The Economics of E-commerce and Technology

Dynamic Pricing

Peak Load Pricing

- Suppose a firm has zero marginal cost, with capacity K
  - Broadband capacity, cell phone towers, hotel rooms
  - Capacity costs z per unit to build.
- There are two periods (or two equally likely states)
  - Period L demand is low, $p_L(q)$
  - Period H demand is high, $p_H(q)$
- Firm chooses q_L, q_H and K to maximize profits

  $\pi = q_L p_L(q_L) + q_H p_H(q_H) - zK$ subject to $q_L, q_H \leq K$
- Lagrangian: choose q_L, q_H and K to maximize

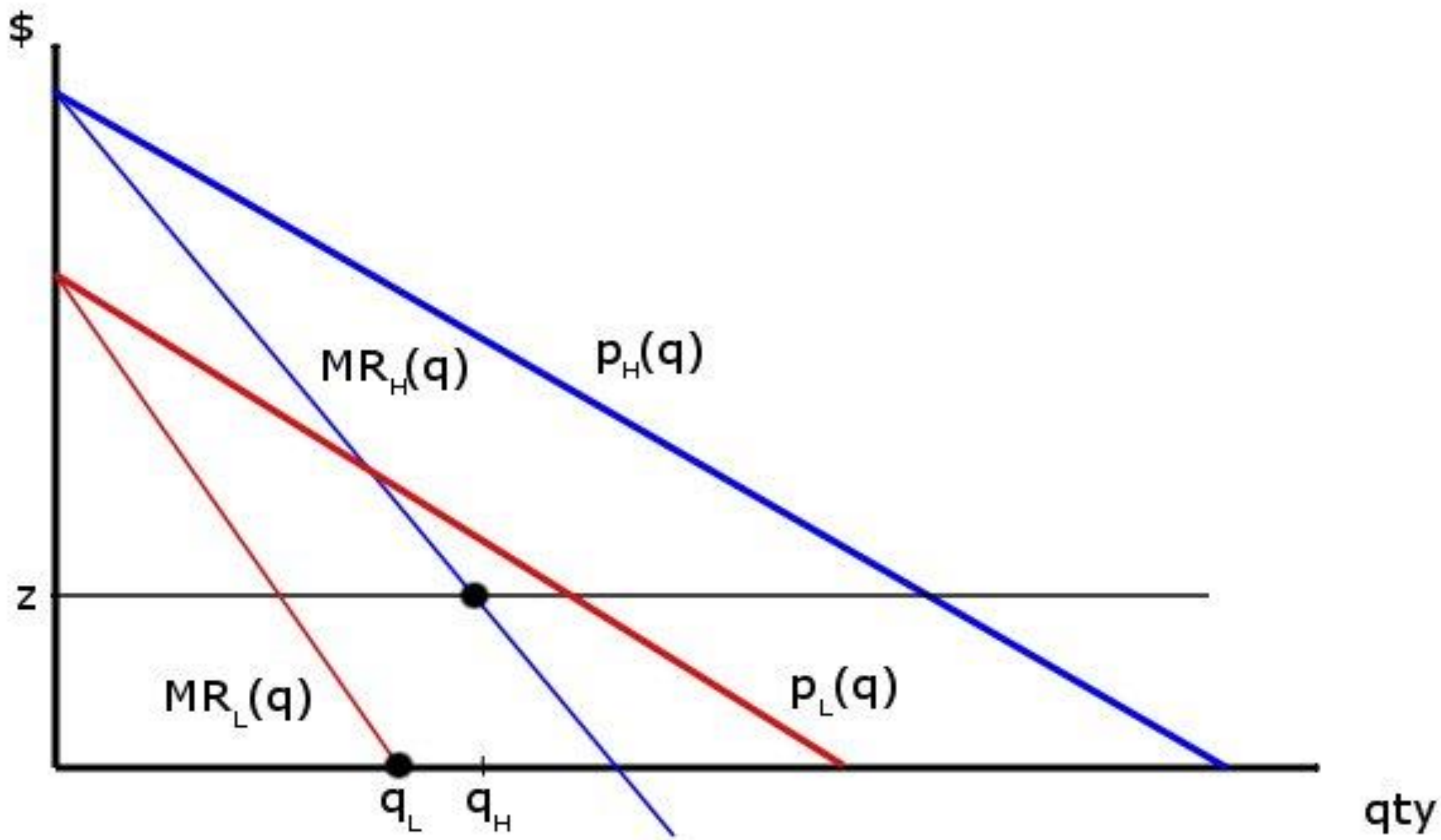
  $L = q_L p_L(q_L) + q_H p_H(q_H) - zK + \lambda_L [K - q_L] + \lambda_H [K - q_H]$

Peak Load Pricing

- Solution
  - FOCs for q_L,q_H and K: $MR_L(q_L^*) = \lambda_L$, $MR_H(q_H^*) = \lambda_H$, $z = \lambda_L + \lambda_H$
  - Optimal capacity: $K^* = q_H^*$
- Idea: Charge capacity when constraint binds.
- Two cases:
  1. Constraint slack in period L (big difference in demands)
  2. Constraint binds in period L (small difference in demands)
- Price in H higher for two reasons
  - (a) The demand is higher,
  - (b) Charging more of the capacity
- Examples: cheap evening calls and Christmas flights

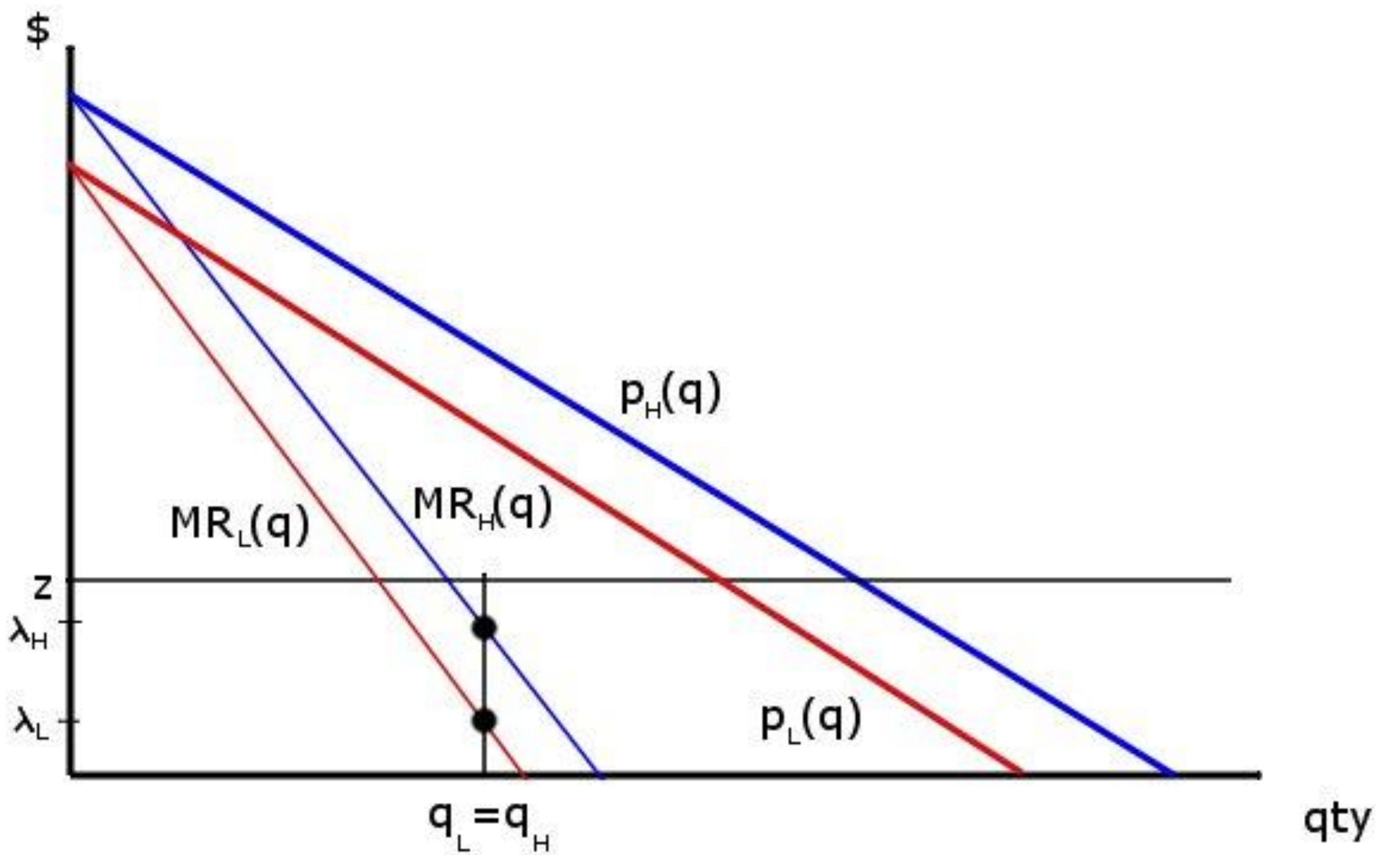
1. Constraint Slack in Period L ($q_L^* < q_H^*$)

- Optimal quantities: $MR_L(q_L^*)=0$, $MR_H(q_H^*)= z$



2. Constraint Binds in Period L ($q_L^* < q_H^*$)

- Optimal quantities: $q_L^* = q_H^*$, $MR_L(q_L^*) = \lambda_L$, $MR_H(q_H^*) = z - \lambda_L$



Revenue Management

- A firm has K tickets to sell
  - Airline seats, hotel rooms, advertising slots
- Customers arrive over time
  - Customers have value v unknown to firm
- How should firm set prices over time? If lower price:

  (a) sell to marginal agents today

  (b) make less revenue from inframarginal agents

  (c) lose opportunity to sell tomorrow

Revenue Management: Example

- Example: one item to sell (K=1)
  - There are N customers with v~U[0,1]
- Last customer
  - Choose p_N to maximize Π_N= (prob sell) x price = $(1-p_N)p_N$.
  - Solution: p_N*=0.5, yielding Π_N*=0.25.
- Dynamic programming: suppose n^{th} customer arrives
  - Choose p_n to maximize $\Pi_n = (1-p_n)p_n + p_n\Pi_{n+1}$.
  - Solution: $p_n^*=0.5[1+\Pi_{n+1}]$, yielding $\Pi_n^*=0.25[1+\Pi_{n+1}]^2$
- Working backwards with 5 customers:

	5^{th}	4^{th}	3^{rd}	2^{nd}	1^{st}
Price, p_n*	0.5	0.63	0.70	0.74	0.78
Profit, Π_n*	0.25	0.39	0.48	0.55	0.60

Durable Goods and Price Commitment

- Apple is thinking how to price the iPhone
  - In the first year it sells to high value customers
  - Then lowers price to sell to low value customers
- Problem: Customers anticipate price will fall
  - Customer delay purchases until price falls
  - Monopolist competes with future selves
- Model applies to durable goods
  - Software, Xbox, Art
- Model applies to durable services
  - Movies, information goods.

Durable Goods: Example

- N customers have $v=30$, N customers have $v=10$.
- Suppose there are two periods, with discount rate δ
  - If commit to one price, charge $p=30$, profit $\Pi = 30N$.
- Suppose sell to high agents in period 1
  - Charge $p_2=10$ and sell to low agents in period 2.
- High agents anticipate price will fall and may wait
  - Charge at most $p_1=30-20\delta$, for high agents to buy in period 1
  - Total profits $\Pi = (30-20\delta)N + \delta(10)N = (30-10\delta)N$
- Firm suffers because it cannot commit
  - Firm cannot resist lowering price in period 2, exerting a negative externality on its former self.

Durable Goods: Solutions

- Solution 1: Destroy the mould (e.g. artist)
  - Without mould cannot create quantity in second period
- Solution 2: Reputation (e.g. Xbox games)
  - Develop reputation for not dropping prices
- Solution 3: Renting (e.g. Xerox)
  - Good no longer "durable", so sell static monopoly quantity each period
- Solution 4: Best-price provision (e.g. iPhone)
  - If firm lowers price then customers get rebate
  - Firm never any incentive to lower price below monopoly price since lose money in rebates

Behavior Based Pricing and Commitment

- Suppose a firm sells to customers multiple times
- Purchasing behavior in early period tells firm about values
  - Firm tempted to condition price on past behavior
- Problem: Customers anticipate "ratchet effect"
  - Customers delay purchases to get lower prices later
  - Monopolist competes with her future selves
- Applications
  - Online sites with cookies, magazine subscriptions, cable TV

Behavior Based Pricing: Example

- N customers have v=30, N customers have v=10.
- Suppose there are two periods, with discount rate δ
  - If cannot see past behavior, charge p=30, profit $\Pi_0 = 30(1+\delta)N$.
- Suppose sell to high agents in period 1
  - Charge $p_2=10$ if did not buy in period 1
  - Charge $p_2=30$ if bought in period 1 (ratchet effect)
- If customers myopic charge $p_1=30$
  - Total profits $\Pi_M = 30N + \delta(30+10)N = (30+40\delta)N > \Pi_0$
- If customers forward looking, anticipate price fall if don't buy
  - Charge at most $p_1=30-20\delta$, for high agents to buy in period 1
  - Total profits $\Pi_F = (30-20\delta)N + \delta(30+10)N = (30+20\delta)N < \Pi_0$
- Firm suffers because it cannot commit
  - Firm cannot resist lowering price in period 2, exerting a negative externality on its former self.

Why are there Introductory Discounts?

- Behavioral-based pricing view
  - Firms can't resist giving discount to people who don't purchase
  - These discounts hurt the firm if

    (a) Consumers are forward looking

    (b) Consumers get annoyed
- Introductory discounts may be good idea
  - Network effects (see network slides)
  - Overcome switching costs (see lockin slides)
  - Encourage customer experimentation (next slide)

Customer Experimentation

- Product is "experience good"
  - Don't know taste until tried it
- Customers have value v=30 or v=10 with equal prob.
  - Optimal pricing: niche market strategy
  - Period 1, charge price p_1=20, and everyone buys
  - Period t≥2, charge price p_t=30, and high value agents buy
- Customers have value v=30 or v=20 with equal prob.
  - Optimal pricing: mass market strategy
  - Period 1, charge price p_1=25, and everyone buys
  - Period t≥2, charge price p_t=20, and everyone buy

Firm Experimentation

- How does a firm price when it does not know demand?
  - Firm wishes to sell a unique good.
  - Customers enter each period (not forward looking)
  - Each buyer has the same value, v, unknown to firm
- Optimal policy: start price high and lower slowly.
  - Solve through backwards induction.
  - Rate of decrease depends on firm's patience.
- What if have good each period to sell?
  - Price may go up or down.
  - But should move prices around to experiment.
- Experimentation very easy online
  - Run A/B tests. Seems scientific, but can be misleading.

Sticky Prices

- For single firm, choose price so $d\pi(p^*)/dp=0$.
- Suppose there is inflation and cost k of changing prices
  - E.g. Physical cost of printing menu
- No reason to change price when almost optimal.
  - Costs k, but only second order gain.
- Optimal policy is called (S,s) rule.
  - When real price hits $p_L<p^*$ then increase to $p_H>p^*$.
- Similar story when demand subject to shocks.
  - If demand has transitory increase, bring
  - If demand has permanent increase, also increase S.