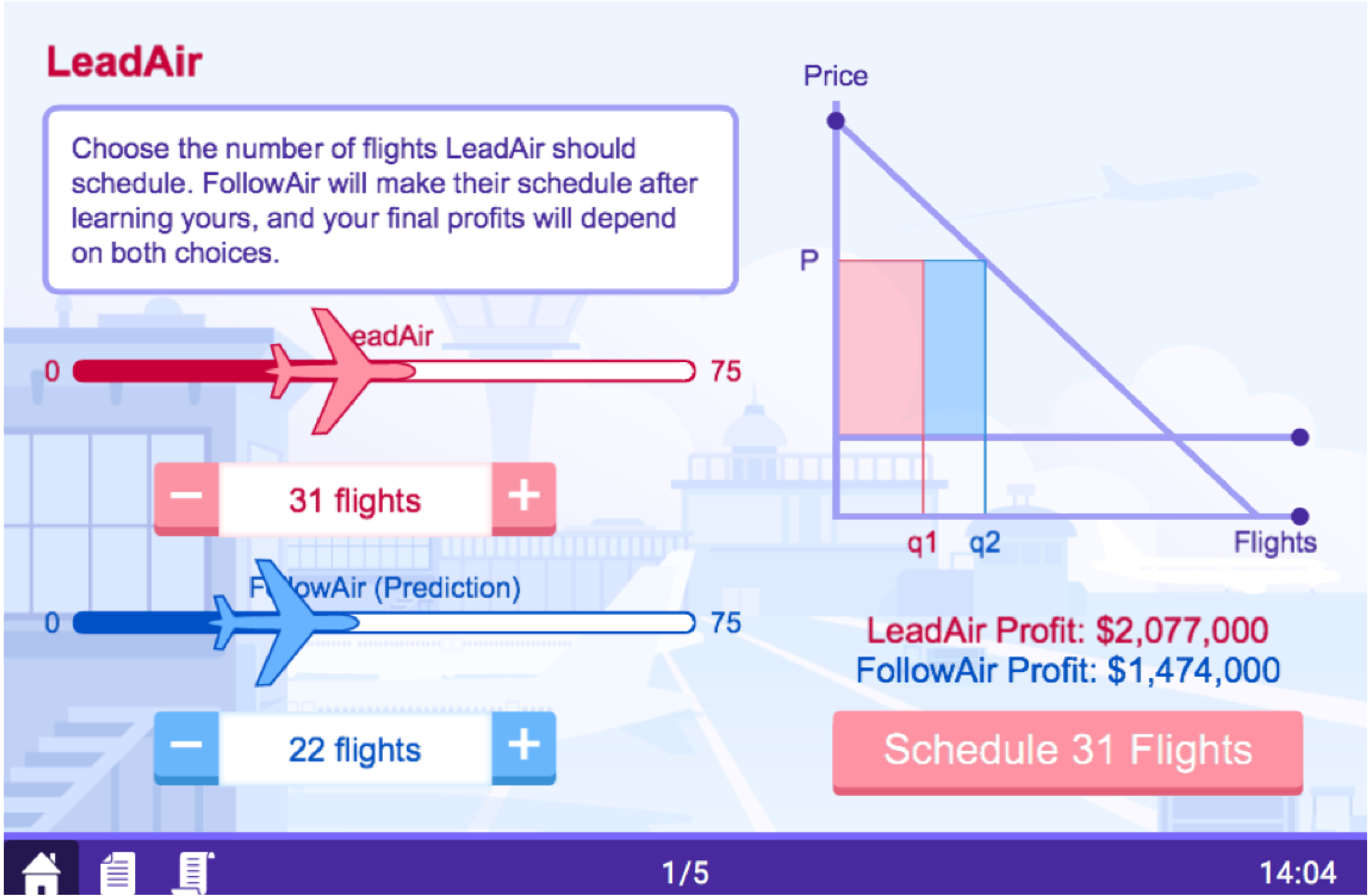
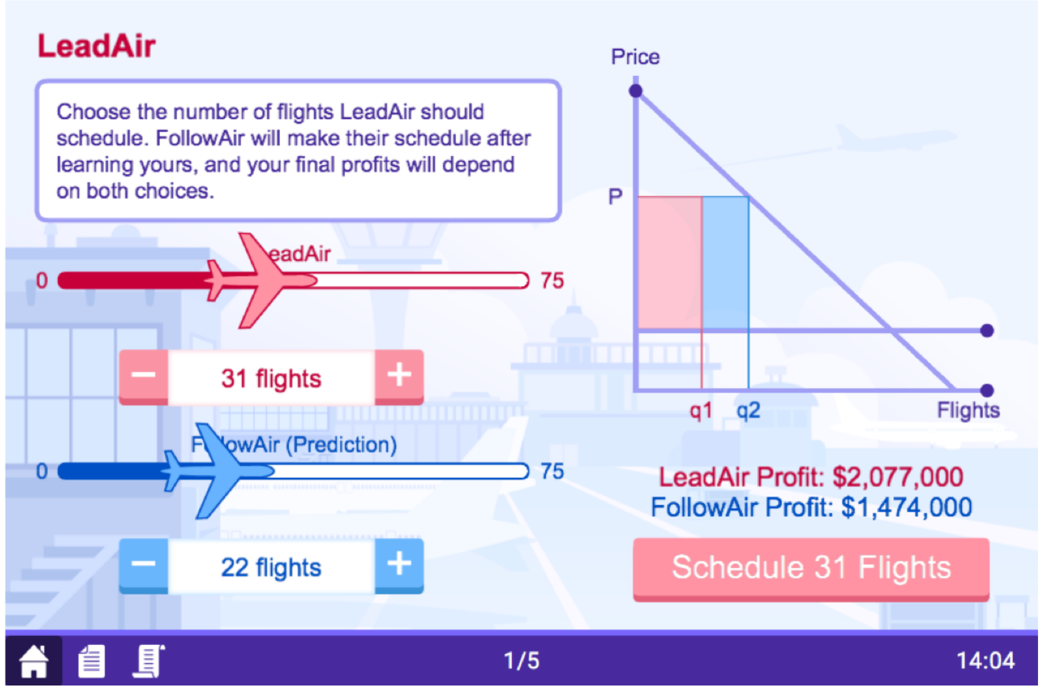
Stackelberg Competition: Moblab



Stackelberg Competition: Moblab

- Each of you is one Airline competing against another in a duopoly
  - Each pays same per-flight cost
  - Market price determined by *total* number of flights in market
- **LeadAir** first chooses its number of flights, publicly announced
- **FollowAir** then chooses its number of flights



Stackelberg Competition

Henrich von Stackelberg

1905-1946

- "Stackelberg competition": Cournot-style competition, two (or more) firms compete on **quantity** to sell the **same good**
- Again, firms' joint output determines the market price faced by all firms
- But firms set their quantities **sequentially**
  - Leader produces first
  - Follower produces second

Stackelberg Competition: Example

- Return to **Coke** and **Pepsi** again, with a constant marginal cost of \$0.50 and the (inverse) market demand:

$$P = 5 - 0.05Q$$
$$Q = q_c + q_p$$

Stackelberg Competition: Example

$$q_c^* = 45 - 0.5q_p$$
$$q_p^* = 45 - 0.5q_c$$

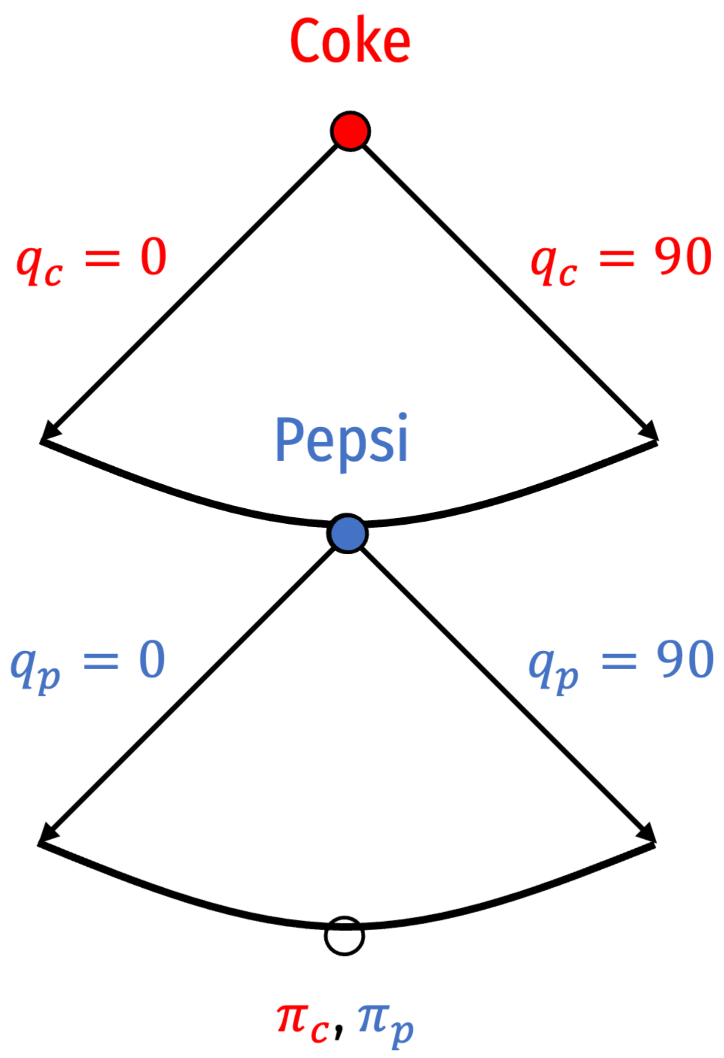
- Suppose now that Coke is the leader and produces q_c **first**
- Coke knows exactly how Pepsi will respond to its output:

$$q_p^* = 45 - 0.5q_c$$

- Coke, as leader, in theory faces **entire market demand**
    - But **not rational** to act like a monopolist!
    - knows that Pepsi (the follower) will still produce afterwards, which pushes down market price for both firms!

Stackelberg Competition as Sequential Game

- This is a sequential game, so we should solve this via **backward induction**
- Though **Pepsi** will move second (last), it will be responding to **Coke**'s output
- So **Coke** must know how **Pepsi** will react in order to choose its optimal output



Stackelberg Competition: Example

- Substitute **follower**'s reaction function into (inverse) market demand function faced by **leader**

$$P = 5 - 0.05q_c - 0.05p_p$$
$$P = 5 - 0.05q_c - 0.05(45 - 0.5q_c)$$
$$P = 2.75 - 0.025q_c$$

- Now find $MR(q)$ for **Coke** from this by doubling the slope:

$$MR_c = 2.75 - 0.05q_c$$

Stackelberg Competition: Example

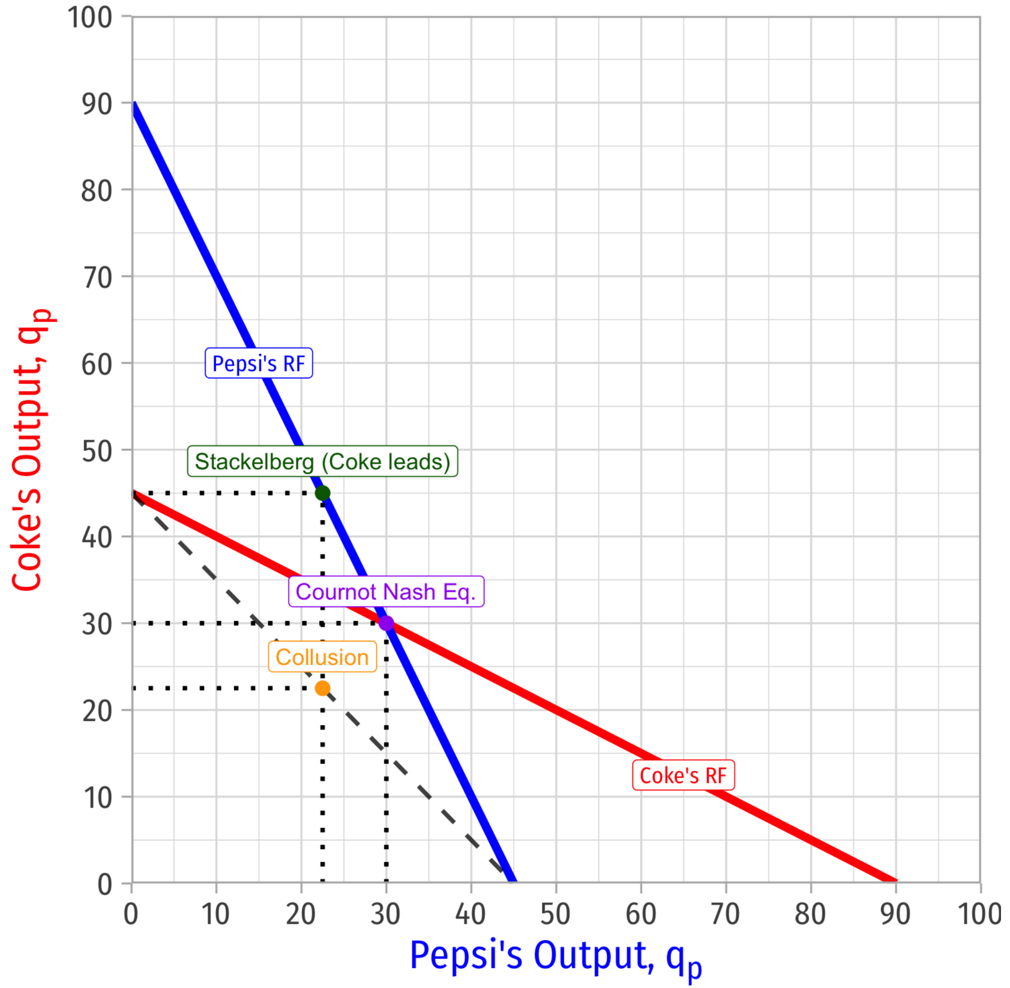
- Now **Coke** can find its optimal quantity:

$$
\begin{aligned}
MR_c &= MC \\
2.75 - 0.05q_c &= 0.50 \\
45 &= q_c^*
\end{aligned}
$$

- **Pepsi** will optimally respond by producing:

$$
\begin{aligned}
q_p^* &= 45 - 0.5q_c \\
q_p^* &= 45 - 0.5(45) \\
q_p^* &= 22.5
\end{aligned}
$$

Stackelberg Competition: Example



- **Stackelberg Nash Equilibrium**:

$$\left(q_c^* = 45, q_p^* = 22.5\right)$$

Stackelberg Competition: Example

- With $q_c^* = 45$ and $q_p^* = 22.5$, this sets a market-clearing price of:

$$P = 5 - 0.05(67.5)$$
$$P = \$1.625$$

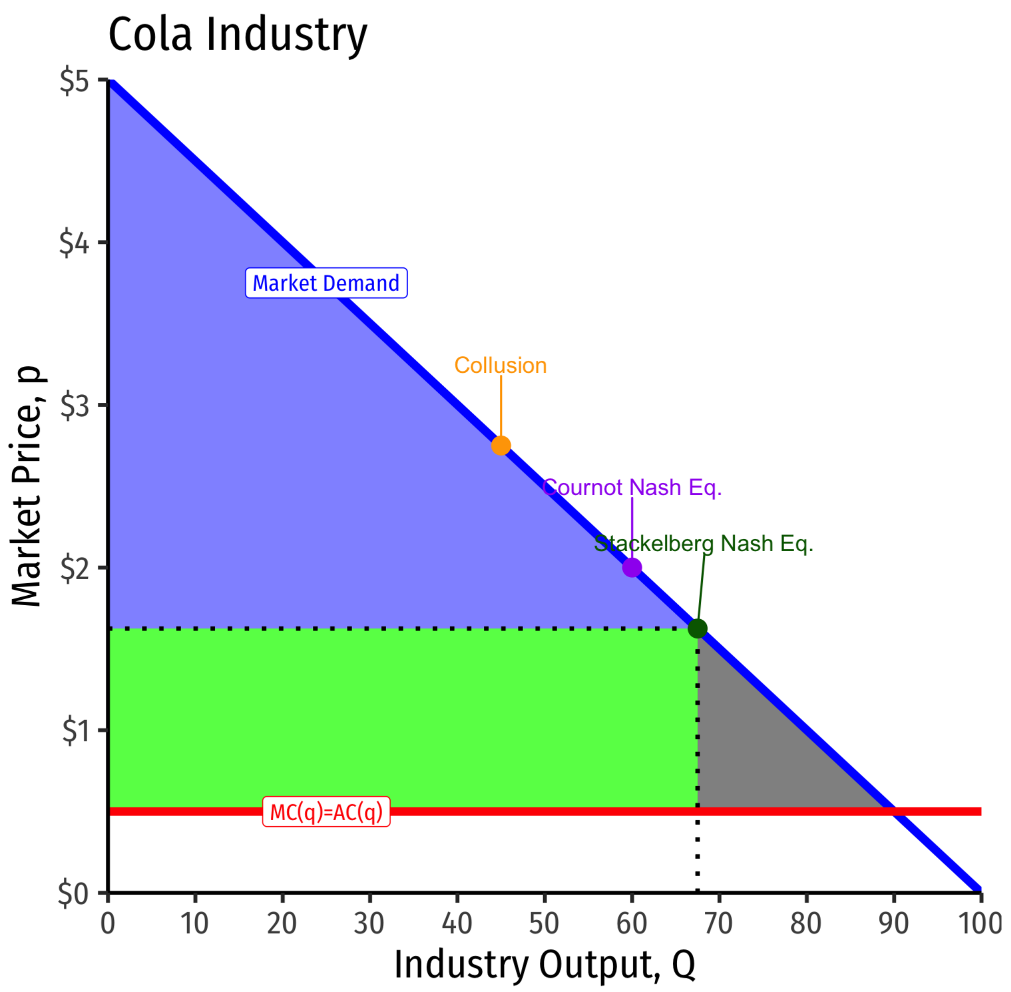
- **Coke's** profit would be:

$$\pi_c = (1.625 - 0.50)45$$
$$\pi_c = \$50.625$$

- **Pepsi's** profit would be:

$$\pi_p = (1.625 - 0.50)22.5$$
$$\pi_p = \$25.3125$$

Stackelberg-Nash Equilibrium, The Market

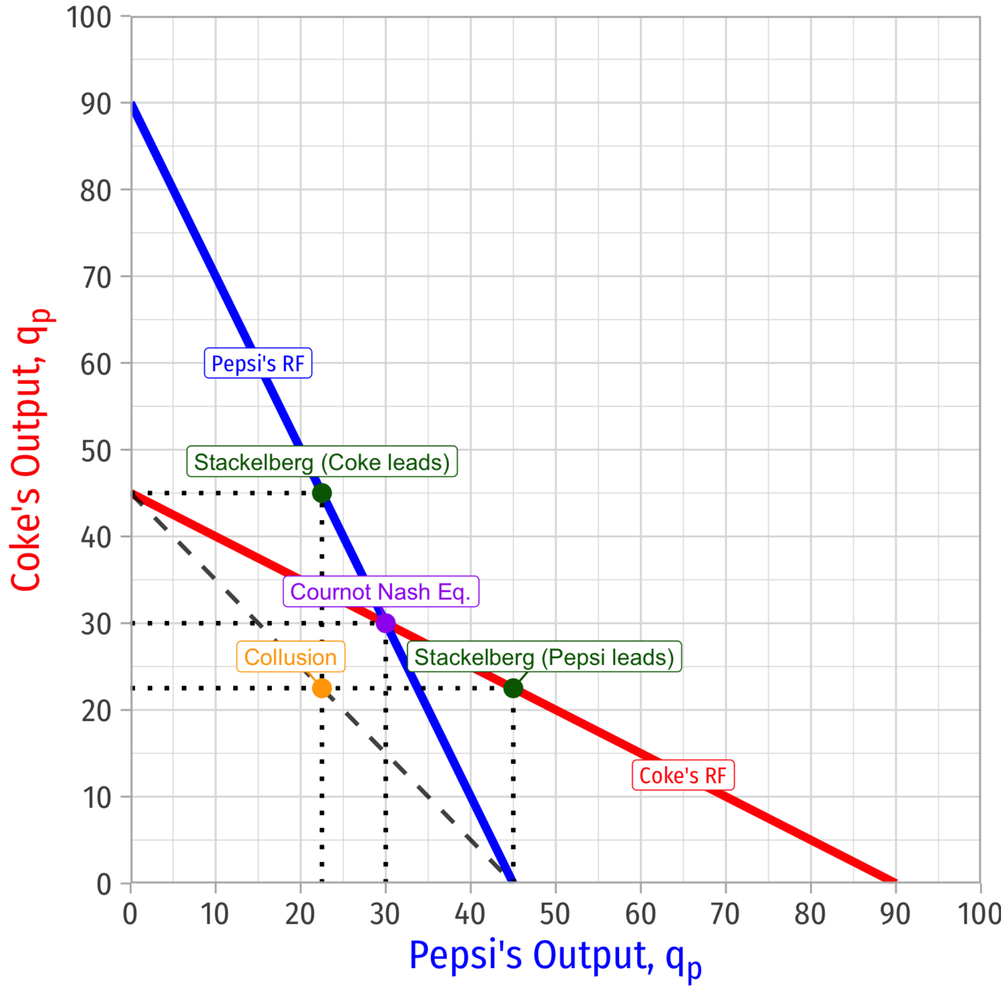


Cournot vs. Stackelberg Competition

Firm	Cournot (p = $2.00)		Stackelberg (p = $1.63)	
	output	profit	output	profit
Coke	30.00	$45.00	45.00	$50.63
Pepsi	30.0	$45.00	22.50	$25.31
INDUSTRY	60.0	$90.00	67.50	$75.94

Stackelberg and First-Mover Advantage

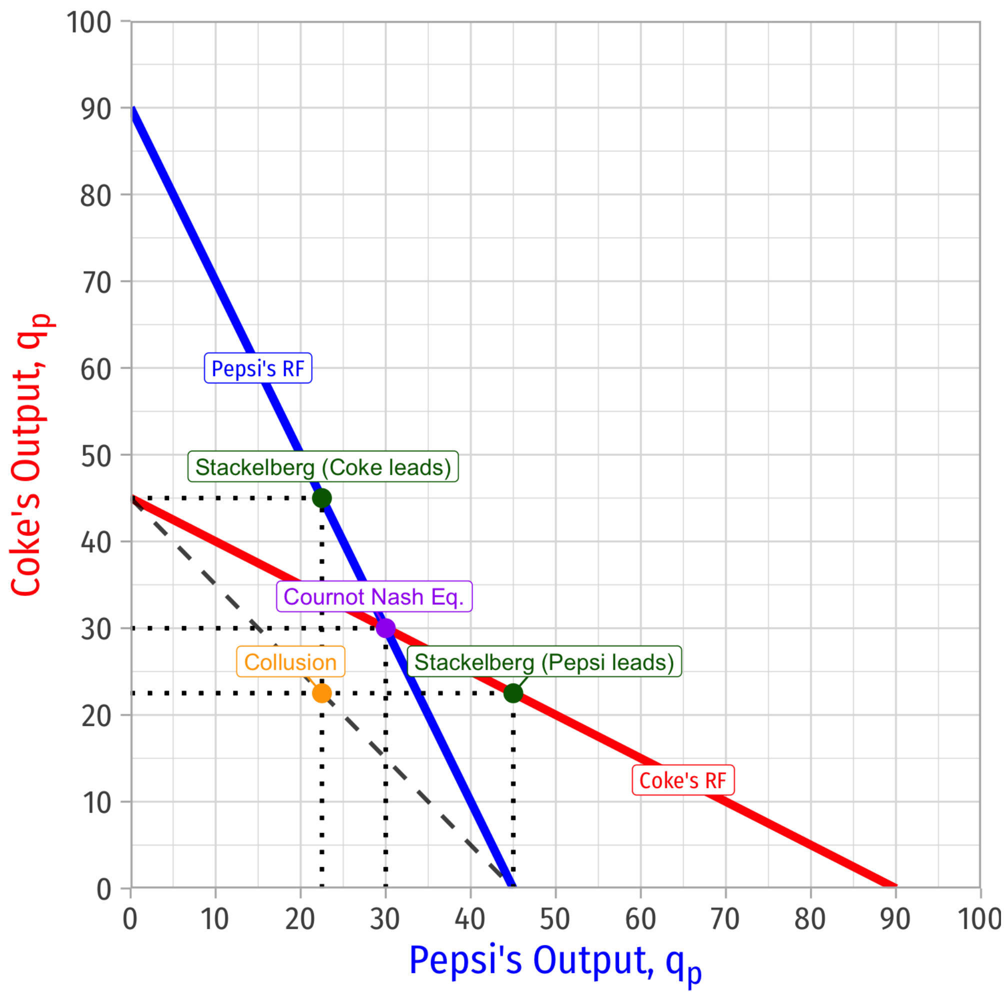
- Stackelberg **leader** clearly has a **first-mover advantage** over the **follower**
    - **Leader**: $q^* = 45$, π = $50.63
    - **Follower**: $q^* = 22.5$, π = $25.31
- If firms compete **simultaneously** (**Cournot**): $q^* = 30$, π = $45.00 each
- Leading $\succ$ simultaneous $\succ$ Following



Stackelberg and First-Mover Advantage

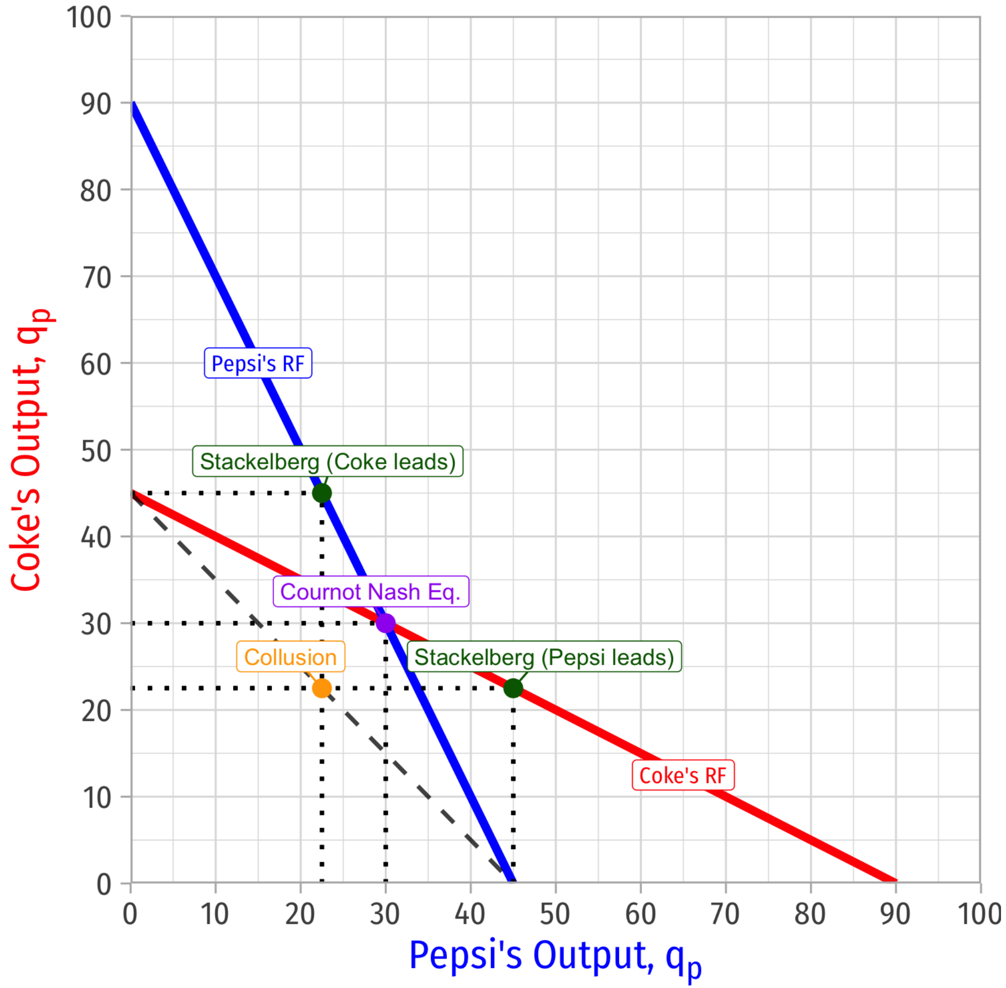
- Stackelberg Nash equilibrium requires **perfect information** for **both** leader and follower
  - Follower must be able to **observe** leader's output to choose its own
  - Leader must **believe** follower will see leader's output and react optimally

- **Imperfect information** reduces the game to (simultaneous) **Cournot competition**



Stackelberg and First-Mover Advantage

- Again, leader *cannot* act like a monopolist
  - A strategic game! Market output (that pushes down market price) is $Q = q_c + q_p$
- Leader's choice of 45 is optimal **only if** follower responds with 22.5



Comparing All Oligopoly Models

Firm	Bertrand (p = $0.50)		Cournot (p = $2.00)		Stackelberg (p = $1.63)		Collusion (p = $1.75)	
	output	profit	output	profit	output	profit	output	profit
Coke	45.00	$0.00	30.00	$45.00	45.00	$50.63	22.50	$50.63
Pepsi	45.00	$0.00	30.00	$45.00	22.50	$25.31	22.50	$50.63
INDUSTRY	90.00	$0.00	60.00	$90.00	67.50	$75.94	45.00	$101.25

- Output: $Q_m < Q_c < Q_s < Q_b$
- Market price: $P_b < P_s < P_c < P_m$
- Profit: $\pi_b = 0 < \pi_s < \pi_c < \pi_m$

Where subscript m is monopoly (collusion), c is Cournot, s is Stackelberg, b is Bertrand