


School of Business,
Economics and Law
GÖTEBORG UNIVERSITY

Oligopoly

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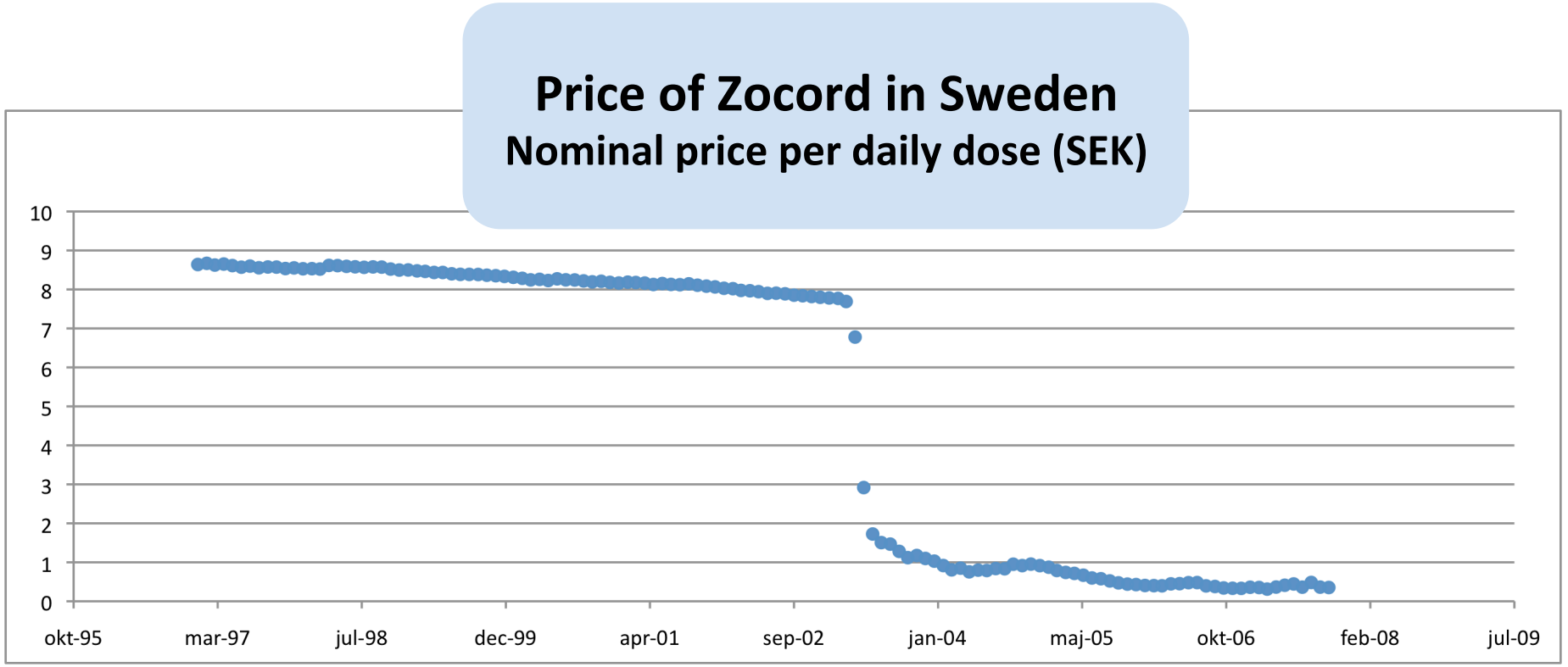
Oligopoly

- Example: Zocord
  - Reduces cholesterol
  - Produced by Merck & Co
  - Patent expired in April 2003 (in Sweden)
  - Other companies started to sell perfect copies

    (= containing exactly the same active ingredient Simvastatin)

Examples


Price of Zocord in Sweden
Nominal price per daily dose (SEK)
10
9
8
7
6
5
4
3
2
1
0
okt-95
mar-97
jul-98
dec-99
apr-01
sep-02
jan-04
maj-05
okt-06
feb-08
jul-09

Oligopoly

- Question
  - How does competition work?
  - How strong is it?
  - How does that depend on the market?
- Compare monopoly and duopoly
  - Given market (technology, demand)
  - Q: How does price depend on #firms?

A duopoly model
(Bertrand)

Duopoly

- Timing

  1. Firms set prices simultaneously

  2. Consumers decide how much to buy and from whom

  NB: Firms have no time to react!

Duopoly

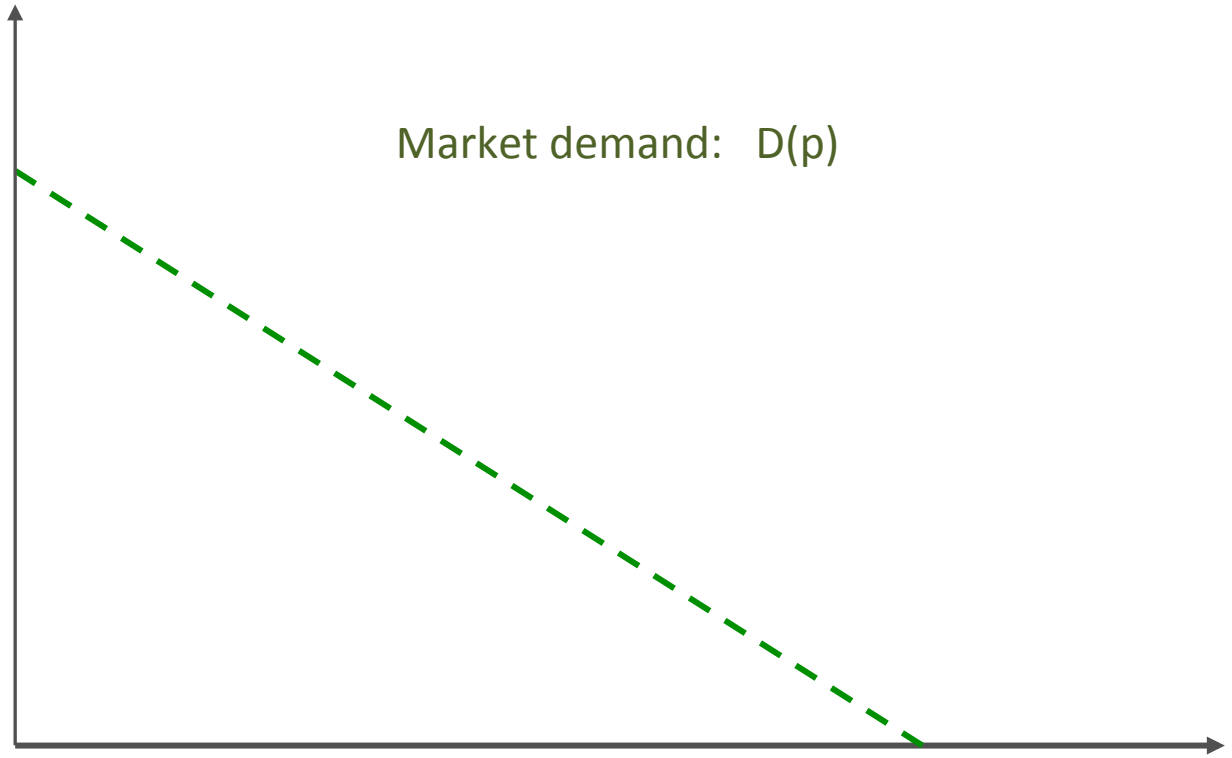
- Technology
  - Constant marginal cost
  - Firms have same marginal cost
- Demand
  - Market demand: Linear (example)
  - Firms' goods homogenous

Duopoly

- Consumer behavior
  - All buy from cheapest firm
  - If same price: 50-50 split

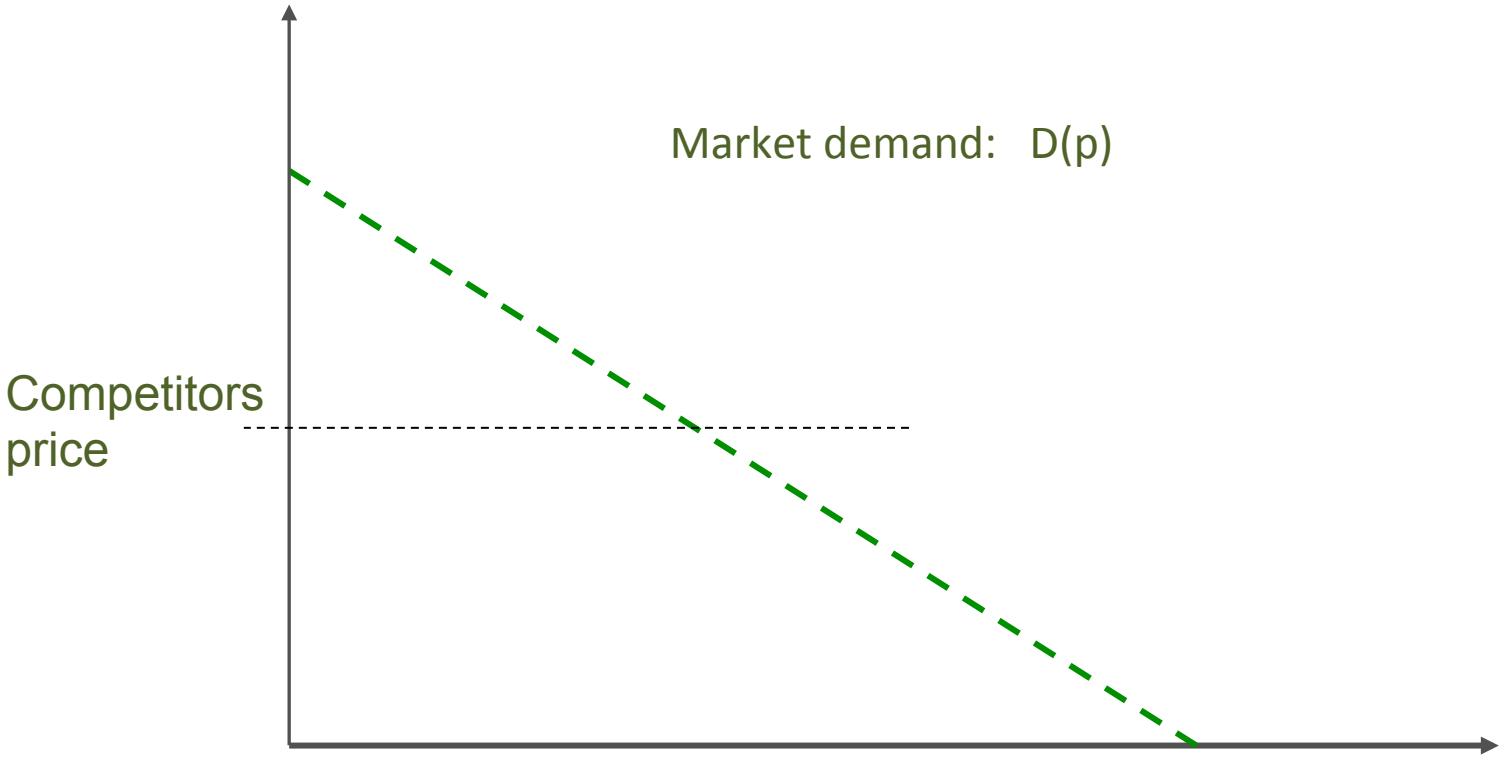
Duopoly

Residual demand



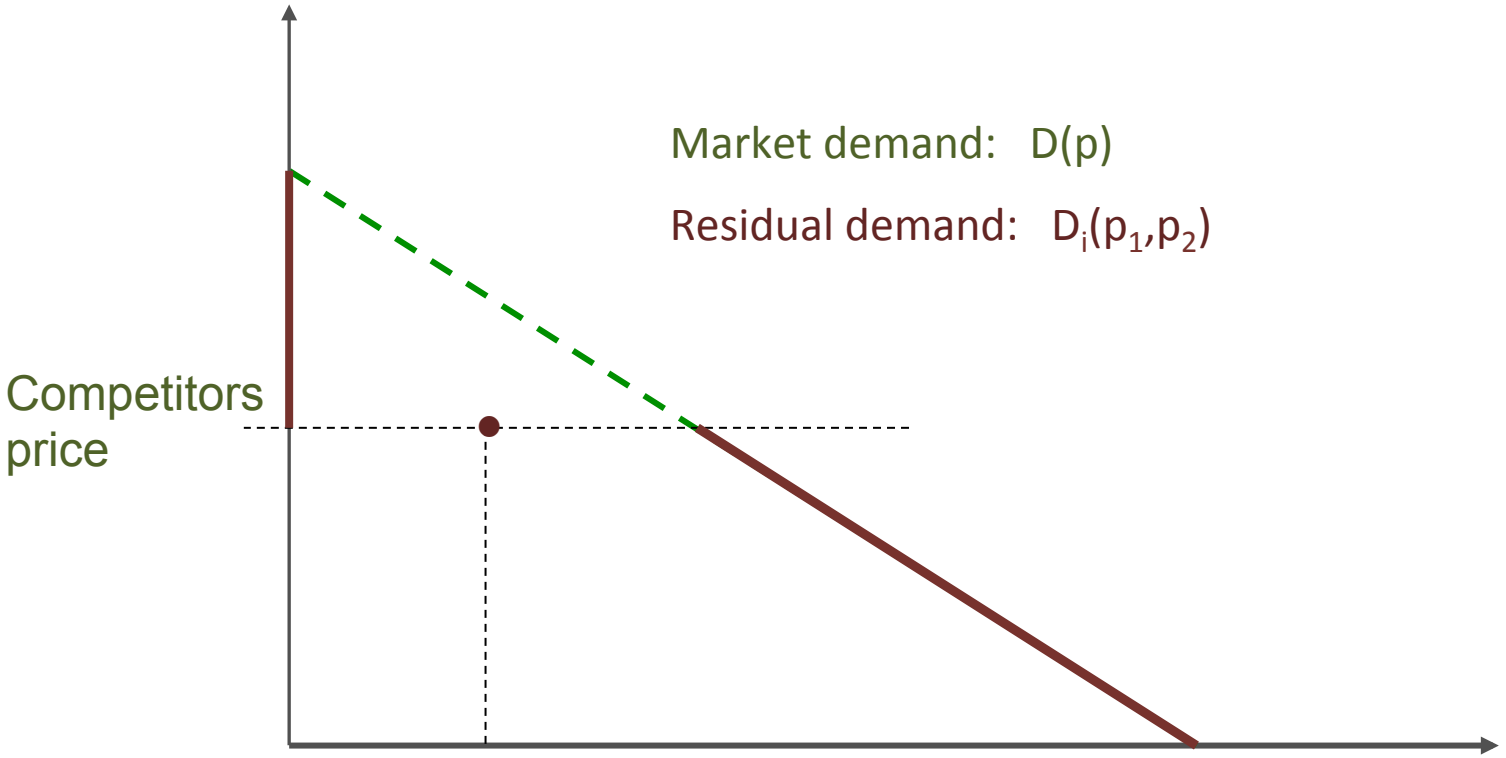
Duopoly

Residual demand



Duopoly

Residual demand



Duopoly

Profits

$$\pi_i(p_1, p_2) = (p_i - c) D_i(p_1, p_2)$$

where

$$D_1(p_1, p_2) = \begin{cases} D(p_1) & p_1 < p_2 \\ \frac{1}{2} D(p_1) & \text{if } p_1 = p_2 \\ 0 & p_1 > p_2 \end{cases}$$

Duopoly

Game Theory

- Inter-dependent decisions
  - Firm 1's optimal price depends on firm 2's price
  - Firm 2's optimal price depends on firm 1's price
- How to analyze
  - Cannot simply assume profit maximizing behavior
  - Game theory

Duopoly

Game Theory

- Game in normal form
  - Q: Elements of a game in normal form?
    - Players, Strategies, Payoffs
  - Players
    - Firm 1 and Firm 2
  - Strategies
    - Each firm chooses a price p_i (a real number)
    - Recall: Strategy profile = A price for each player (p_1, p_2)
  - Payoffs
    - Profits
    - Recall: Payoff function assigns a payoff for every possible strategy profile, $\pi_i(p_1, p_2)$

Duopoly

Game Theory

- Nash equilibrium
  - "A common understanding among all players of how they are all going to behave"
  - A strategy profile such that no player can increase its payoff given that all other players follow their strategies

Duopoly

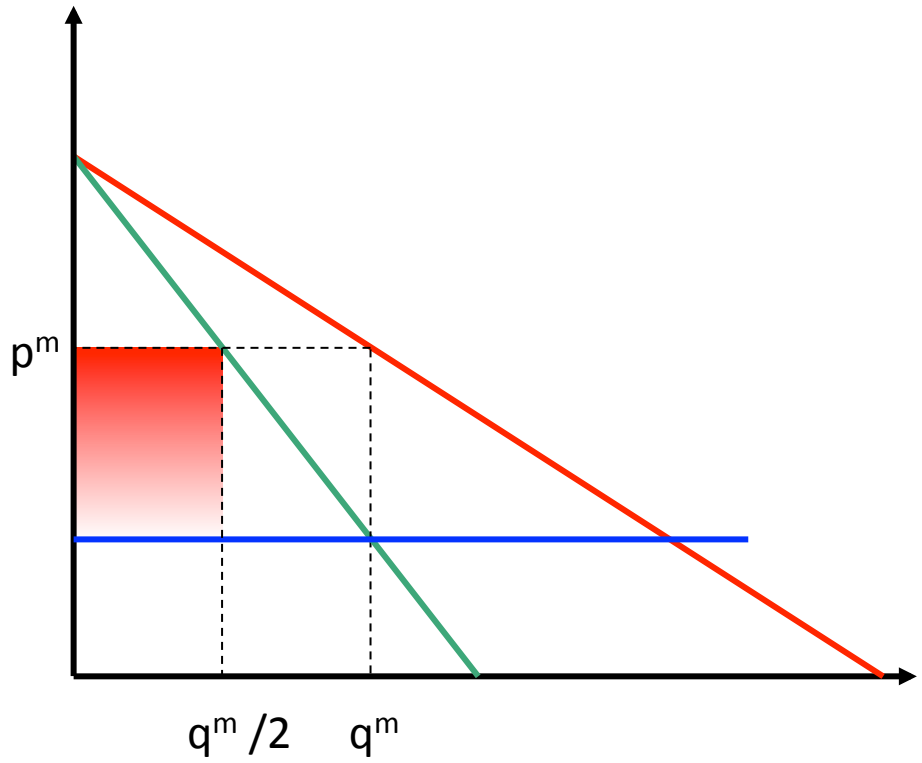
Game Theory

- Nash equilibrium in duopoly game
  - A pair of prices (p_1, p_2) such that
    - $\pi_1(p_1, p_2) \geq \pi_1(p'_1, p_2)$ for all p'_1
    - $\pi_2(p_1, p_2) \geq \pi_2(p_1, p'_2)$ for all p'_2

Duopoly

Intuitive Analysis

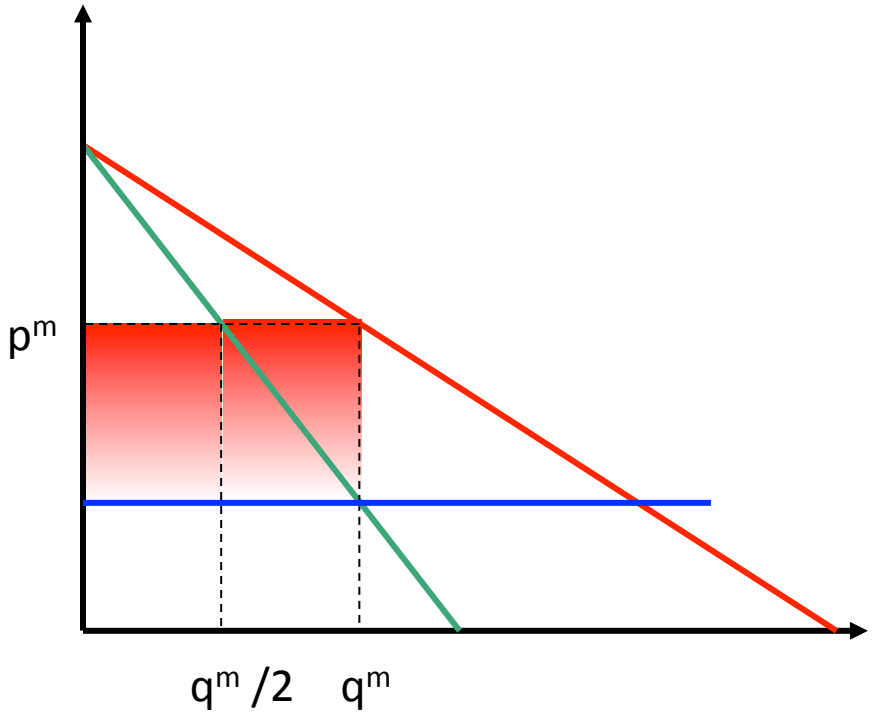
- Q: Will the two firms charge p^m?
  - Each would sell $q^m/2$
  - Each would earn $\pi^m/2$



Duopoly

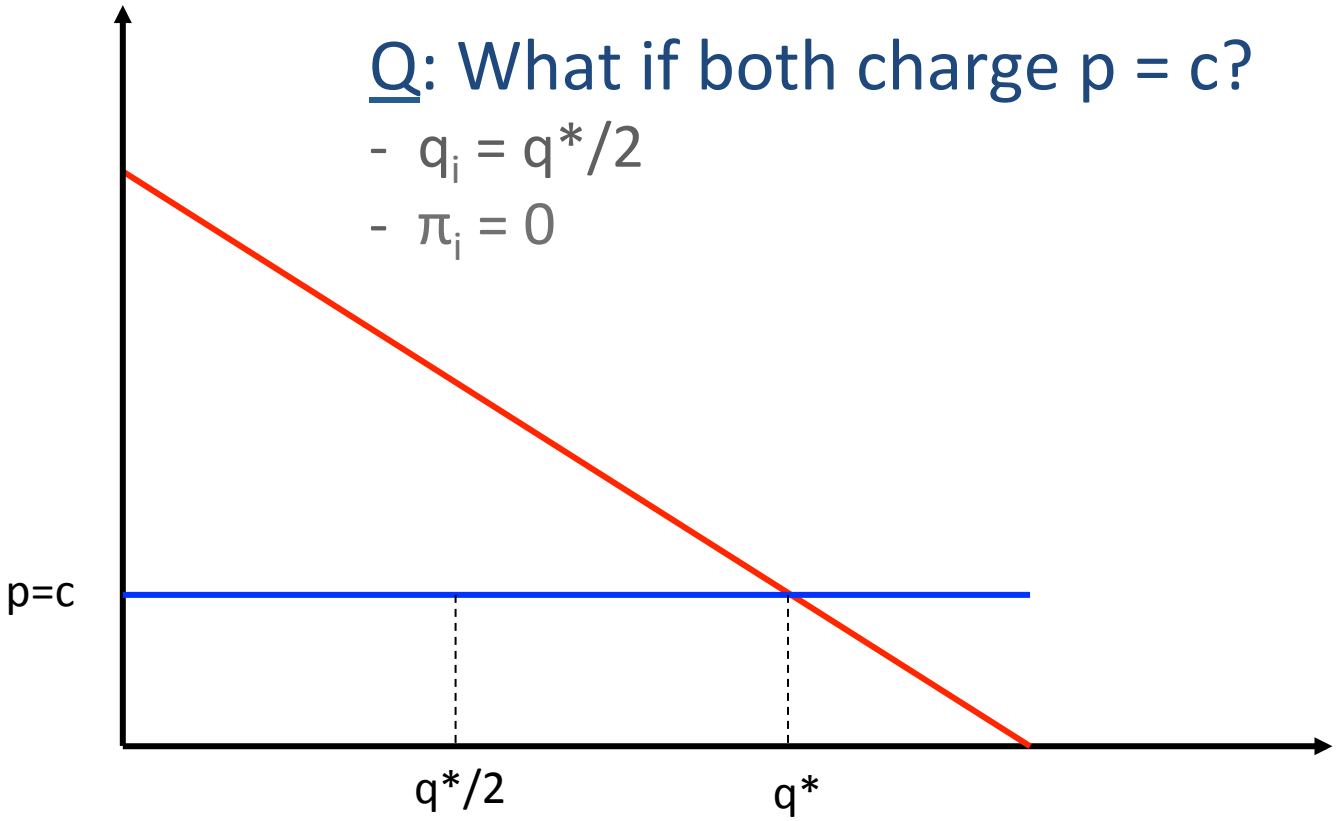
Intuitive Analysis

- What if a firm undercuts to $p^m - \varepsilon$?
  - It would sell $\approx q^m$
  - It would earn $\approx \pi^m$
- Conclusion
  - Small reduction in price ➔ Massive expansion of sales
  - p^m not reasonable prediction



Duopoly

Intuitive Analysis



Q: What if both charge p = c?

- $q_i = q^*/2$
- $\pi_i = 0$

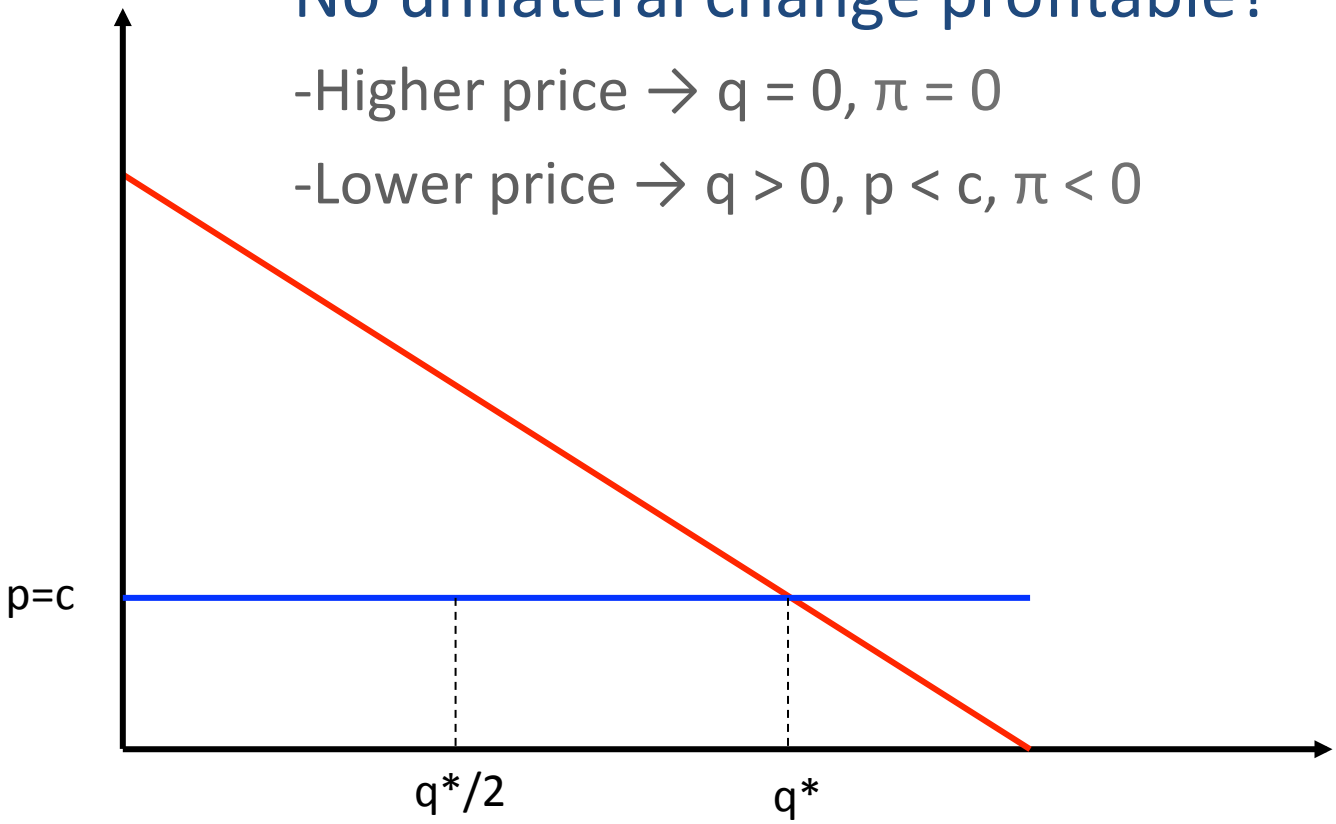
Duopoly

Intuitive Analysis

No unilateral change profitable?

-Higher price → $q = 0, \pi = 0$

-Lower price → $q > 0, p < c, \pi < 0$



Duopoly

Intuitive Analysis

- If both firms charge $p = c$
  - No incentive to change behavior
  - Reasonable prediction
  - Nash equilibrium

Duopoly

- Two formal proofs
  - For every possible outcome, investigate if someone has incentive to deviate
  - Best reply analysis

Duopoly

Candidate	Profitable deviation	
$p_1 > p_2 > c$	who?	what?

Duopoly

Candidate	**Profitable deviation**	
$p_1 > p_2 > c$	Firm i	$p_i = p_j - \varepsilon$ (max p^m)

Duopoly

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Duopoly

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Duopoly

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Duopoly

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Duopoly

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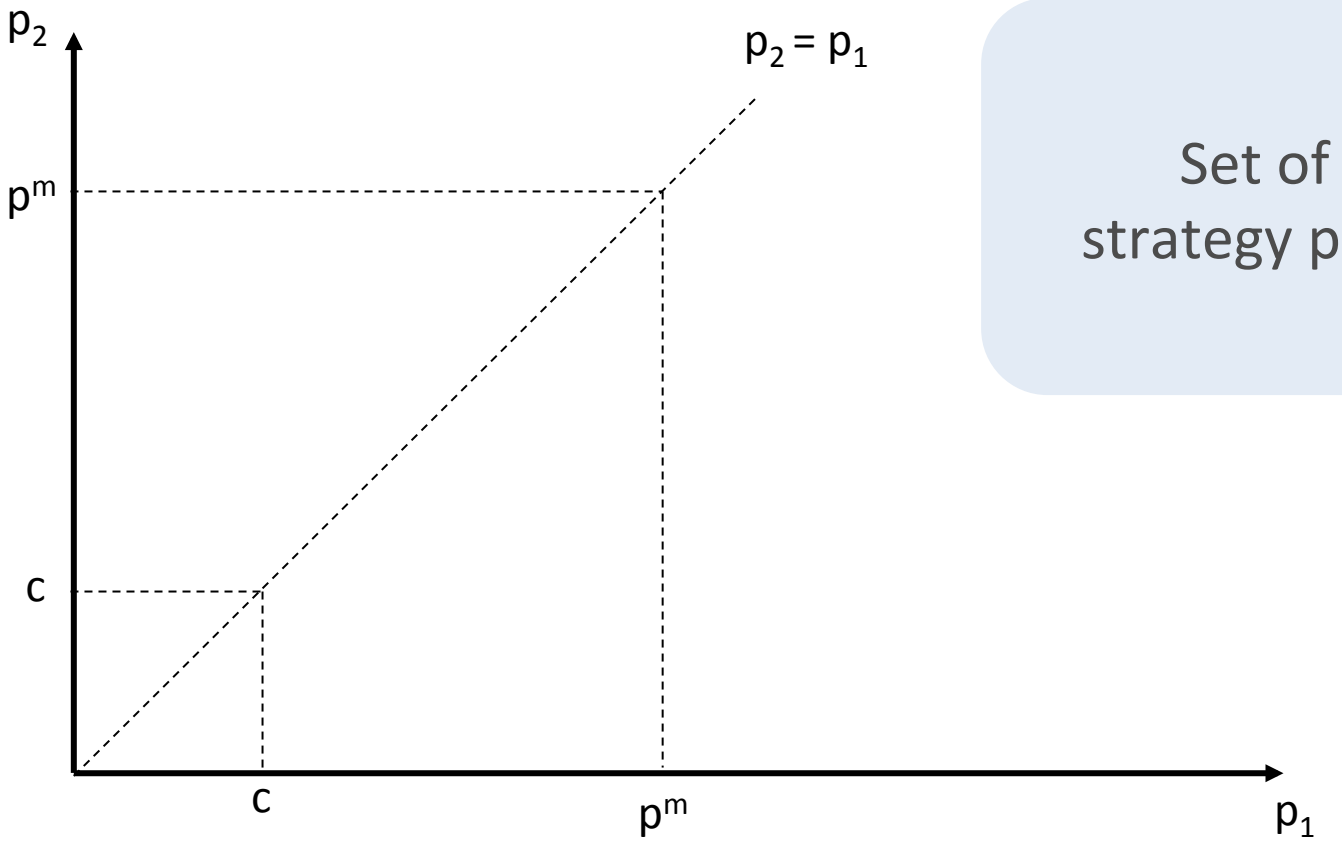
Duopoly

Best-reply analysis

Duopoly

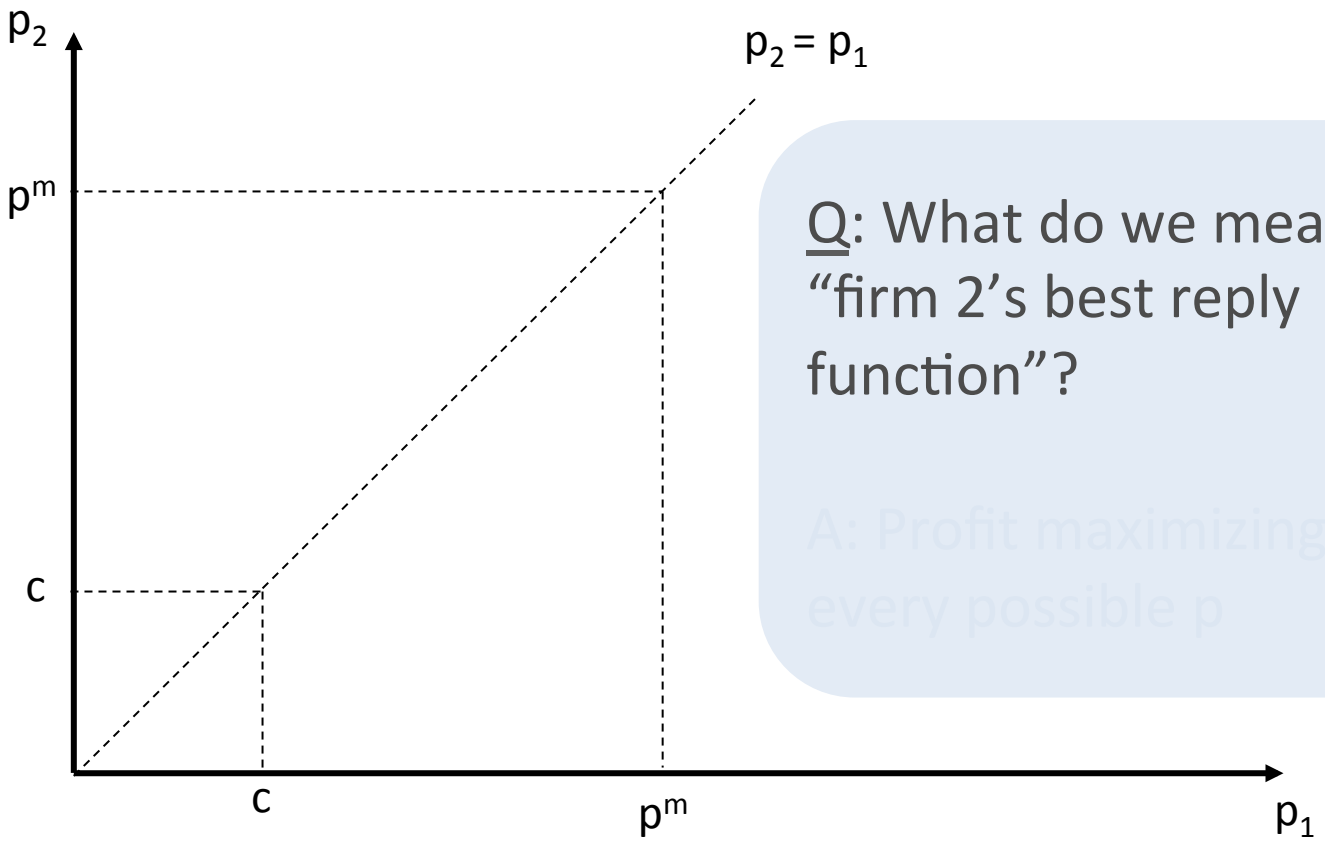
Best-reply analysis



Set of all strategy profiles

Duopoly

Best-reply analysis

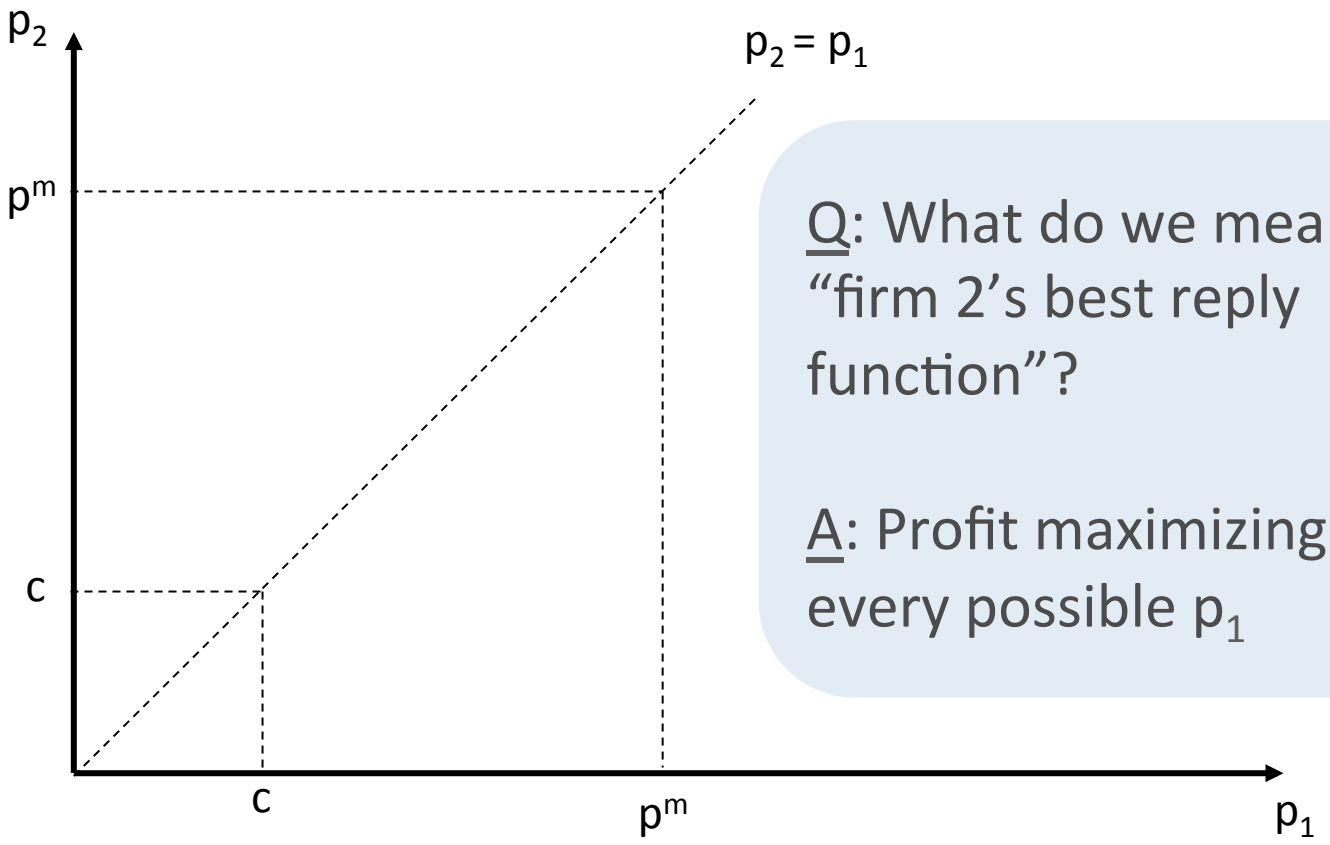


Q: What do we mean by "firm 2's best reply function"?

A: Profit maximizing p_2 for every possible p_1

Duopoly

Best-reply analysis



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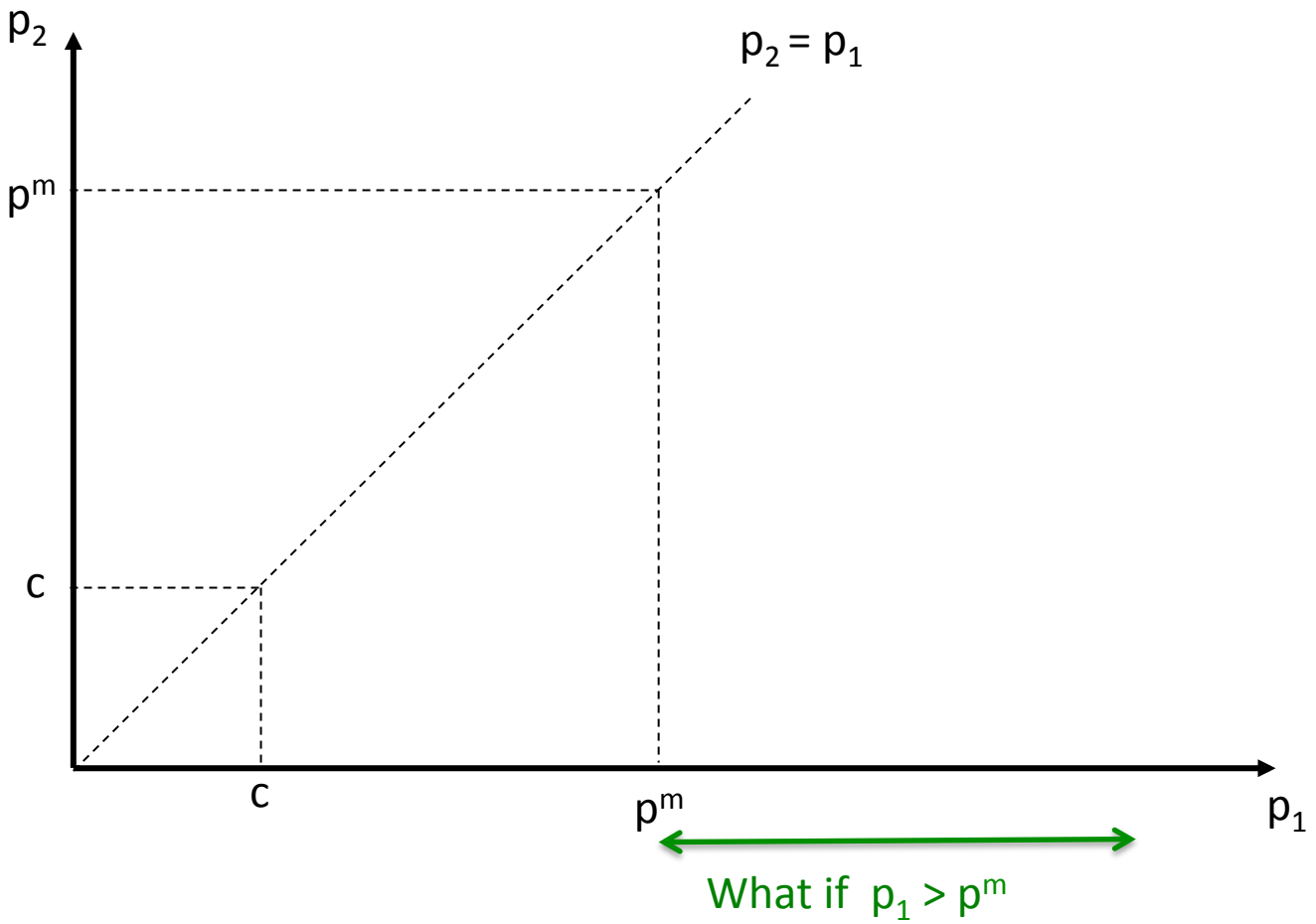
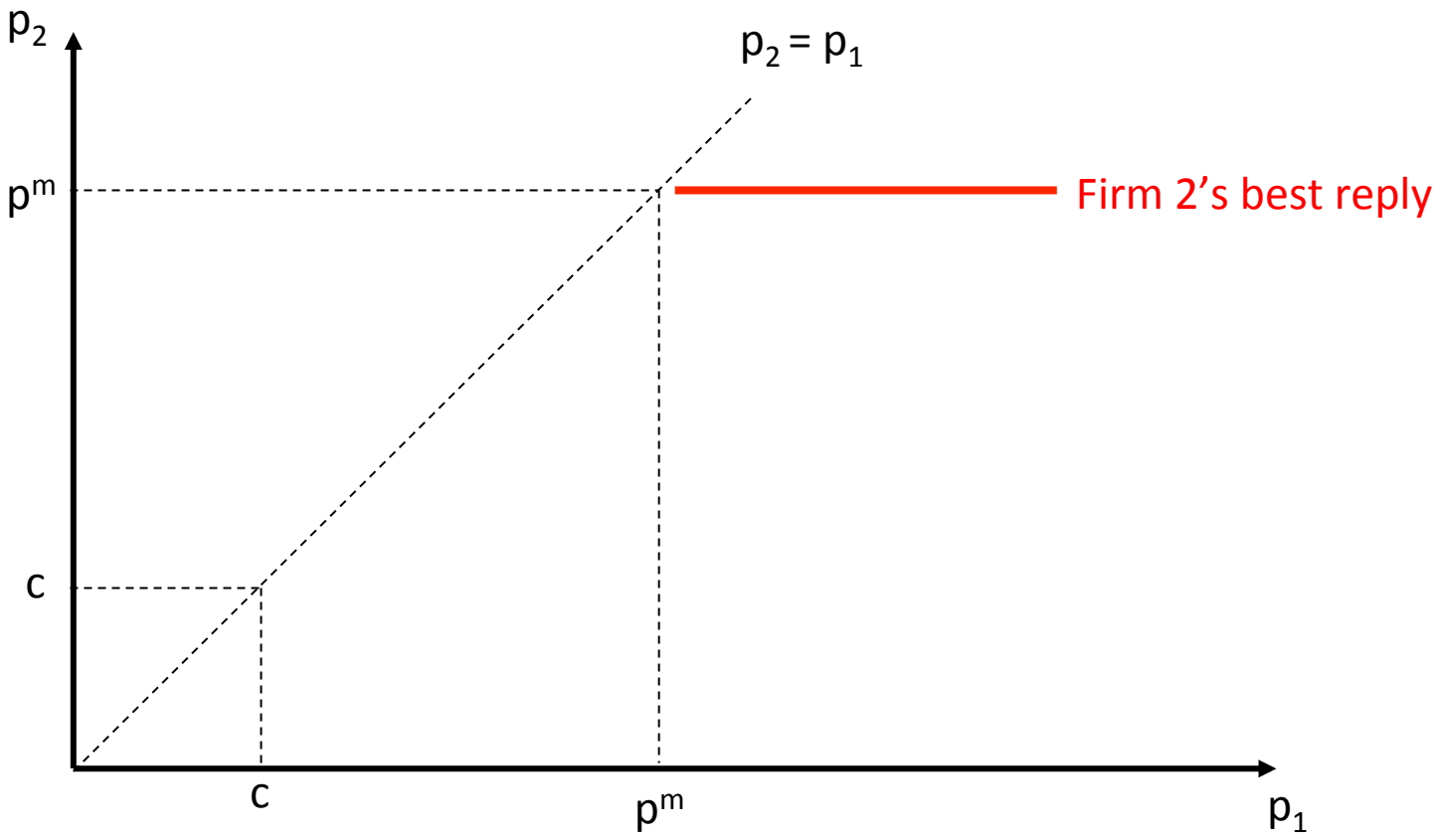
Duopoly

Best-reply analysis



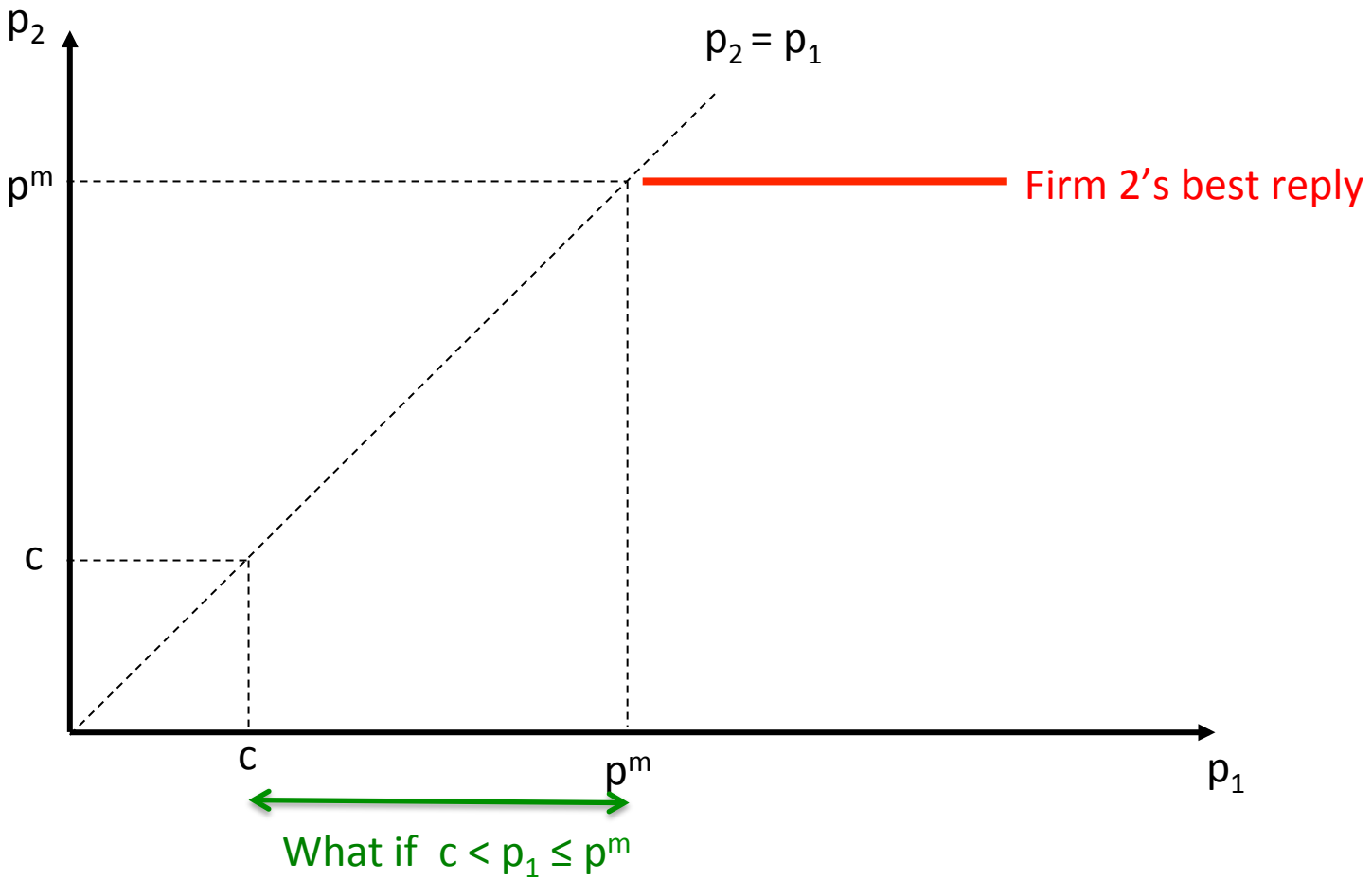
Duopoly

Best-reply analysis



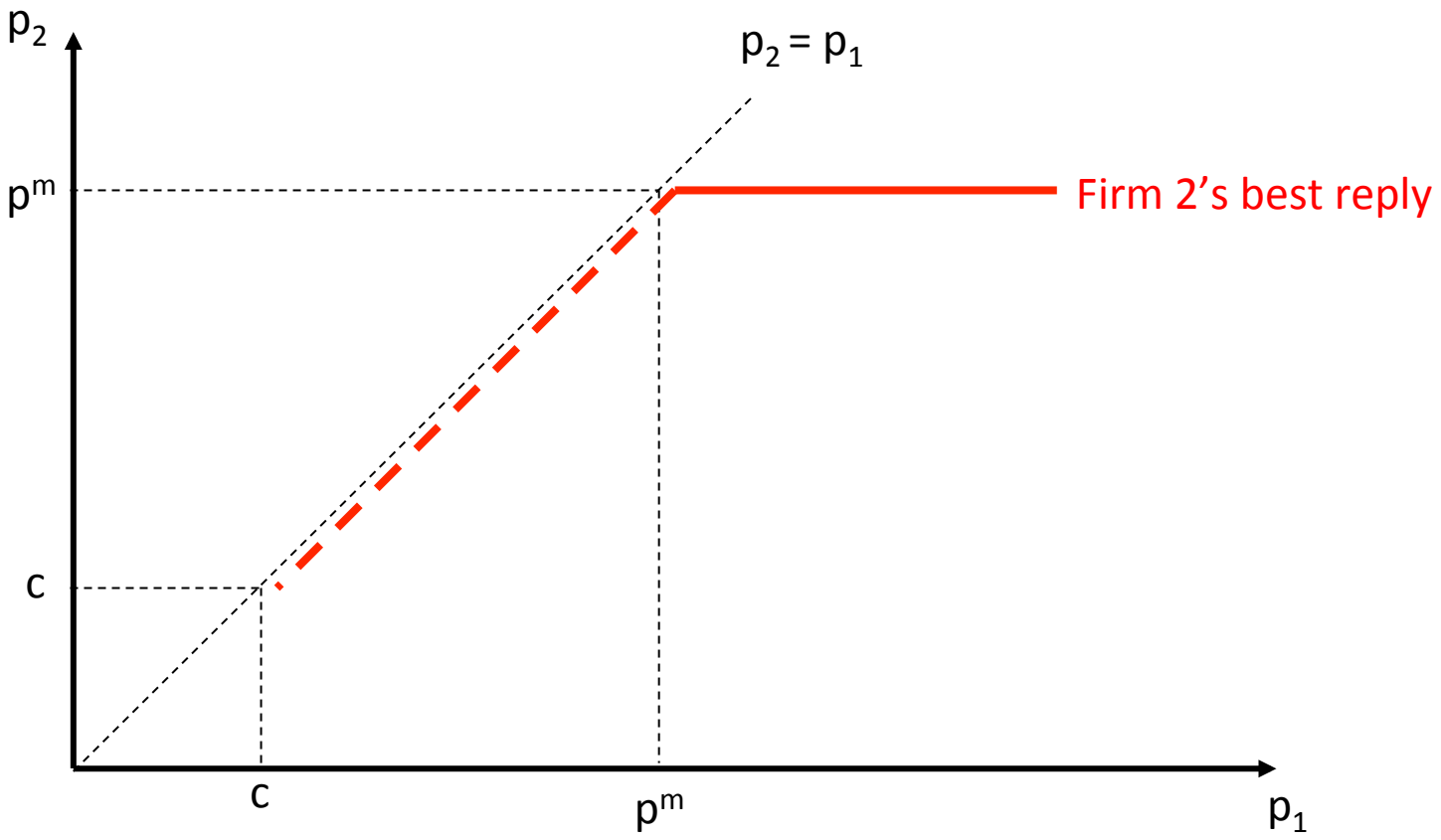
Duopoly

Best-reply analysis



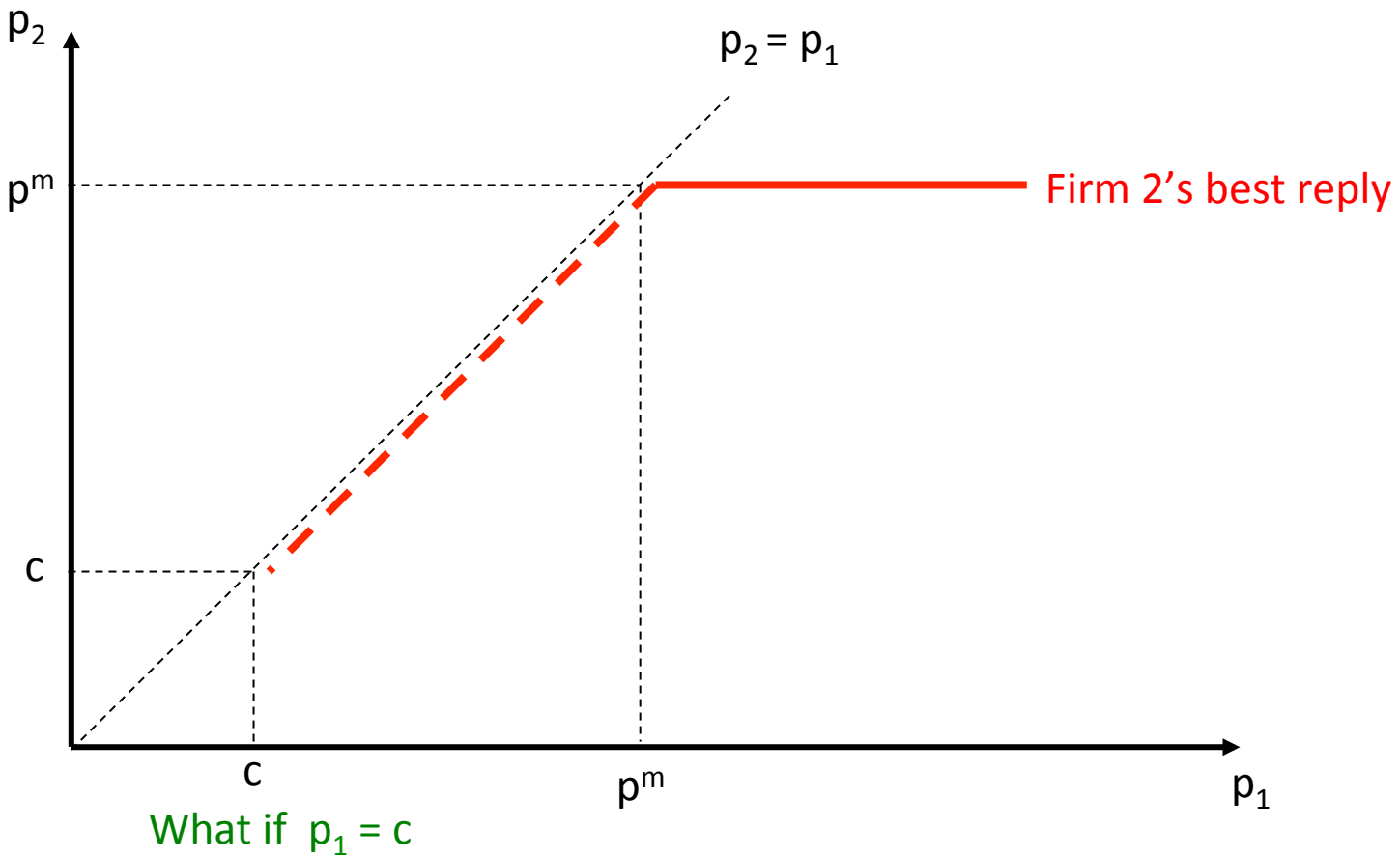
Duopoly

Best-reply analysis



Duopoly

Best-reply analysis



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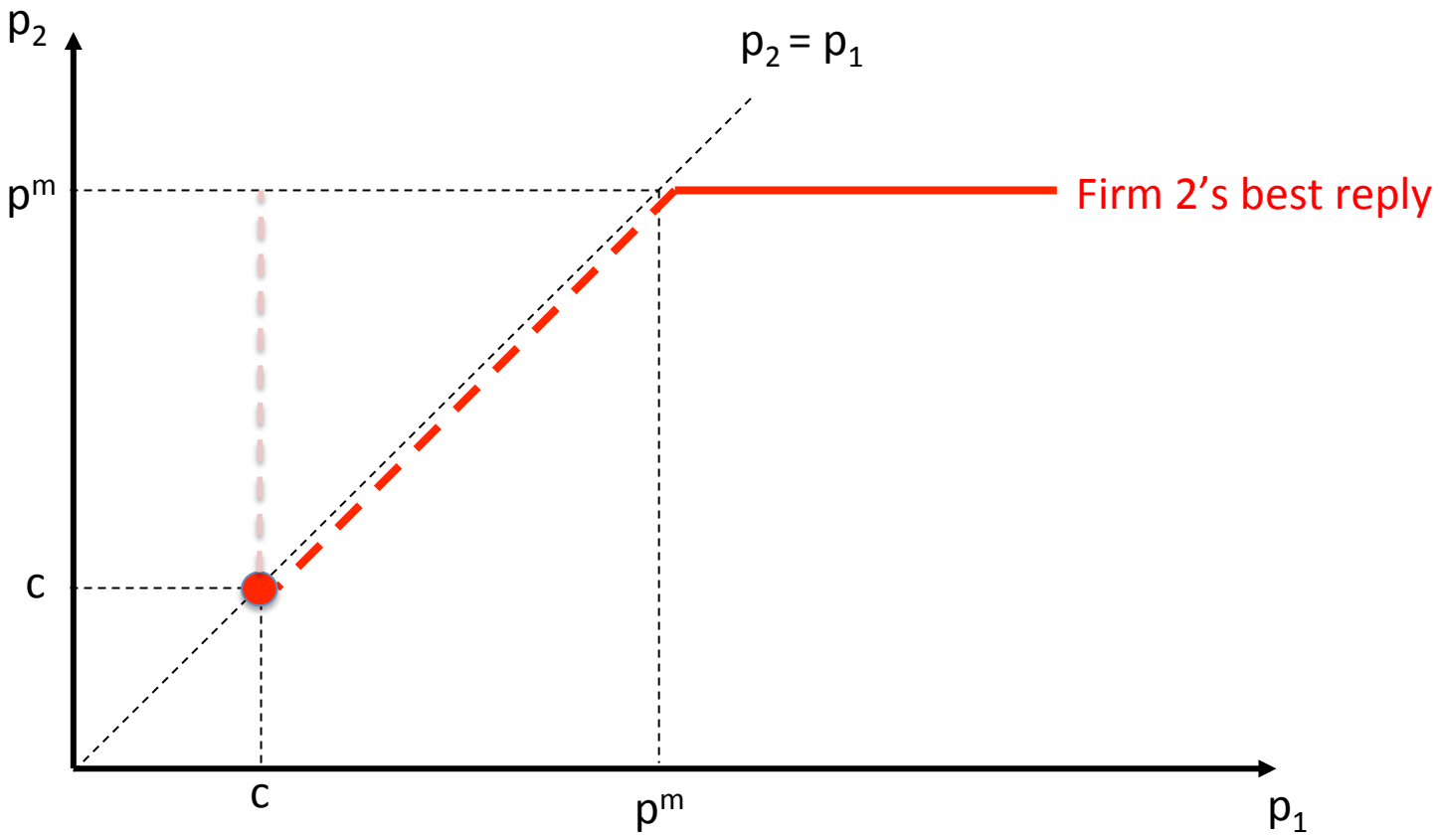
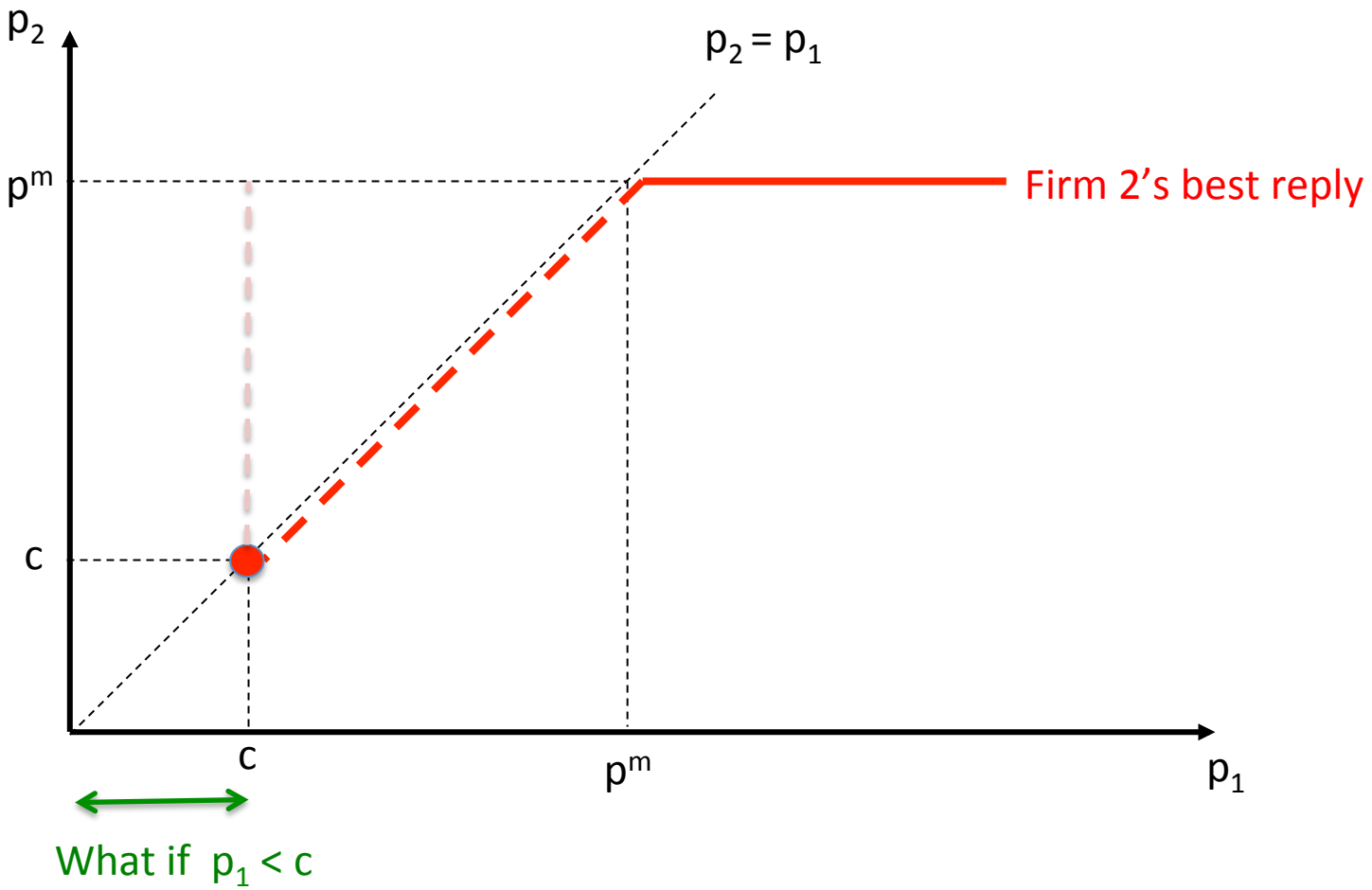


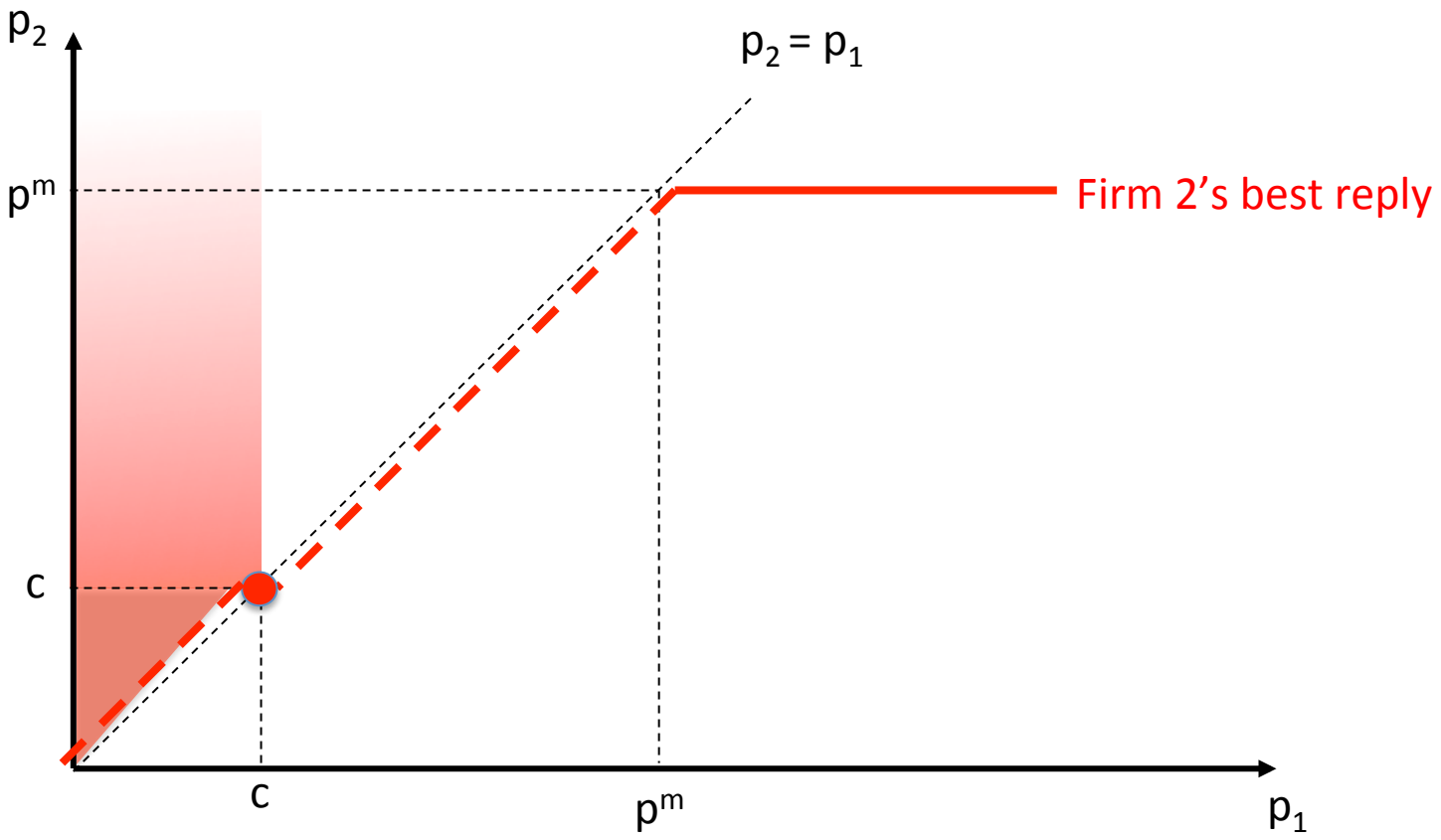
Duopoly

Best-reply analysis



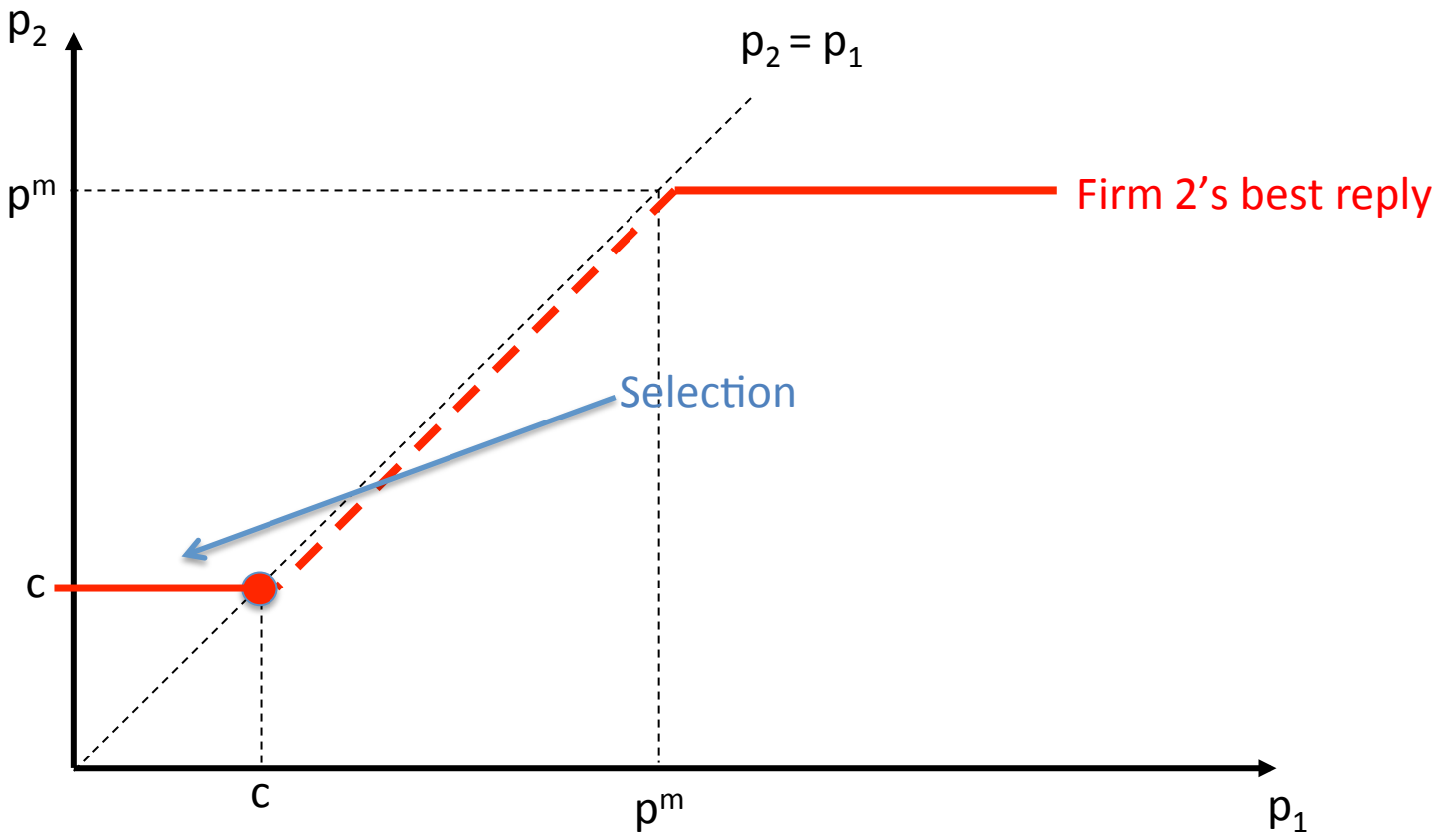
Duopoly

Best-reply analysis

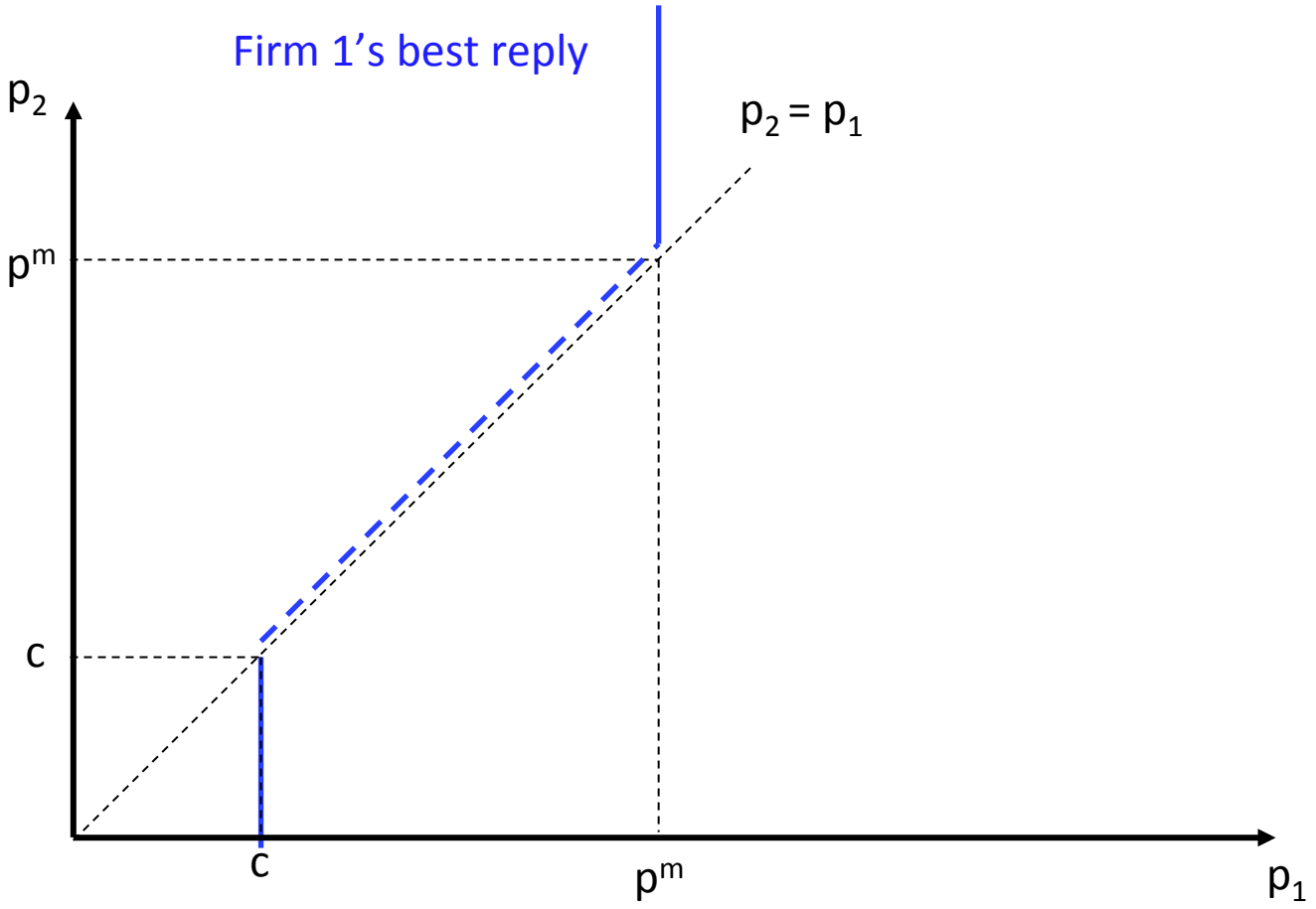


Duopoly

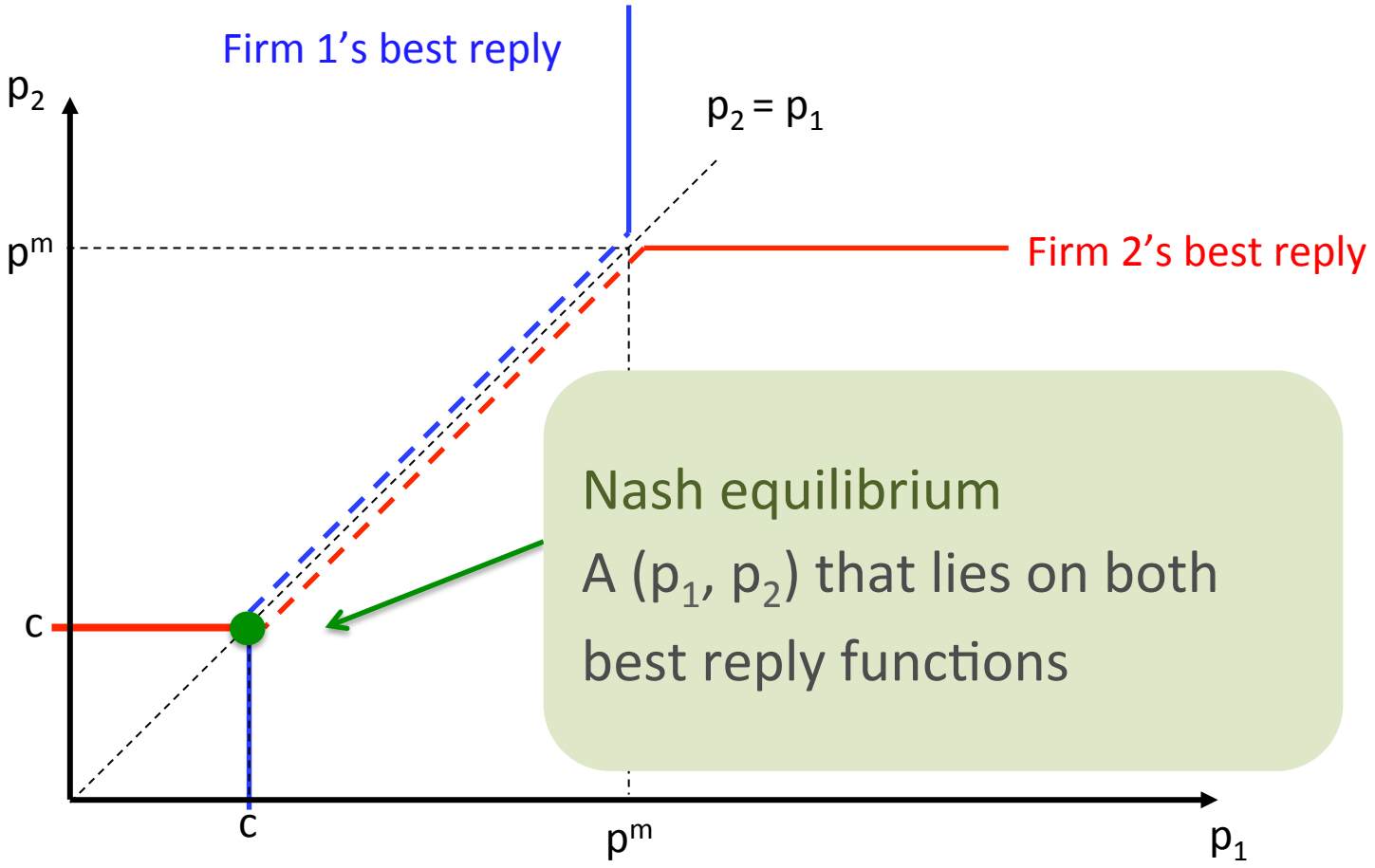
Best-reply analysis



Duopoly



Duopoly



Nash equilibrium

A (p_1, p_2) that lies on both best reply functions

What is price competition?
Compare monopoly and duopoly

What is price competition?

- Prediction
  - More firms ➔ Lower prices
- Is this prediction true?

What is price competition?

- Extreme prediction ("Bertrand paradox")
  - 2 firms => $p = c$ & $\pi = 0$
- Q: Reason for extreme prediction?
  - Reduce price one cent, get all customers
  - Always profitable to reduce price below competitor, as long as $p > c$.

What is price competition?

- More often
  - More firms: $p > c$ & $\pi > 0$
  - Reason: Don't get all customers
  - Examples: Product differentiation

What is price competition?

- Estimated Lerner indexes (mark-ups) in automobiles

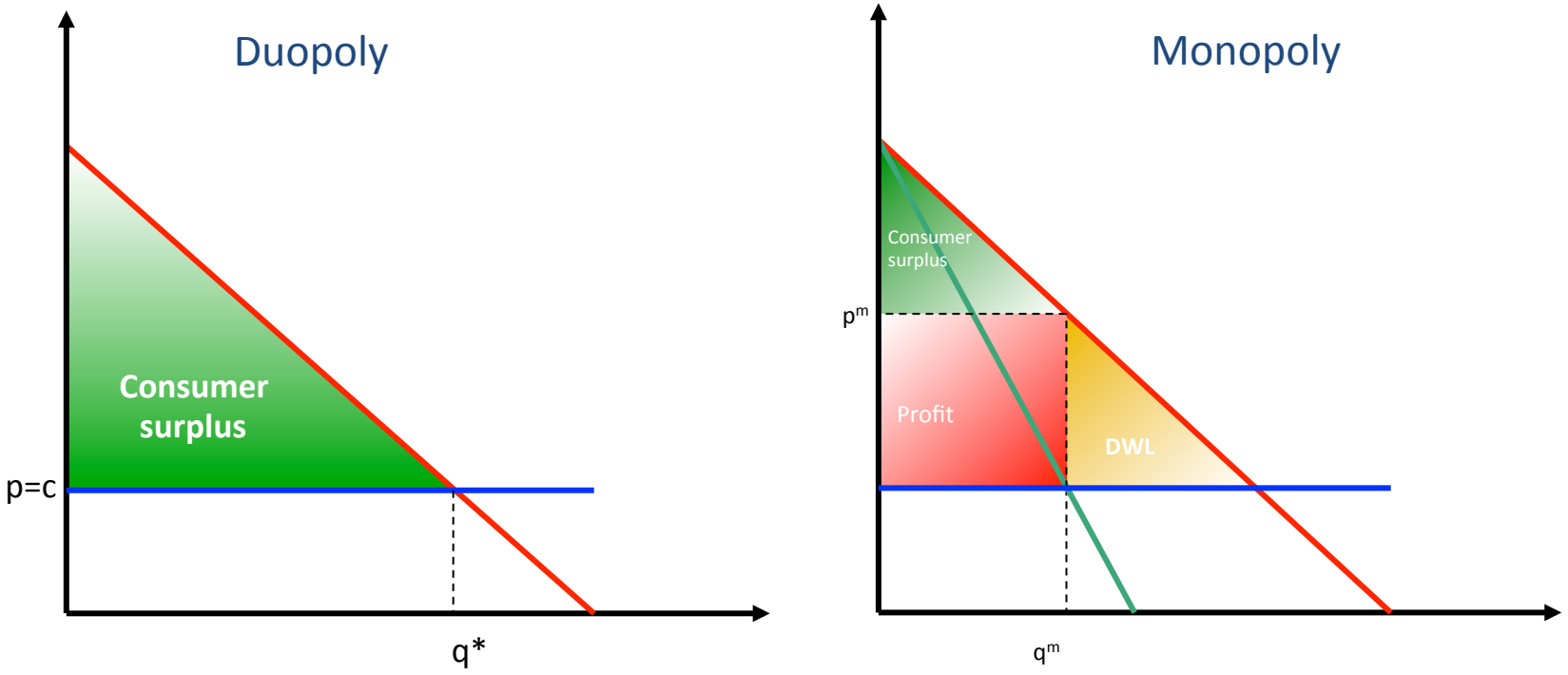
Model	Belgium	France	Germany	Italy	UK
Fiat Uno	7.6	8.7	9.8	21.7	8.7
Ford Escort	8.5	9.5	8.9	8.9	11.5
Peugeot	9.9	13.4	10.2	9.9	11.6
Mercedes	14.3	14.4	17.2	15.6	12.3

- Conclusion
  - Competition does not eliminate all markups
- Also
  - 3rd degree price discrimination also with competition
  - High markups in home countries

What is price competition?

- Theoretically robust
  - Many other models of oligopoly give same qualitative prediction
- Empirically "confirmed"
  - Many empirical studies suggest that competition leads to lower prices

Does Competition Matter?



Sources of market power

1. Few firms & Entry barriers
2. Product differentiation: horizontal & vertical
3. Quantity competition/Capacity constraints
4. Cost advantage
5. Uninformed customers
6. Customer switching costs
7. Price discrimination: information & arbitrage
8. Cartelization

Economic Methodology

- Economic model = An imaginary economy
  - Include key features for issues at hand
  - Remove all complications (eg competition)
  - Add features sequentially (eg competition)
- Pros
  - Easy to see principles
  - Can do experiments (eg What is the effect of competition)
- Cons
  - Not the full picture
  - Are conclusions true or artifacts?

Cournot Model
(Alternative to Bertrand)

Quantity Competition

- Bertrand model
  - Firms set prices
  - Consumers decide quantities (firms must deliver)
- Cournot model
  - Firms chose quantities
  - Then price is set to clear the market
- Note 1: Difference matters (contrast to monopoly)
- Note 2: Two different interpretations

Quantity Competition

- First interpretation
  - Stage 1: Firms produce: q_1, q_2
  - Stage 2: Firms bring produce to auction: $p = P(q_1+q_2)$
- Example
  - Fishing village
- Note
  - Pricing decision is delegated
  - But equilibrium price affected by amount produced
  - We omit the issue why $p = P(q_1+q_2)$

Quantity Competition

- Second interpretation: Two-stage game
  - Stage 1: Firms chose capacities: k_1, k_2
  - Stage 2: Firms set prices: p_1, p_2
- Note:
  - Under some conditions $p_1 = p_2 = P(k_1 + k_2)$
  - Then study choice of capacity (= quantity)

Duopoly

Game Theory

- Game in normal form
  - Q: Elements of a game in normal form?
    - Players, Strategies, Payoffs
  - Players
    - Firm 1 and Firm 2
  - Strategies
    - Each firm chooses a quantity q_i (a real number)
    - Recall: Strategy profile = A quantity for each player (q_1, q_2)
  - Payoffs
    - Profits: $\pi_i(q_1, q_2) = P(q_1 + q_2) \cdot q_i - C(q_i)$
    - Recall: Payoff function assigns a payoff for every possible strategy profile, $\pi_i(p_1, p_2)$

Exogenous conditions

- Simplify 1: Technology
  - Constant marginal cost
  - Firms have same marginal cost
- Simplify 2: Demand
  - Firms' goods homogenous
  - Market demand: Linear

Cournot Duopoly

- Technology
  - Constant marginal costs, c
- Demand (linear)
  - Individual demand: $q = a - p$
  - Number of consumers: m
  - Market demand: $Q = m*(a - p)$

Cournot Duopoly

- Exercise:
  - Solve the model
- Steps:
  1. Set up profit functions
  2. Find best-reply functions
  3. Find equilibrium quantities
  4. Find equilibrium price

Define the game

Profit

$$\pi_1(q_1,q_2) = P(q_1+q_2)\cdot q_1 - C(q_1)$$

Rewrite

$$\pi_1(q_1,q_2) = \left(a - \tfrac{1}{m}\cdot(q_1+q_2) - c\right)\cdot q_1$$

Demand

$$Q(p) = m\cdot(a-p)$$

Indirect demand

$$p = a - \tfrac{1}{m}\cdot(q_1+q_2)$$

Derive best-reply functions

Profit

$$\pi_1(q_1,q_2) = P(q_1+q_2)\cdot q_1 - C(q_1)$$

Rewrite

$$\pi_1(q_1,q_2) = \left(a - \tfrac{1}{m}\cdot(q_1+q_2) - c\right)\cdot q_1$$

FOC

$$\frac{\partial \pi_1(q_1,q_2)}{\partial q_1} = \left(a - \tfrac{1}{m}\cdot(q_1+q_2) - c\right) - \tfrac{1}{m}\cdot q_1 = 0$$

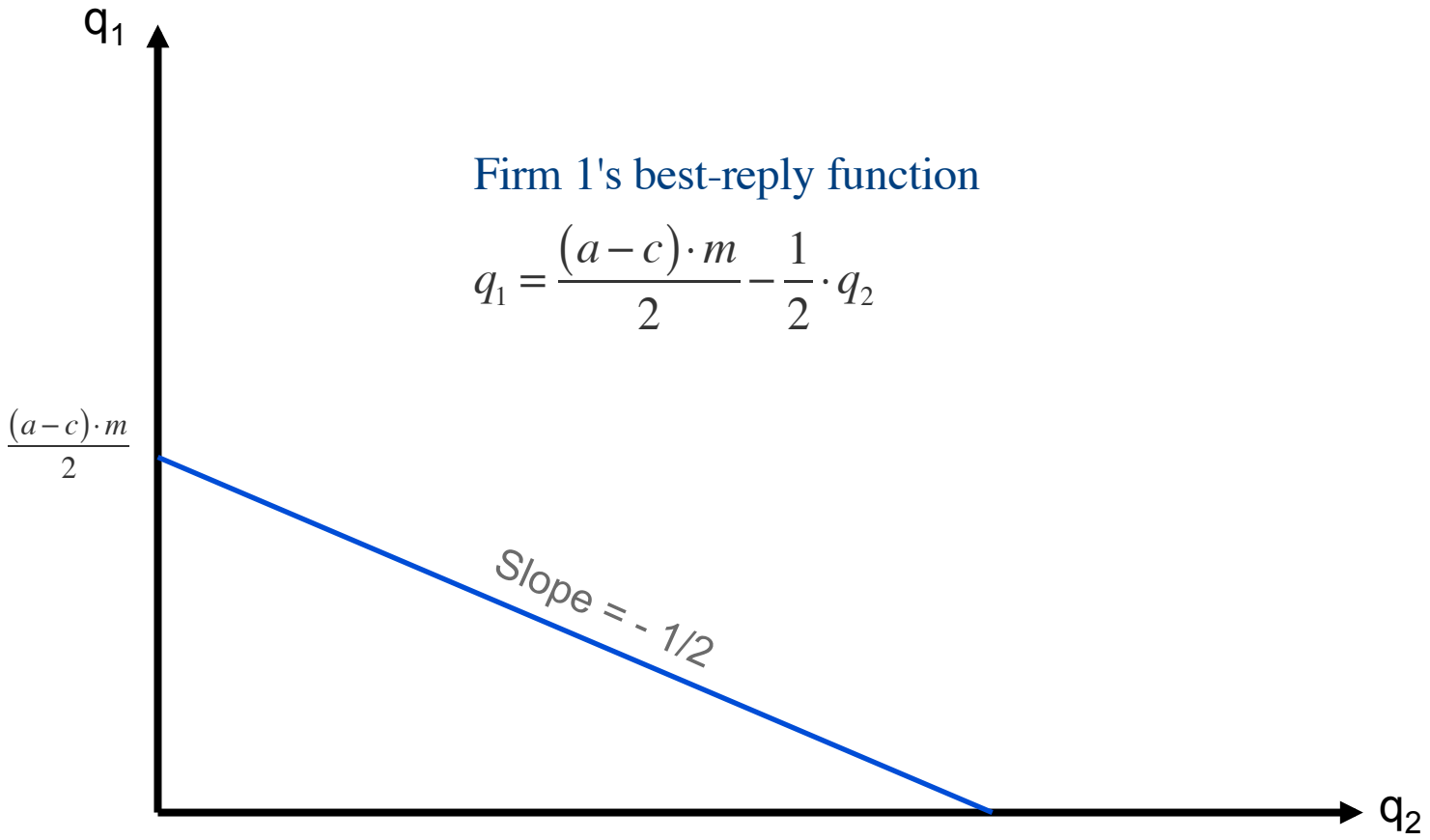
Solve for best reply function

$$q_1 = \frac{m\cdot(a-c)}{2} - \frac{1}{2}\cdot q_2$$

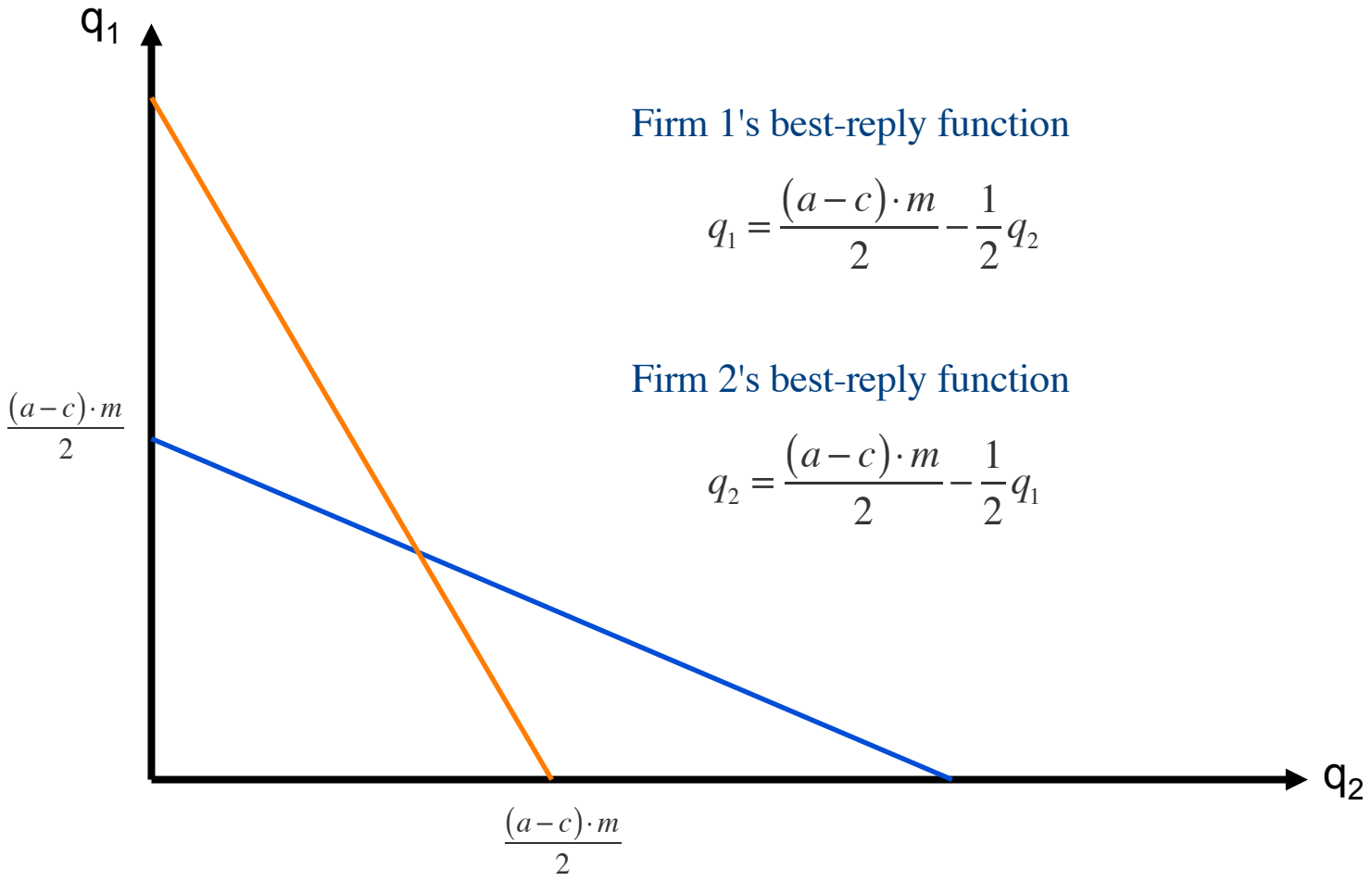
Derive best-reply functions

Firm 1's best-reply function

$$q_1 = \frac{(a-c)\cdot m}{2} - \frac{1}{2}\cdot q_2$$



Derive best-reply functions



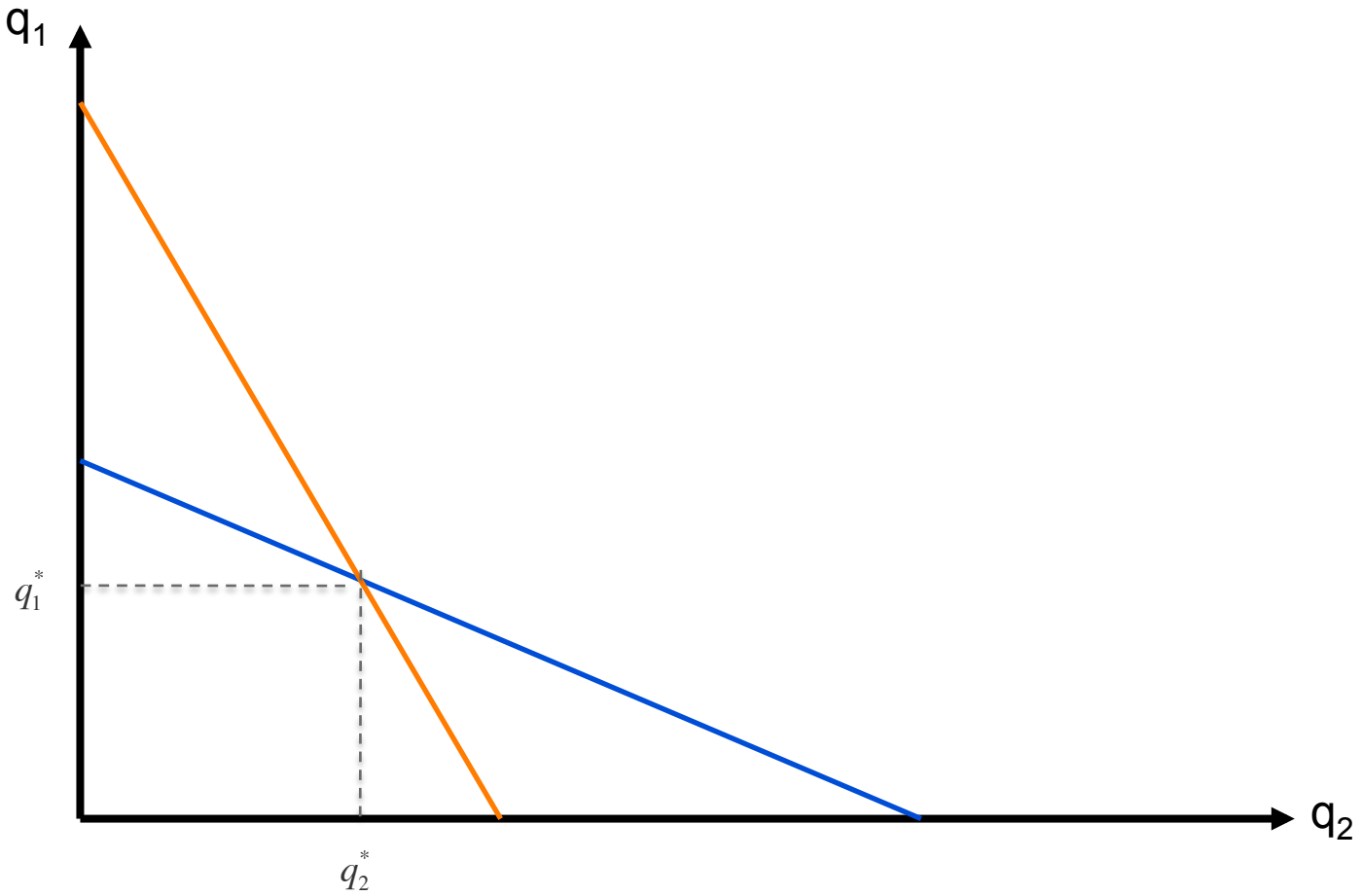
Firm 1's best-reply function

$$q_1 = \frac{(a-c)\cdot m}{2} - \frac{1}{2}q_2$$

Firm 2's best-reply function

$$q_2 = \frac{(a-c)\cdot m}{2} - \frac{1}{2}q_1$$

Compute equilibrium quantities



Compute equilibrium quantities

Equilibrium

$$q_1 = \frac{(a-c)\cdot m}{2} - \frac{1}{2}\cdot q_2$$

$$q_2 = \frac{(a-c)\cdot m}{2} - \frac{1}{2}\cdot q_1$$

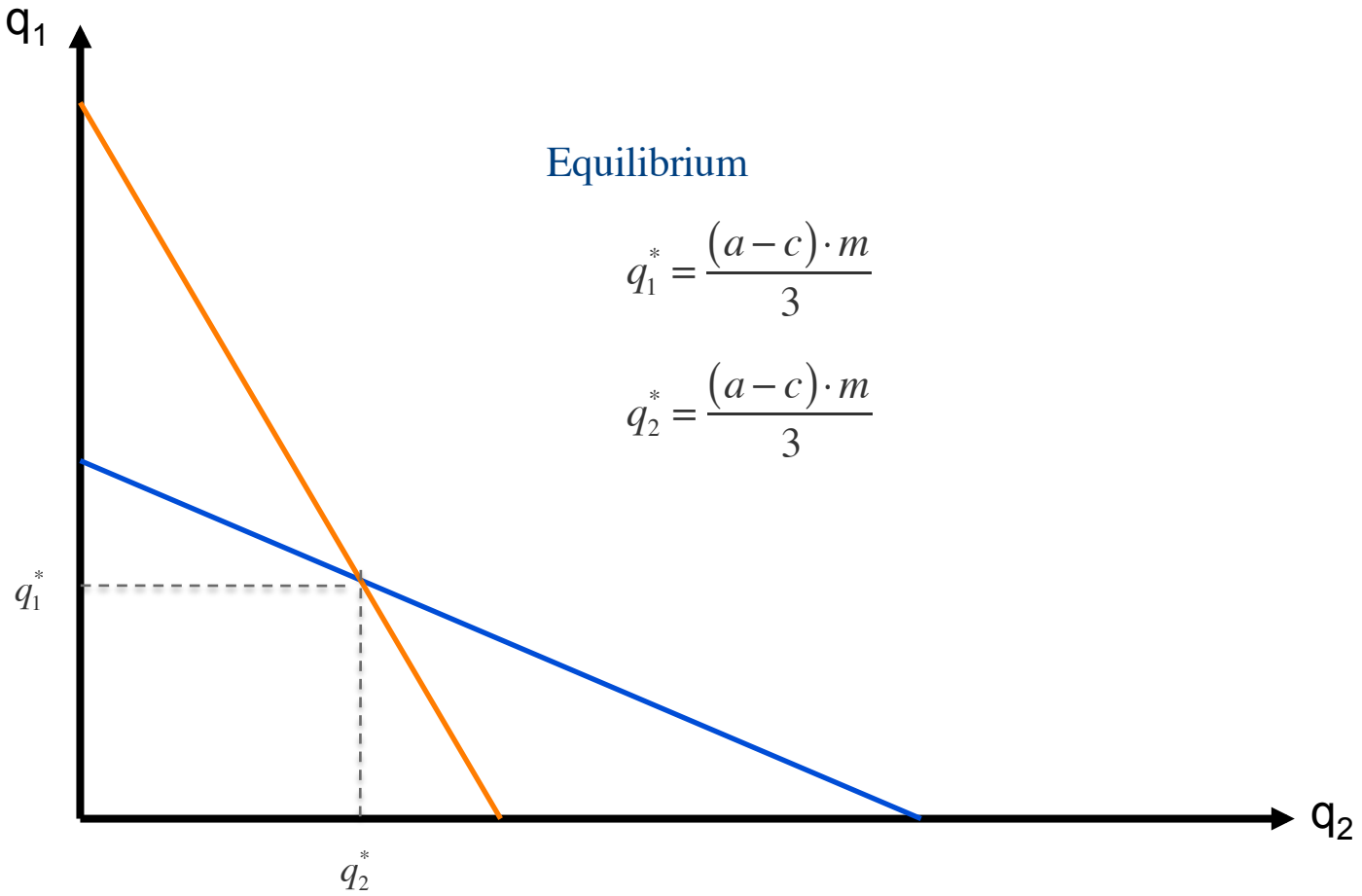
Find q_1^*

$$q_1^* = \frac{(a-c)\cdot m}{2} - \frac{1}{2}\cdot\left(\frac{(a-c)\cdot m}{2} - \frac{1}{2}\cdot q_1^*\right)$$

Solve for q_1^*

$$q_1^* = \frac{(a-c)\cdot m}{3}$$

Compute equilibrium quantities



Equilibrium

$$q_1^* = \frac{(a-c)\cdot m}{3}$$

$$q_2^* = \frac{(a-c)\cdot m}{3}$$

Compute equilibrium price

Equilibrium price

$$p^* = a - \frac{1}{m} \cdot \left(q_1^* + q_2^* \right)$$

$$p^* = a - \frac{1}{m} \cdot \left(\frac{(a-c) \cdot m}{3} + \frac{(a-c) \cdot m}{3} \right)$$

$$p^* = \frac{a + 2 \cdot c}{3}$$

Compare with monopoly

Question: Effect of competition on price?

$$p^* = \frac{a + 2 \cdot c}{3}$$

$$p^m = \frac{a + c}{2}$$

Conclusion:
More firms implies lower prices

Answer: Duopoly price lower

$$p^* < p^m$$

$$\frac{a + 2 \cdot c}{3} < \frac{a + c}{2}$$

$$c < a$$

Compare Cournot - Bertrand

Bertrand

$$p^* = c$$

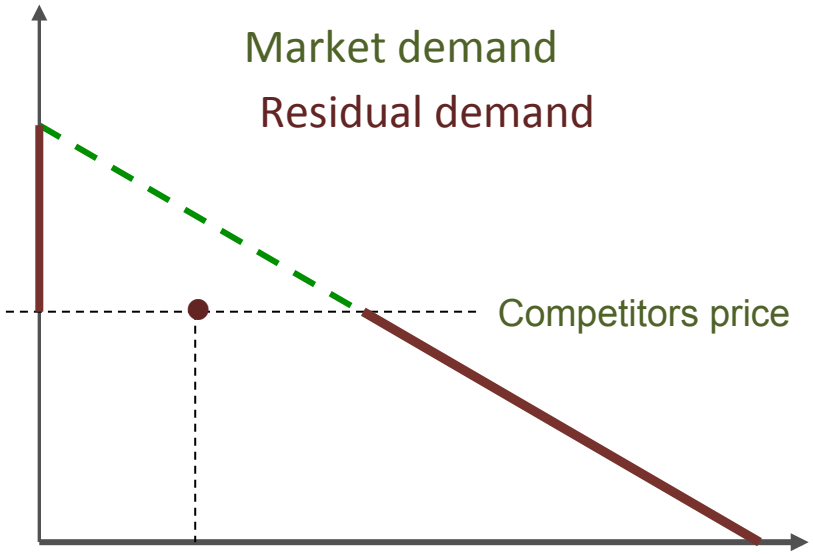
Cournot

$$p^* = \frac{a + 2 \cdot c}{3} > c$$

Compare Cournot - Bertrand

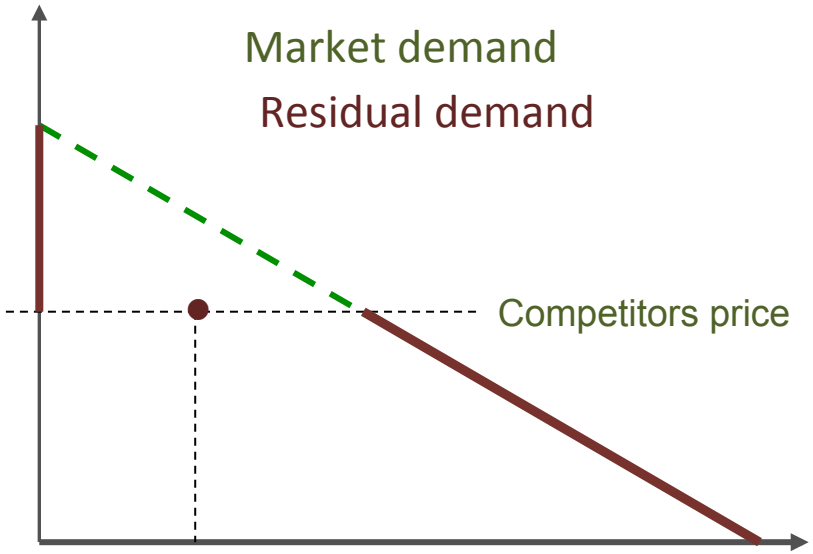
- Bertrand: Cheap to steal customers
  - Lower price a little ⇒ Steal all consumers
- Cournot: Expensive to steal customers
  - To steal a lot of consumers, a firm needs to increase its production a lot ⇒ large reduction in equilibrium price

Compare Cournot - Bertrand

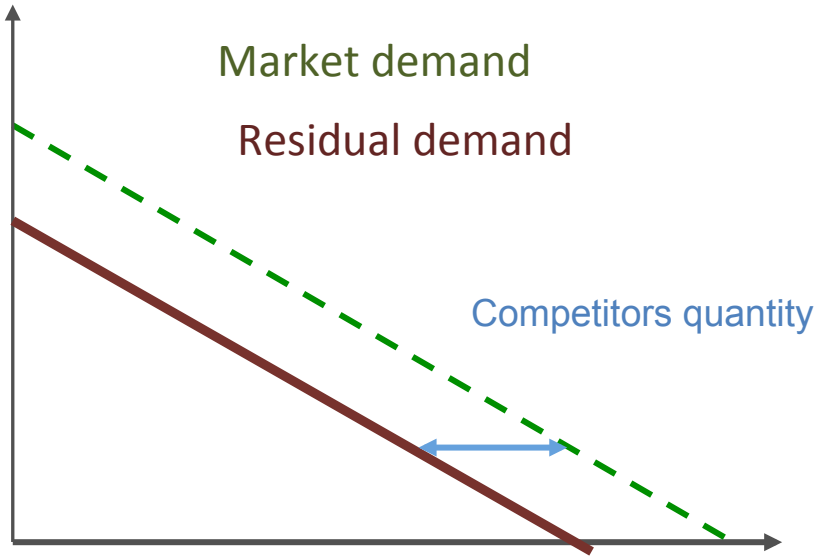


Bertrand

Compare Cournot - Bertrand



Bertrand

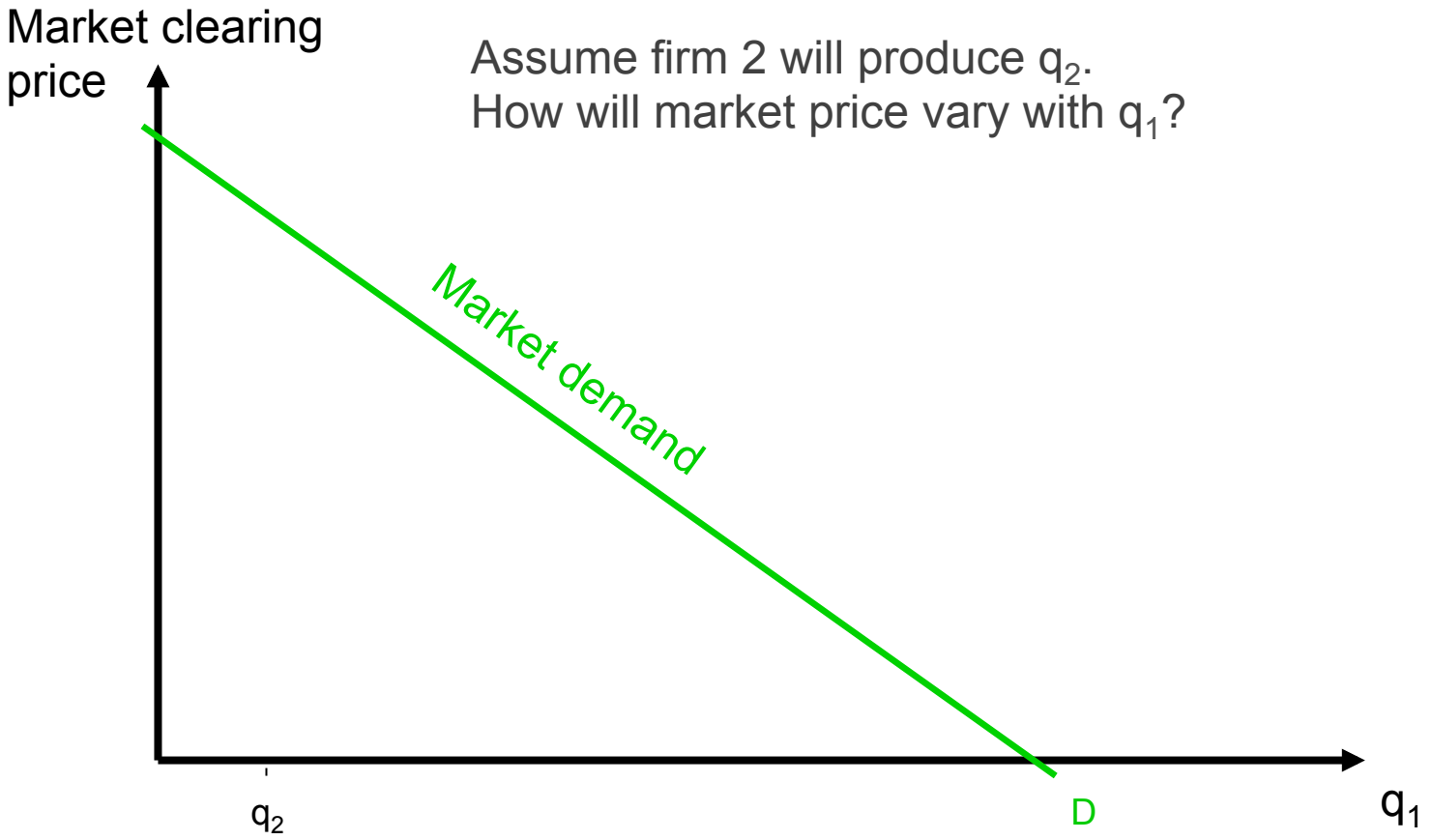


Cournot

Cournot Duopoly: Graphical Solution

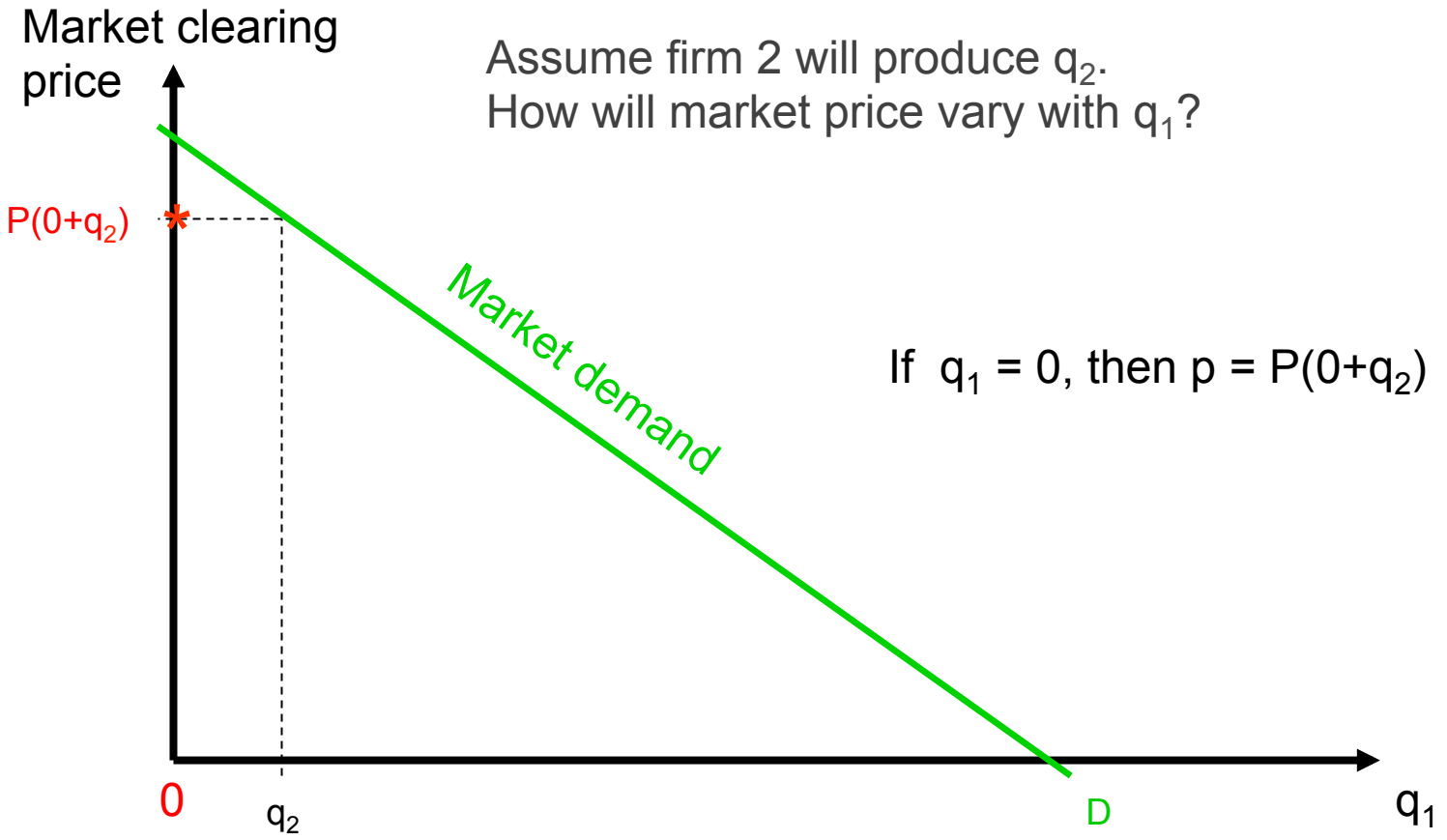
Cournot Duopoly

Residual Demand



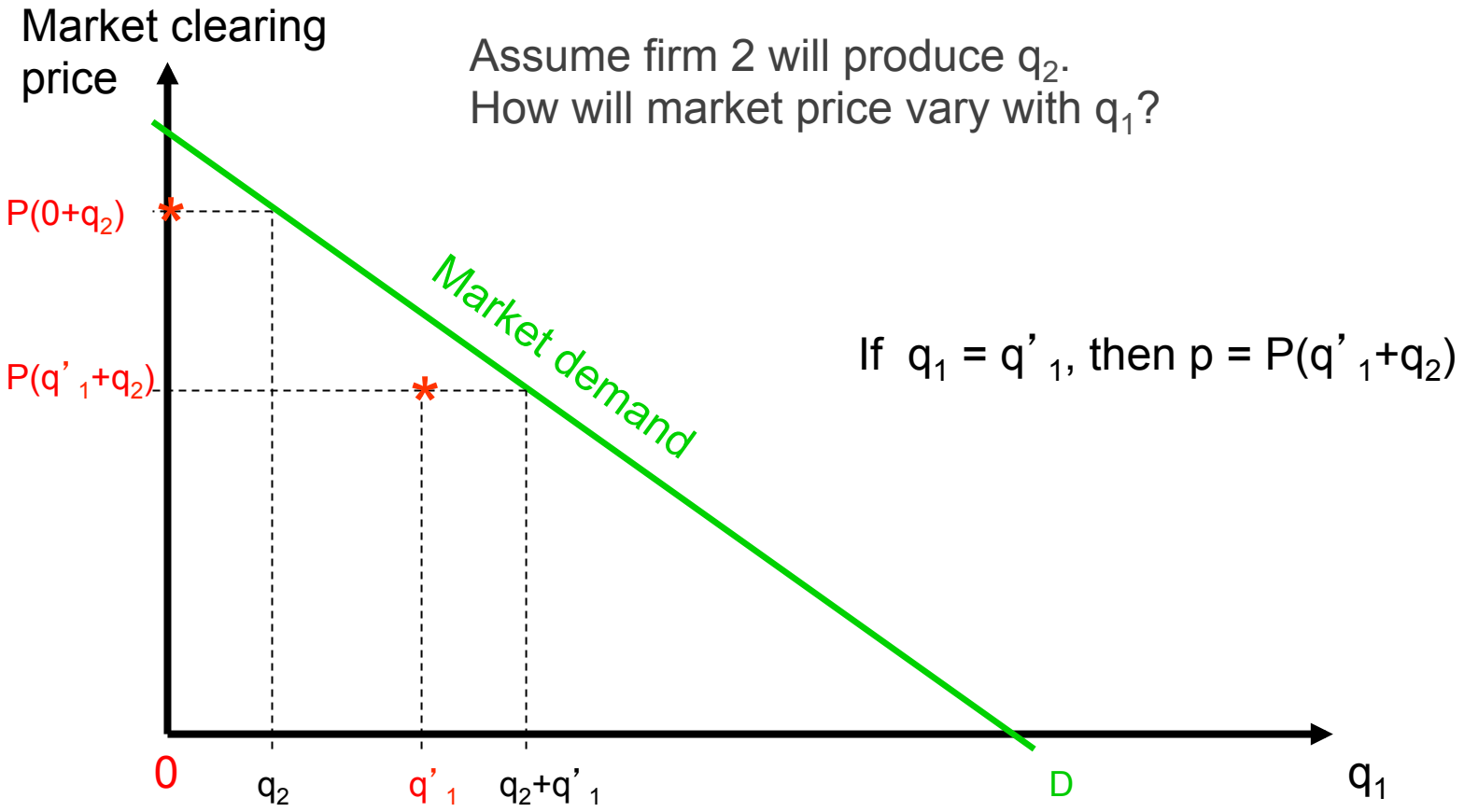
Cournot Duopoly

Residual Demand



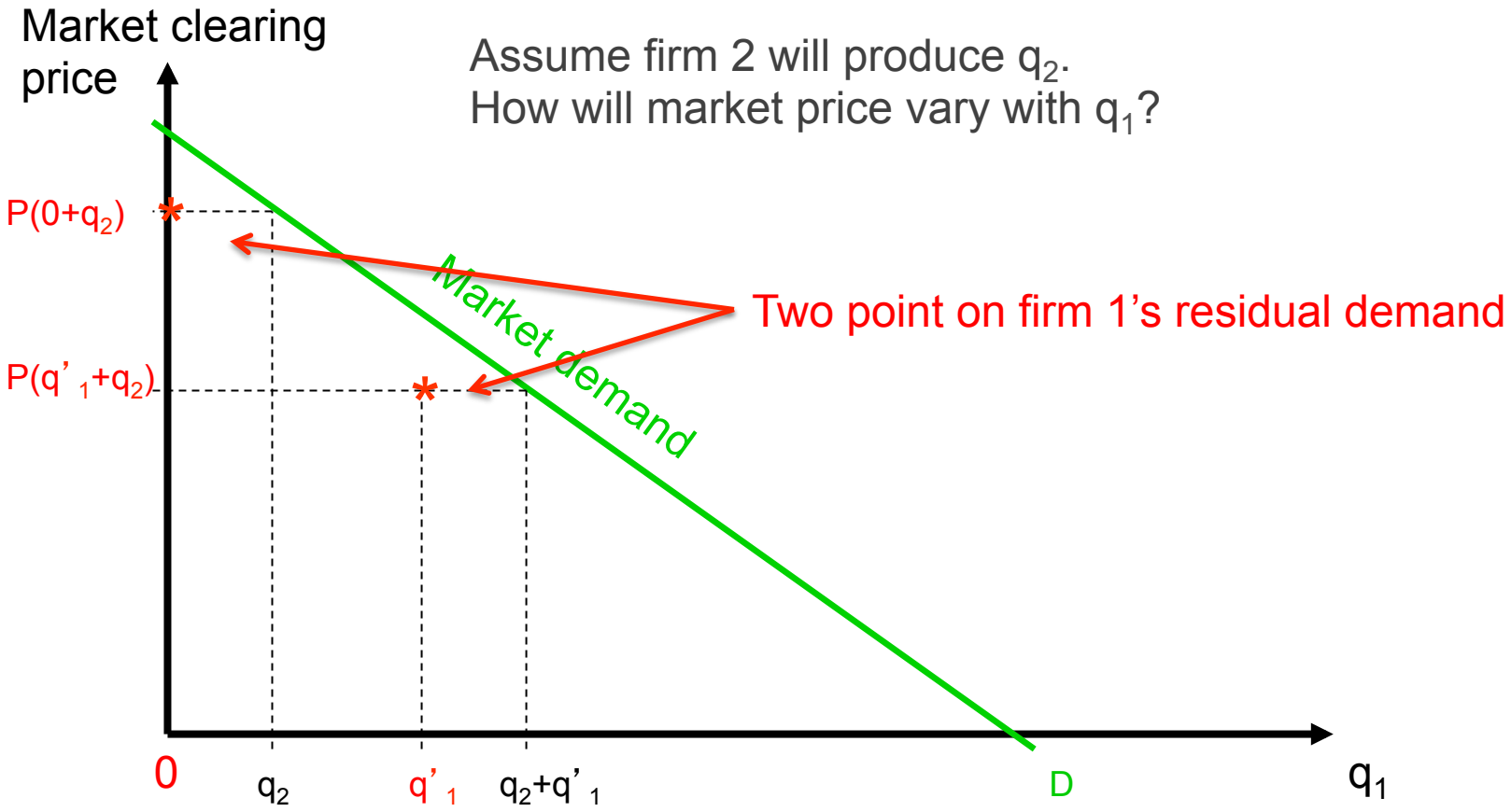
Cournot Duopoly

Residual Demand



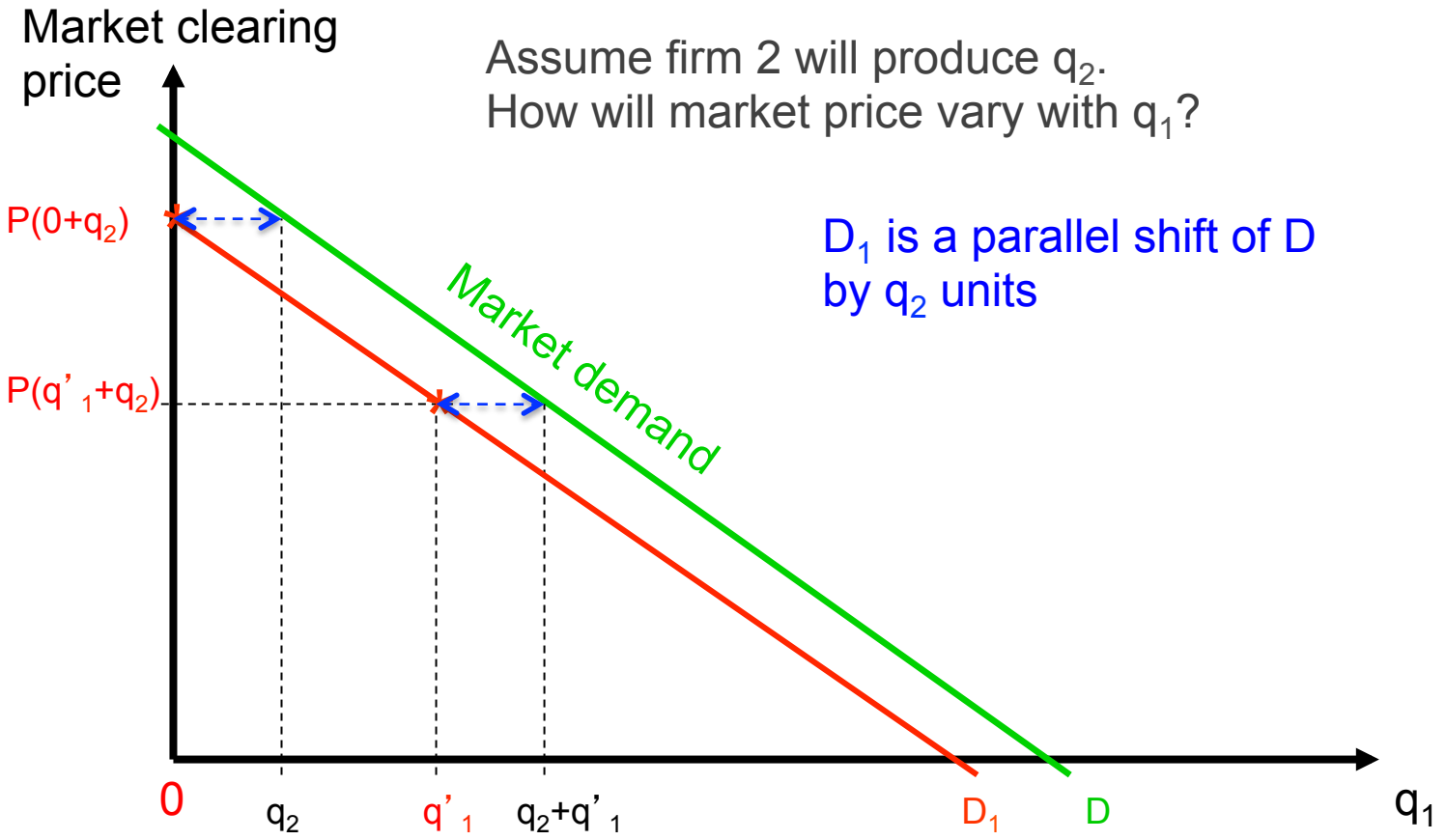
Cournot Duopoly

Residual Demand



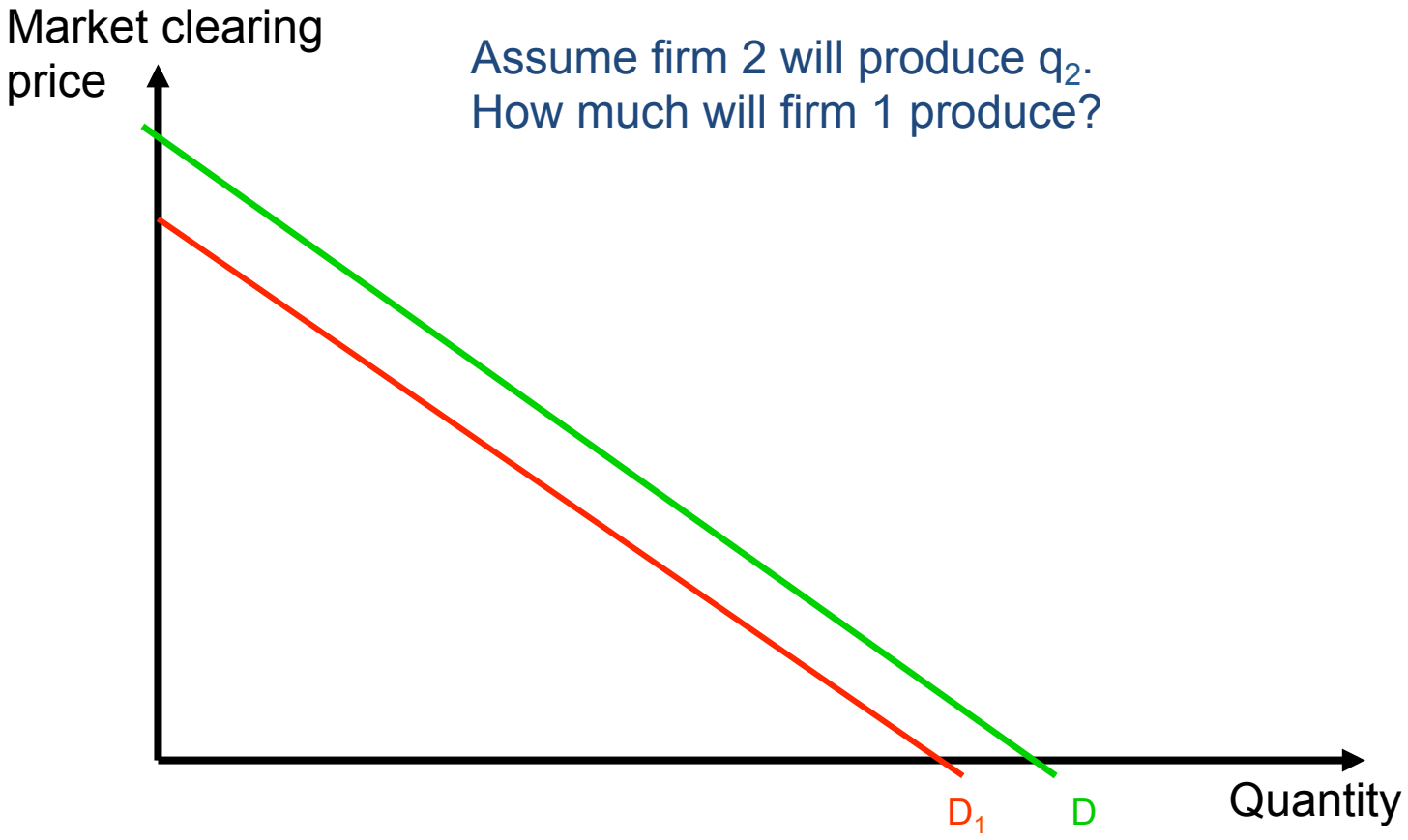
Cournot Duopoly

Residual Demand



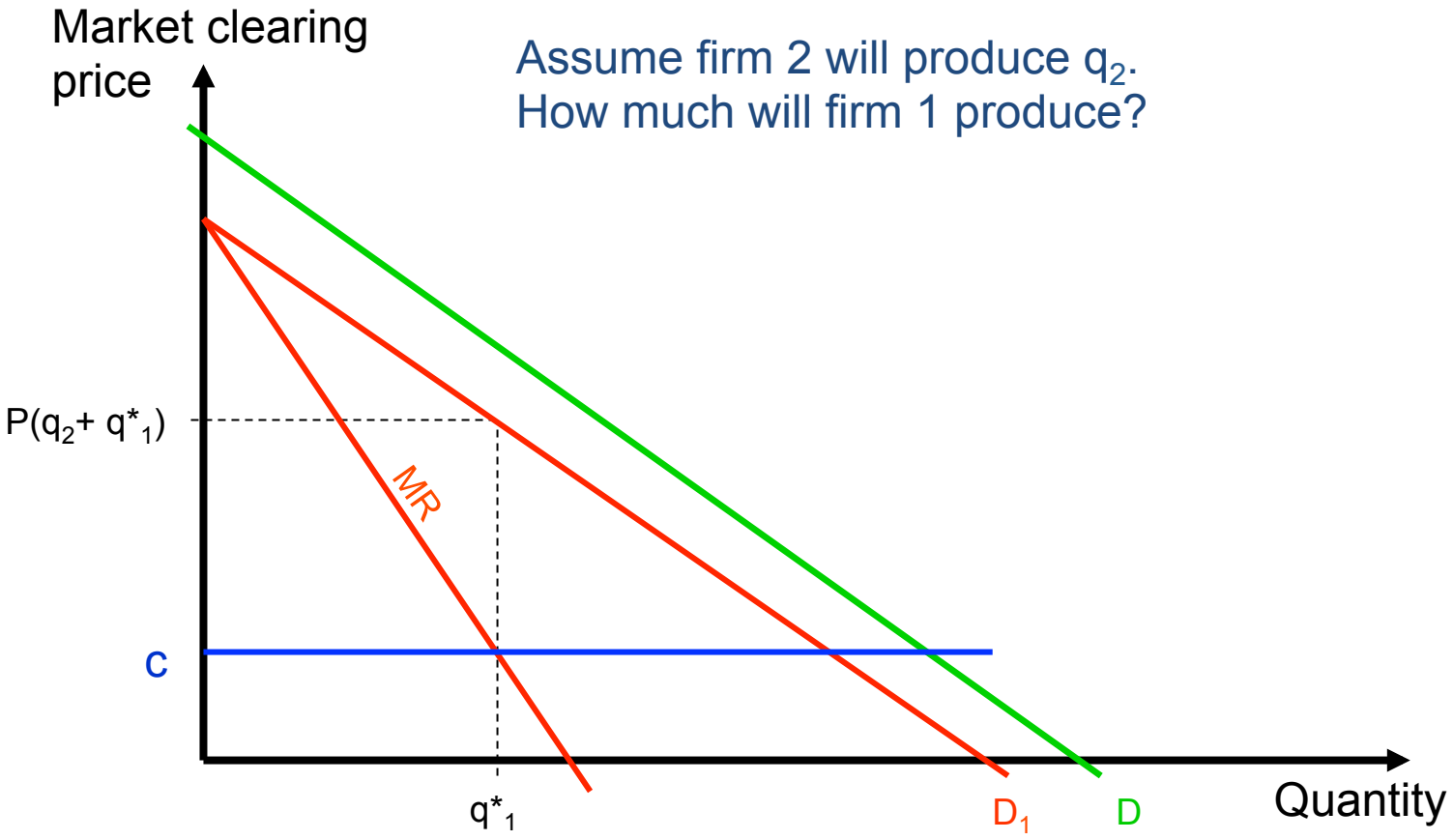
Cournot Duopoly

Best Reply



Cournot Duopoly

Best Reply



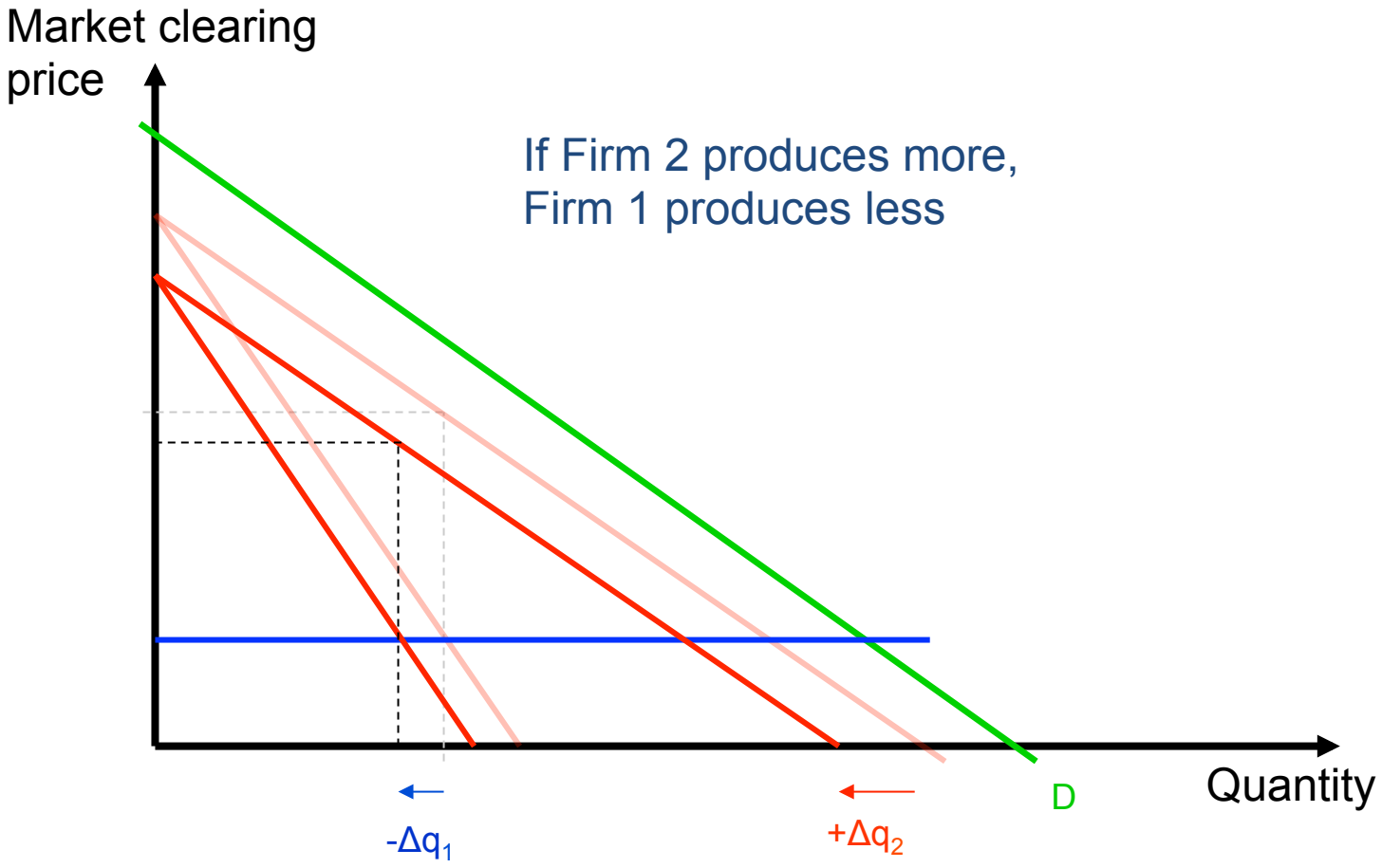
Cournot Duopoly

Best Reply

Assume firm 2 will increases production.
How will firm 1 react?

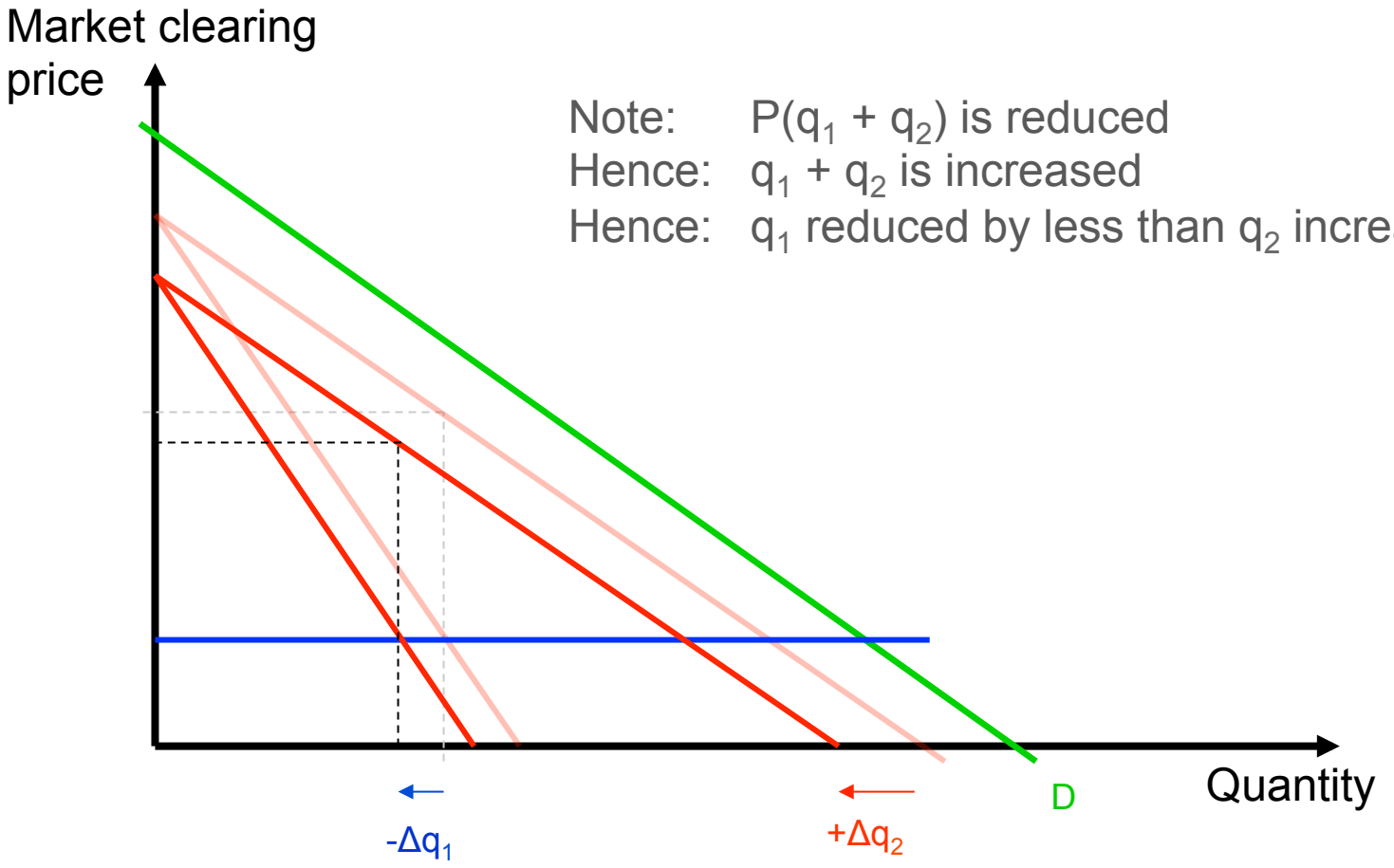
Cournot Duopoly

Best Reply



Cournot Duopoly

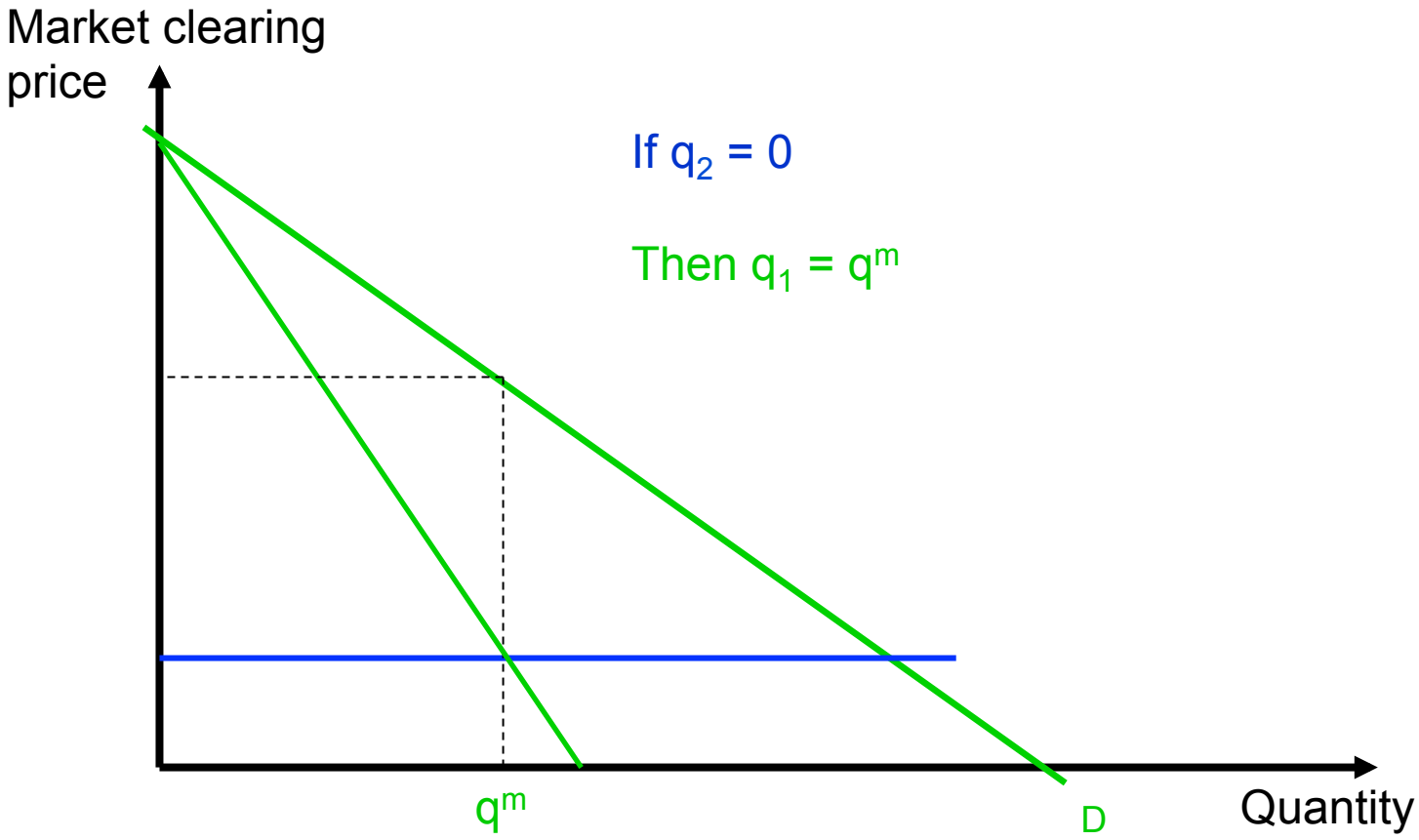
Best Reply



Note: $P(q_1 + q_2)$ is reduced
Hence: $q_1 + q_2$ is increased
Hence: q_1 reduced by less than q_2 increased

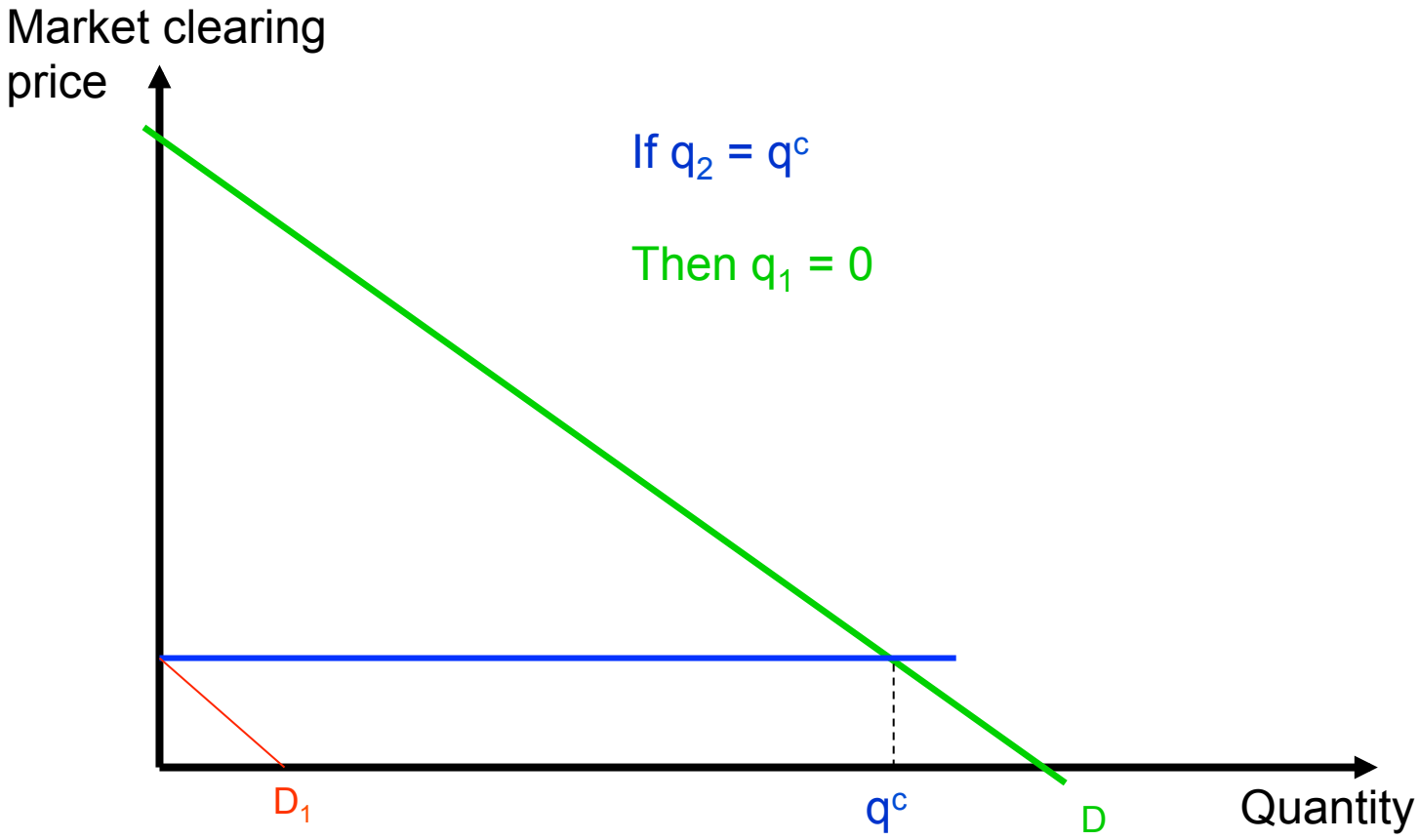
Cournot Duopoly

Best Reply



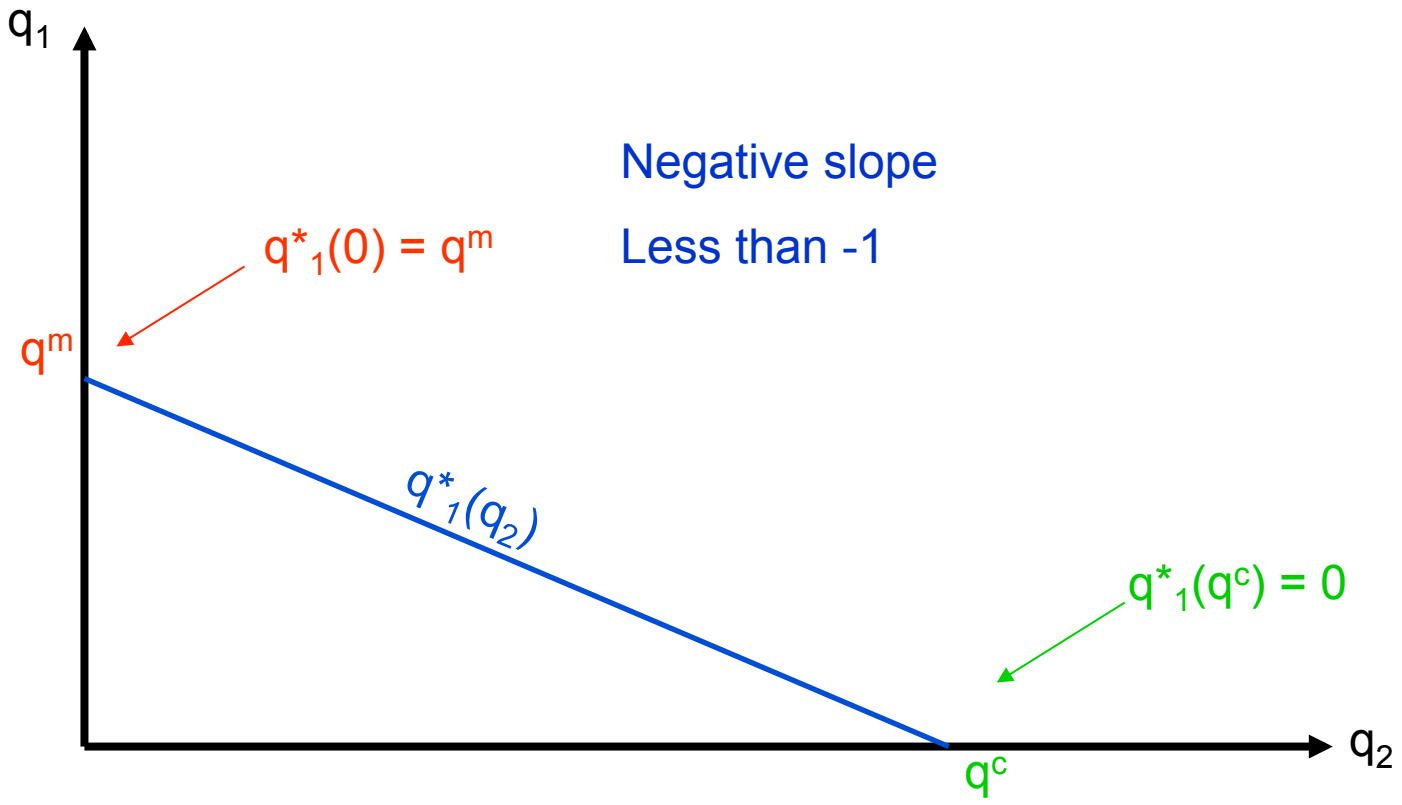
Cournot Duopoly

Best Reply



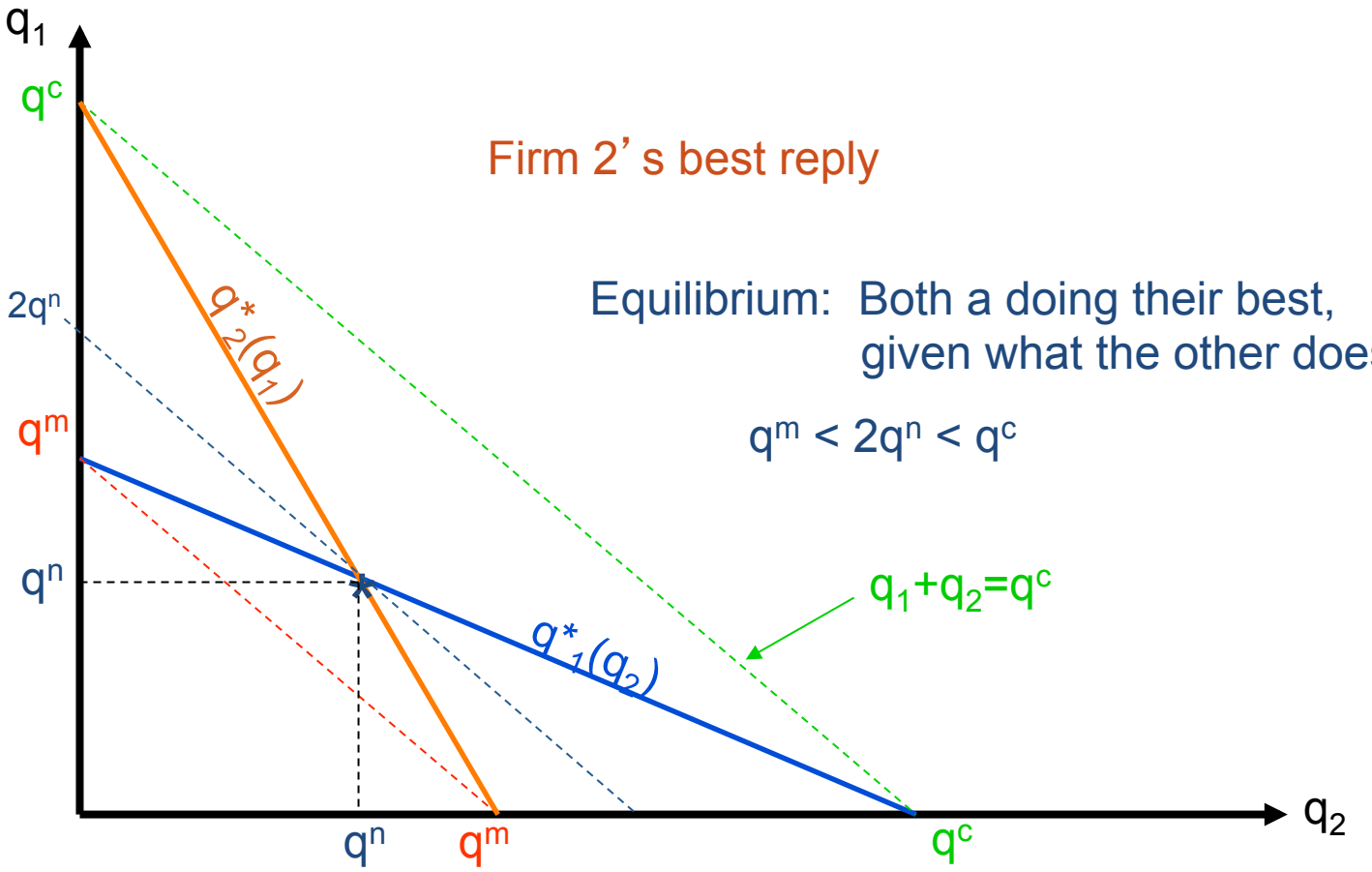
Cournot Duopoly

Best Reply



Cournot Duopoly

Equilibrium



Firm 2's best reply

Equilibrium: Both a doing their best, given what the other does

$q^m < 2q^n < q^c$