2.4 — Stackelberg Competition

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Models of Oligopoly

Three canonical models of Oligopoly

1. Bertrand competition
   - Firms **simultaneously** compete on **price**
2. Cournot competition
   - Firms **simultaneously** compete on **quantity**
3. Stackelberg competition
   - Firms **sequentially** compete on **quantity**

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

Example: Return to **Saudi Arabia** (sa) and **Iran** (i), again with the market (inverse) demand curve:

$$P = 200 - 3Q$$
$$Q = q_{sa} + q_i$$

- We solved for Saudi Arabia and Iran's **reaction functions** in **Cournot competition** last class:

$$q_{sa}^{*} = 30 - 0.5q_i$$
$$q_i^{*} = 30 - 0.5q_{sa}$$

Stackelberg Competition: Example

$$q_{sa}^* = 30 - 0.5q_i$$
$$q_i^* = 30 - 0.5q_{sa}$$

- Suppose **Saudi Arabia** is the **Stackelberg leader** and produces q_{sa} **first**
- Saudi Arabia knows exactly how Iran will respond to its output

$$q_i^* = 30 - 0.5q_{sa}$$

- **Saudi Arabia**, as leader, essentially faces **entire market demand**
  - But **can't** act like a pure monopolist!
  - knows that **follower** will still produce afterwards, which pushes down market price for both firms!

Stackelberg Competition: Example

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

$$P = 200 - 3q_{sa} - 3(30 - 0.5q_{sa})$$
$$P = 110 - 1.5q_{sa}$$

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

$$MR_{Leader} = 110 - 3q_{sa}$$

Stackelberg Competition: Example

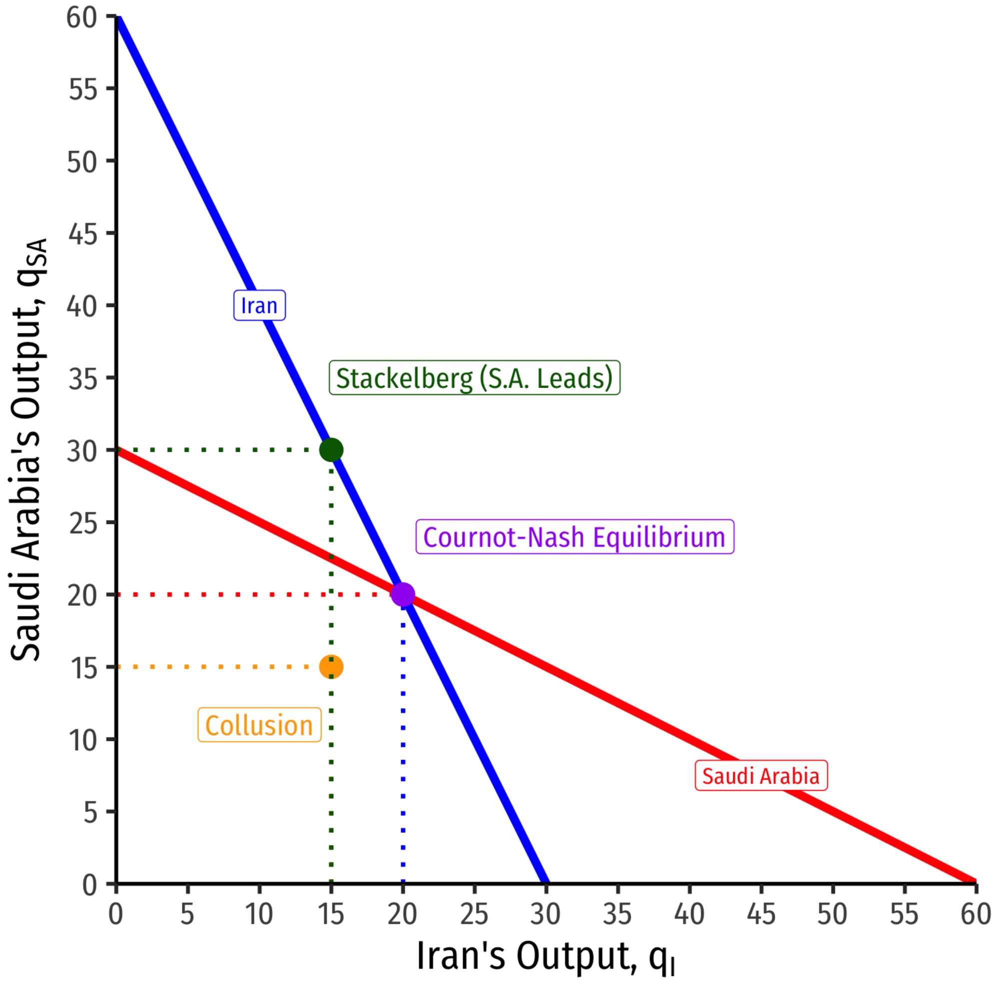
- Now **Saudi Arabia** can find its optimal quantity:

$$
\begin{aligned}
MR_{Leader} &= MC \\
110 - 3q_{sa} &= 20 \\
30 &= q^*_{sa}
\end{aligned}
$$

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

$$
\begin{aligned}
q^*_i &= 30 - 0.5q_{sa} \\
q^*_i &= 30 - 0.5(30) \\
q^*_i &= 15
\end{aligned}
$$

Stackelberg Equilibrium, Graphically



- **Stackelberg Nash Equilibrium**:

$$\left(q^*_{sa} = 30, q^*_i = 15\right)$$

Stackelberg Competition: Example

- With $q_{sa}^* = 30$ and $q_i^* = 15$, this sets a market-clearing price of:

$$P = 200 - 3(45)$$
$$P = 65$$

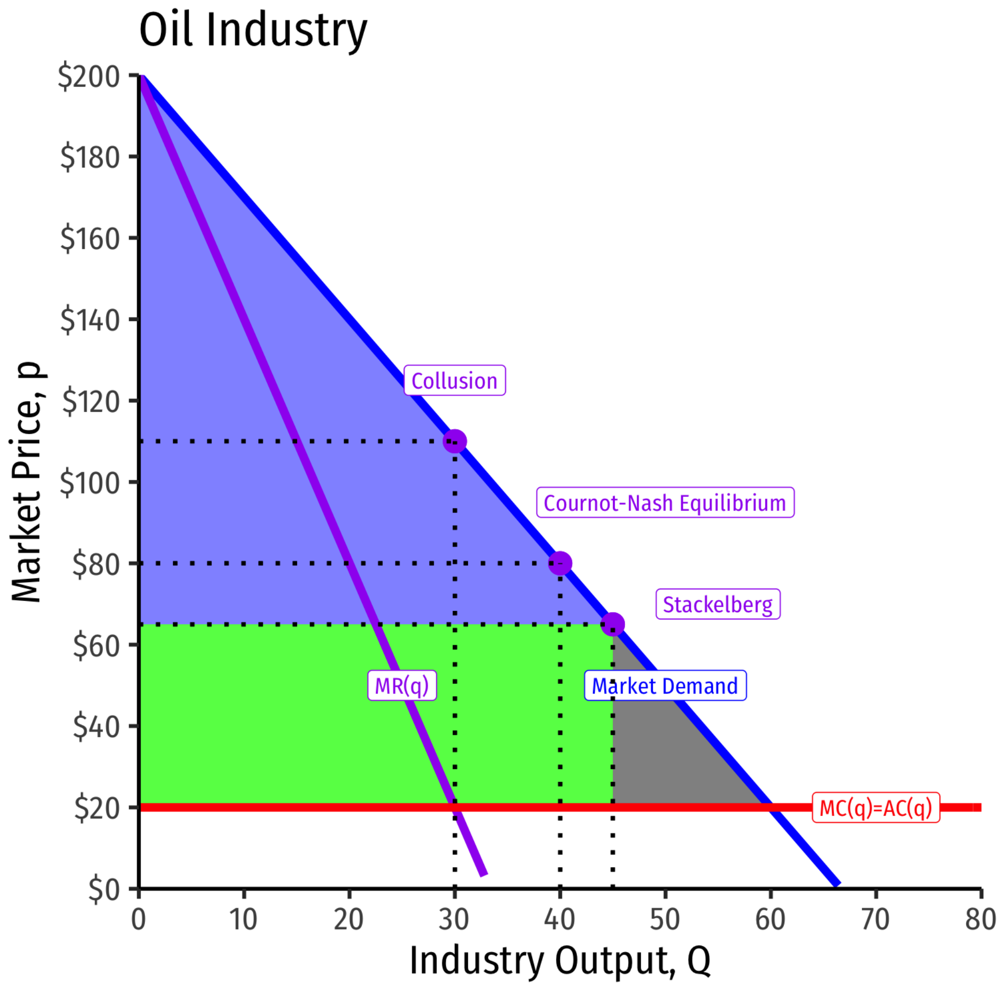
- **Saudi Arabia's** profit would be:

$$\pi_{sa} = 30(65 - 20)$$
$$\pi_{sa} = \$1,350$$

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

$$\pi_i = 15(65 - 20)$$
$$\pi_i = \$675$$

Stackelberg Equilibrium, The Market

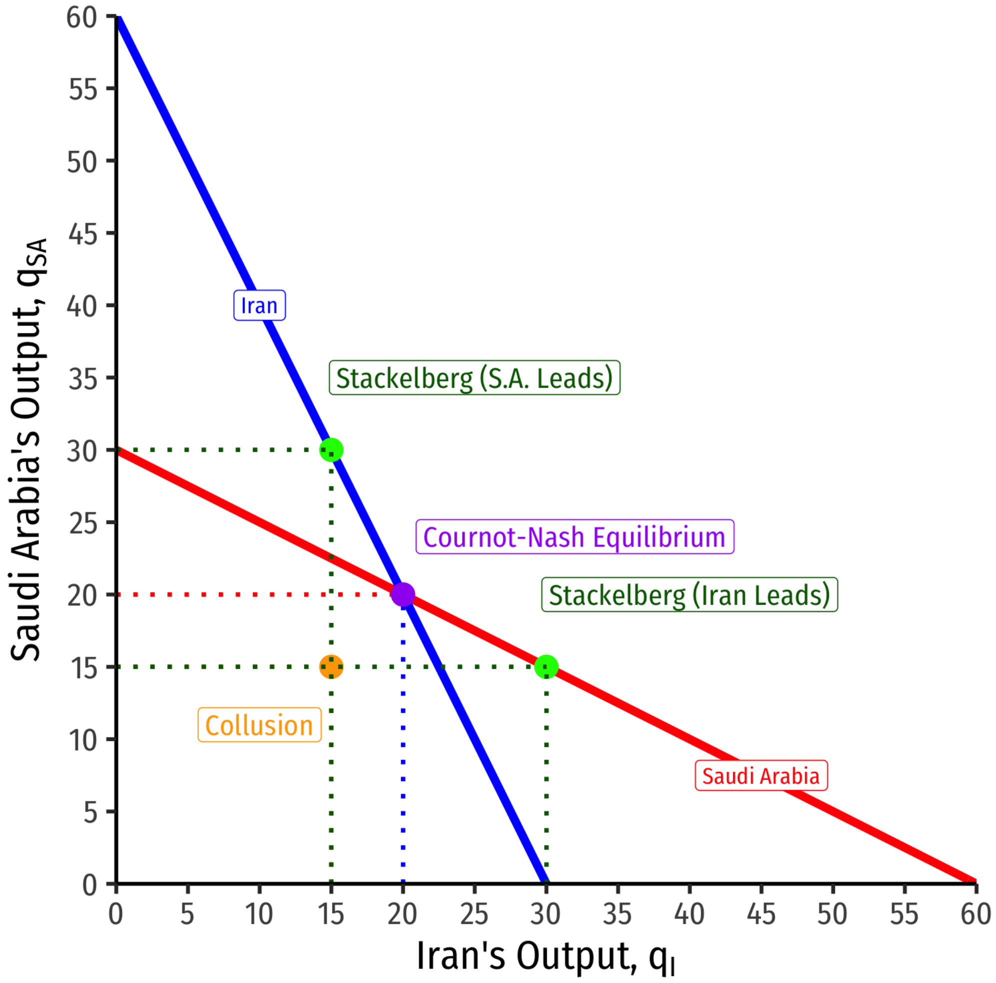


Cournot vs. Stackelberg Competition

	Cournot (p*=$80)		Stackelberg (p*=$65)	
Firm	Output	Profit	Output	Profit
Saudi Arabia	20	$1,200	30	$1,350
Iran	20	$1,200	15	$675
Industry	40	$2,400	45	$2,025

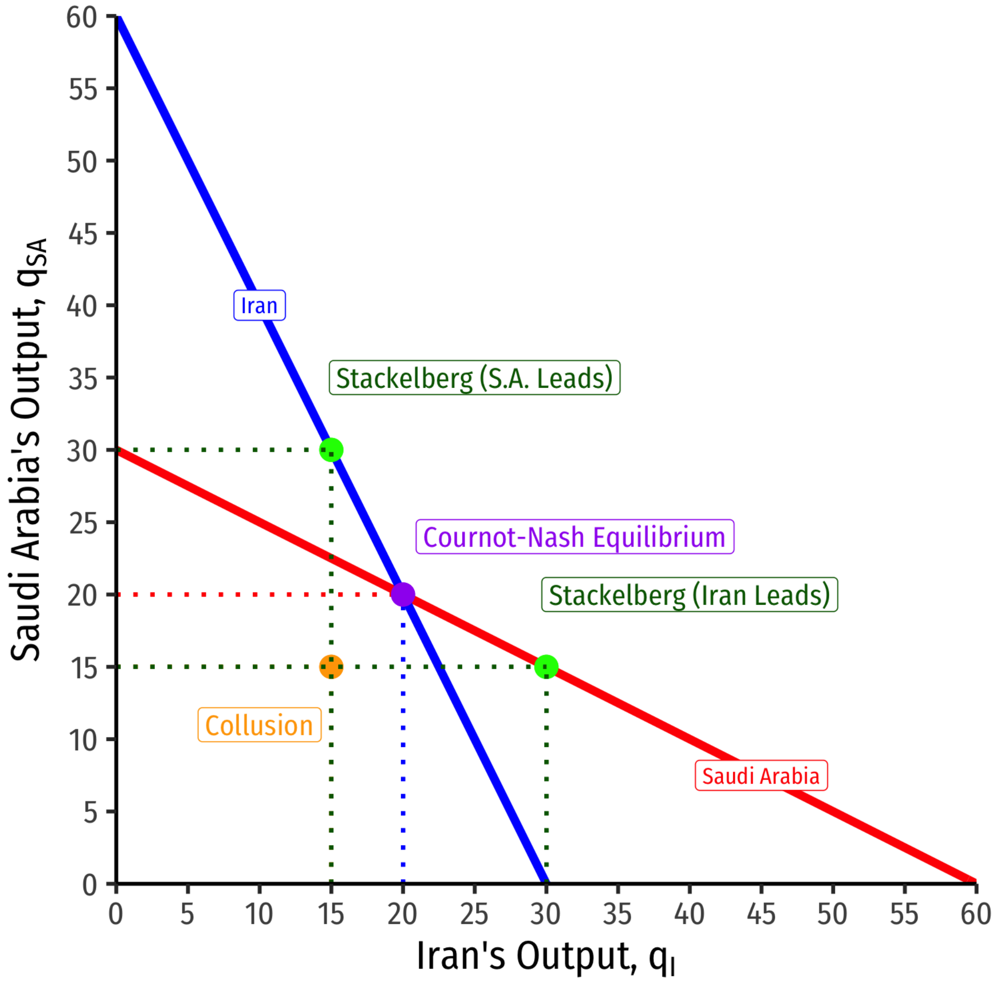
- **Leader** Saudi Arabia ↑ its output and ↑ profits
- **Follower** Iran forced to ↓ its output and accept ↓ profits

Stackelberg and First-Mover Advantage



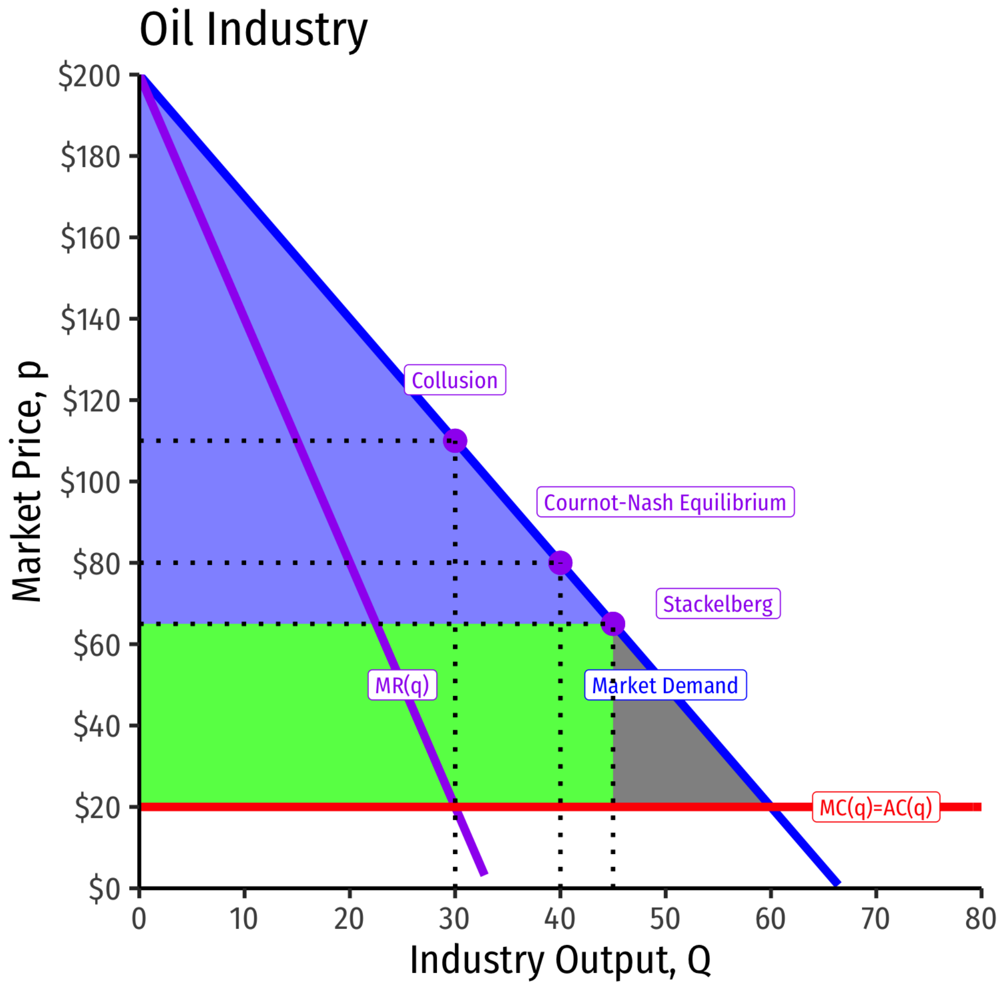
- Stackelberg **leader** clearly has a **first-mover advantage** over the **follower**
  - **Leader**: $q^* = 30, \pi = 1,350$
  - **Follower**: $q^* = 15, \pi = 675$
- If firms compete **simultaneously** (**Cournot**): $q^* = 20, \pi = 1,200$ each
- Leading $\succ$ simultaneous $\succ$ Following

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 $Q = q_{sa} + q_i$
- Leader's choice of 30 is optimal **only if** follower responds with 15

Comparing All Oligopoly Models

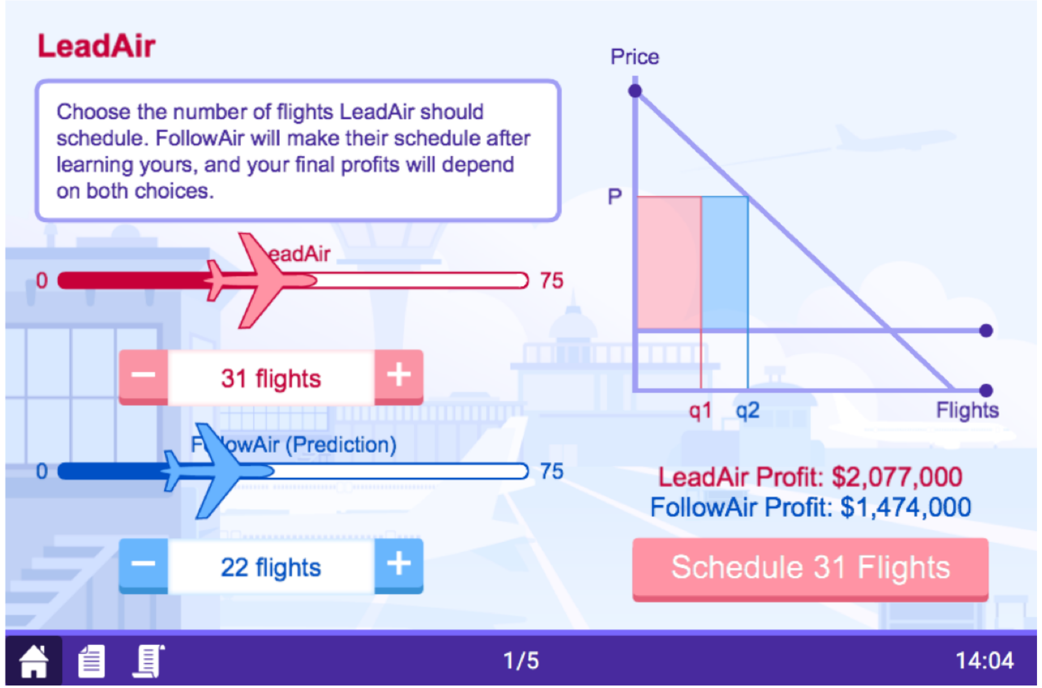
	Bertrand			Cournot			Stackelberg			Collusion		
Country	q	p	π	q	p	π	q	p	π	q	p	π
Saudi Arabia	30	$20	$0	20	$80	$1,200	30	$65	$1,350	15	$110	$1,350
Iran	30	$20	$0	20	$80	$1,200	15	$65	$675	15	$110	$1,350
Industry	60	$20	$0	40	$80	$2,400	45	$65	$2,025	30	$110	$2,700

- 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

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