

# Product Design

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# Introduction

On Tuesday: incentives for creating new products

- Today: design of existing (line of) products
  - Monopoly choice of non-price characteristics
- Just as monopoly helped with other problems...
  - Analysis today will help enrich analysis of policy
- We will look at this from a variety of perspectives:
  - 1 Goals and tools in designing products
  - 2 Spence's model of quality-choosing monopoly
    - Difference between marginal and average consumers
  - 3 Hotelling's spatial model of competition
    - Applications to political, newspaper competition
  - 4 Platforms where users generate characteristics
  - 5 Heterogeneity of user generated characteristics
    - Applications to insurance, loans, platforms etc.

# Considerations in designing products

When designing products, firms have several goals:

- 1 Keep costs low and price high
  - Supplying some services can be costlier than others
  - Some ways of charging extract a lot of revenue, others less
  - Cheaper and more expensive ways of achieving other goals
- 2 Attract as many customers as possible
  - More important to attract than to please customers
  - Only customers who will switch get attention
  - Same logic as price discrimination
  - Client services often cater to this
- 3 Attract most valuable (avoid most costly) customers
  - May have direct value/cost (insurance, loans, workers)
  - Or may have indirect value in attracting other to purchase
    - In this case right consumers both goal and tool

# Types of product characteristics

Tools or instruments to achieve these goals include:

- ① Price: not focus today
- ② Charges beyond basic: less focus today (discrimination)
  - But logic will be very similar
  - Target value at the marginal not infra-marginal
- ③ Range of products offered
  - Allows segmentation of market to appeal to variety
  - Not primary interest today but similar logic
- ④ Product quality, ease of use, etc.
  - What is right trade-off between this and lower price?
- ⑤ Product niche, market segment, etc.
  - Narrow v. broad, long tail v. fat tail
- ⑥ Advertising, marketing to consumers, placement, etc.
- ⑦ Group of consumers for others to interact with: platforms

# Vertical and horizontal characteristics

Common way of dividing up tools/instruments is:

## 1 Vertical

- *All consumers agree it is good (or bad)*
- Price is simplest example, but quality more generally
- Speed of internet connection, level of insurance coverage
- Consumers may differ in how much value they put on it

## 2 Horizontal

- *Some consumers view as good, some as bad*
- Often have “ideal points” that differ
- We'll see simple model of this below
- Colors, flavors, designs, styles, political bias

## 3 But also, and most often, *diagonal*

- Most, but not all, view it same way
- But some feel differently, everyone differs in many ways

⇒ Key to all of this is *nature of consumer heterogeneity*

# Spence's model of quality-choosing monopoly

Spence offered simple model allowing any of this

- Highlights importance, role of this heterogeneity
- Suppose many consumers, each buys product or doesn't
- Each consumer gets utility  $u(\rho; \theta)$  from consuming
  - $\theta$  is the consumer's *type*,  $\rho$  is product characteristic
  - Types distributed (in some space) according to  $f(\theta)$
- Anyone with  $u \geq P$ , the price, purchases; sales are

$$N = \int_{\theta: u(\rho; \theta) \geq P} f(\theta) d\theta$$

- $\frac{\partial N}{\partial P} =$ , by Leibnitz's rule,  $-\int_{\theta: u(\rho; \theta) = P} f(\theta) d\theta \equiv -M$ 
  - Integral around *boundary*, by inverse  $\frac{\partial P}{\partial N} = -\frac{1}{M}$
  - Called the *density of marginal users*, marginal have  $u = P$
- Measure everything in fraction participating, cost  $C(N, \rho)$
- Firm makes, and seeks to maximize, profits  $PN - C(N, \rho)$
- Optimal price still  $P - \frac{P}{M} = P + P'N = MC = C_N$ , same

## Solving the model

More interesting is level of  $\rho$

- First, what would be socially optimal? Value

$$\int_{\theta: u(\rho; \theta) \geq P} u(\rho; \theta) f(\theta) d\theta - C(N, \rho)$$

- We want to *hold N fixed when we optimize*

- Goal not overall value, but relative quality focus

- Derivative by Leibnitz? How much does  $P$  for  $N$  fixed?

- $0 = \frac{dN}{d\rho} = \frac{\partial N}{\partial P} \frac{dP}{d\rho} + \frac{\partial N}{\partial \rho} = -M \frac{dP}{d\rho} + \int_{\theta: u(\rho; \theta) = P} u'(\rho; \theta) f(\theta) d\theta$

- $\tilde{u}' \equiv \frac{\int_{\theta: u(\rho; \theta) = P} u'(\rho; \theta) f(\theta) d\theta}{M}$  *average MU of marginals*

- Then becomes  $0 = -M \frac{dP}{d\rho} + M \tilde{u}'$  so  $\frac{dP}{d\rho} = \tilde{u}'$

- Gives derivative of social welfare wrt  $\rho$  where  $N$  fixed?

$$\int_{\theta: u(\rho; \theta) \geq P} u'(\rho; \theta) f(\theta) d\theta - C_\rho$$

- Let  $\bar{u}' = \frac{\int_{\theta: u(\rho; \theta) \geq P} u'(\rho; \theta) f(\theta) d\theta}{N}$ , *average MU of average*

## Marginal and average consumers

Then we get simple formula for optimum:

$$N \cdot \underbrace{\bar{u}'}_{\text{average marginal utility of average}} = \underbrace{C_\rho}_{\text{marginal cost of quality}}$$

- Equates marginal cost and benefits to *average purchaser*
- Derivative of profits  $PN - C(N, \rho)$ ?  $\tilde{u}'N - C_\rho$
- Thus we obtain different expression?

$$N \cdot \underbrace{\tilde{u}'}_{\text{average marginal utility of marginals}} = \underbrace{C_\rho}_{\text{marginal cost of quality}}$$

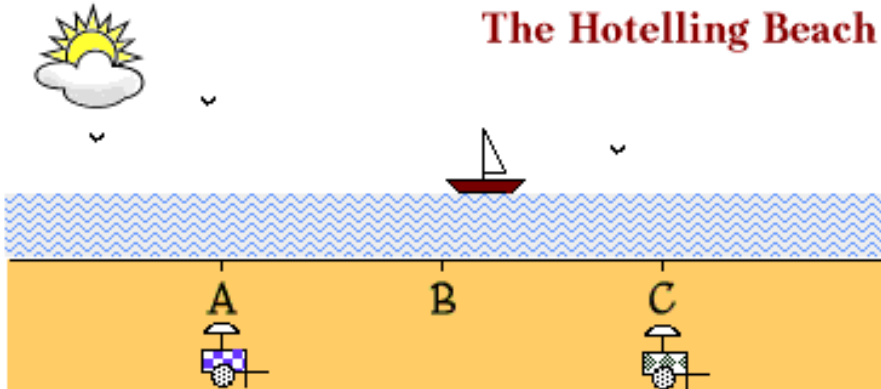
- Cater to *marginal not average*; called the *Spence distortion*
  - Quality too high (low) if marginals value more (less)
  - May be offset by other influence of infra-marginals: voice

# The Hotelling line

One very simple examples of this given by Hotelling

- Product characteristic ranges from  $\rho_j \in [0, 1]$
- Consumer  $i$  lives at  $x_i \in [0, 1]$ , uniformly distributed
- Consumer  $i$  pays  $t(x_i - \rho_j)$  to travel to store  $j$ 
  - Classic example of horizontal, single-peaked, other spatial
- All consumers buy one or the other product
- Technically not monopoly by similar logic
  - Suppose each firm starts at  $\rho_1, \rho_2$ , where to move?
    - Spence says: cater to the marginal consumer
    - Here she is half way between you and competitor
    - ⇒ Move towards your competitor
  - This holds at every point, so wind up in same spot!
  - This spot has to be in center or steal on either side
  - This leads to simple, extreme prediction?

# Graphical depiction of Hotelling



# Solving Hotelling's model

Let's try deriving this mathematically:

- What is value to marginal consumer of distance?
  - Imagine we start at symmetric prices, symmetric positions
  - $\rho_j > \frac{1}{2}$ ; marginal at  $\frac{1}{2}$
  - Willingness of marginal to pay for  $\rho_j$  is  $-t$
  - No cost of moving  $\implies$  always incentive to move towards  $\frac{1}{2}$ 
    - True for symmetric prices (any, if marginal in middle)
- $\implies$  Must be on top of one another at equilibrium!
  - What if this point is not  $\frac{1}{2}$ ?
    - Suppose  $\frac{1}{4}$
    - If I move to  $\frac{1}{4} + \epsilon$  I get everyone to right
    - Clearly better than staying at  $\frac{1}{4}$
- $\implies$  Only both at  $\frac{1}{2}$  can be stable
  - This is called *Hotelling's Law*

# Hotelling's Law

## Hotelling's Law

*In this simple model, both firms end up at center.*

- Extremely famous result
  - Everyone better off if firms spread out to .25 and .75
  - But no firm does this on its own, monopoly would do better
  - Very widely applied and very relevant for geography...
  - But not necessarily right direction (even for geography)
    - Some consumers might buy nothing; these marginal too
    - Not everything horizontal like this
    - Are switchers or exiters more representative?
    - Depends if dimension main one of differentiation or not
    - If not, then opposite result typically true
- ⇒ Interesting way of thinking about things, useful baseline
- But Spence offers broader answer, check on reasoning

# Connecting Hotelling to political competition

We phrased Hotelling's model as competition in sales

- But logic can also be applied when no money transferred
  - As long as you want more "consumers"...
  - Still marginal rather than average you cater to
- Particularly salient case is political parties
- Need majority to win election, seek to win enough
- Imagine that there is one-dimensional political spectrum
- Parties position themselves on left-right
  - In some countries, other major axis...guns v. butter
- Voters vote for party closest to their position
  - *Everyone* votes, just a question of for who
  - Only two political parties

⇒ Hotelling's logic extends directly

# The Median Voter Theorem

## The Median Voter Theorem

*Both political parties will adopt the positions of the median voter, who has an equal number of voters to her left and right.*

- This is most basic result in all of political science
- Also matches common sense/conventional wisdom:
  - In two-party, winner-take-all system, both run to “center”
  - This is why, after primaries, both candidates fight for center
  - Obviously skewed by electoral college, etc.
- Subsidiary: if more competition, more towards center
  - One dominant party may be able to favor its own view more
  - Dictatorships often more extreme than democracy
- Also multi-party systems less subservient to median
- But this all is very simplified, more general principle behind

# Swing voters and getting out the vote

What's missing from the simple Median Voter model?

- 1 Voters in one dimension, usually in more
- 2 Not everyone votes, need to make sure people turn out

Spence's logic shows us how to extend:

- 1 Swing voters, not just "median voter", are the targets?
  - Different groups of swing voters
    - Sensible centrist v. "radical middle"
  - Different policies try to target these groups
  - Core of political strategy
- 2 Parties also cater to base that may not turn out?
  - Get-out-the-vote efforts, but also policies targeting
  - This is constant debate within party: non-voters also pivotal
    - However, half as much weight as don't benefit other side

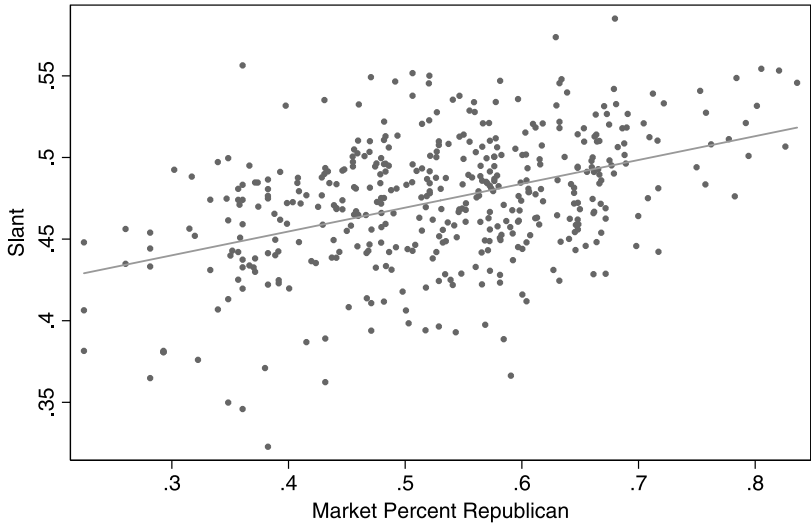
⇒ Much political science application of Spence

## Gentzkow and Shapiro (2010) on media slant

Gentzkow and Shapiro (2010) use to study media slant

- Local, monopoly newspapers around US
- Consider single dimension, but anyone may stop reading
- Choose as in Spence model
- Measure slant by language used by newspapers
  - Phrases used by Republicans: “death tax”, “illegal aliens”
  - Democrats use “poor people”, “workers rights”, “tax breaks”
  - Calibrate based on Congressional record
  - Rate papers on whether they write like each party
- Break local markets into districts with different politics
- Measure which districts do and do not read
  - Left-wing papers read less in right-wing zip codes
- Shows how much value slant, what would maximize profit
  - Do papers max profits? Or do they serve owner's goals?
  - Important for policy on media ownership, diversity

# Gentzkow-Shapiro data



# The idea and examples of platforms

In many situations, characteristics determined by consumers

- Serve both as consumers and producers of characteristics
- Thus we will refer to them by vaguer term “users”
- When user-generation important, call monopoly “platform”
  - Also called “two-sided markets” or “networks”
- Examples abound and increasingly important
  - 1 Media platforms: newspapers, television, websites
    - Primarily readers valuable to advertisers
  - 2 Payment platforms: credit, debit, PayPal
    - Payment acceptance and payment use
  - 3 Operating systems: smart phones, video games, etc.
    - Application developers and system users
  - 4 Transaction platforms: eBay, financial markets, etc.
    - Sellers, buyers, liquidity suppliers and consumers
  - 5 Other examples: dating, yellow pages, shopping malls

# Intuitive economics of platforms

In platforms users both *consume* and *produce*

⇒ Two distortions to level of participation

- 1 Basic, classic Cournot distortion downward
- 2 Spence distortion may go either way
  - Credit cards v. newspapers

- Distortions occur to same people/margin

⇒ May cancel out or magnify

- Thus Spence distortion may be good or much worse!
- Some users subsidized if bring lots of value to others:

$$P^I = C_I + \underbrace{\mu^I}_{\text{Cournot distortion}} - \sum_J N^J \cdot \underbrace{\widetilde{u}_I^J}_{\text{Spence distortion}}$$

# Heterogeneity of contributions

In many cases *composition* not just *number* of users key

- 1 "Soap" operas and selling soap
- 2 American Express travel services and merchant fees

Also beyond platforms: insurance level, down payments

- Key idea is that these instruments *sort* users:
  - 1 Lower quality, higher melodrama
    - ⇒ More soap-purchasing women for advertisers
  - 2 More travel services, higher annual fee
    - ⇒ Free spending clientele, charge merchants for access
  - 3 Less coverage, lower premiums
    - ⇒ Healthier clients, lower claims (or does it?)
  - 4 Right-wing political slant of a paper
    - ⇒ Potentially better-off right-wing readership
- Crucial is how preferences, contributions covary

## Cov [preferences, contributions|margin]

- More precisely?
- Simplest model: user generates characteristic  $k(\theta)$
- Has utility  $u(K; \theta)$ , platform cost  $C(N)$ ,  $MC = C'$
- Total characteristic  $K = \int_{\theta: u(K; \theta) \geq P} k(\theta) f(\theta) d\theta$ 
  - ⇒ Users heterogeneous in both *preferences* and *contribution*
- Key is relationship between these; use central quantities:
  - $N, M, \mu, \tilde{u}', \bar{u}'$  as before, now  $\tilde{k}$  is average characteristic
  - Crucial new is Cov [preferences, contributions|margin]

$$\sigma \equiv \text{Cov} [u', k | u = P]$$

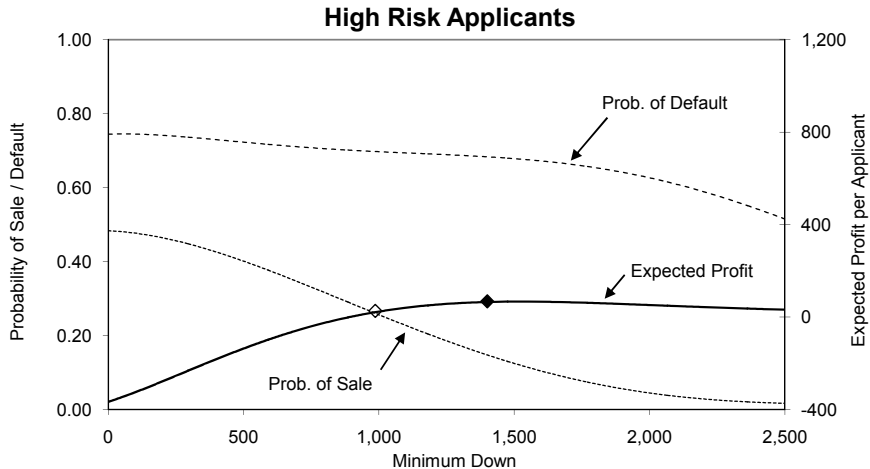
- Covariance, on margin, between MU and marginal product
- Shows up all over the place (won't give formula here)

## Einav et al. (2011) on subprime lending

A nice application of this is given by Einav et al. (2011)

- Logic applies outside of platforms
  - Relevant whenever different consumers of different value
- Example: subprime auto loans to diverse consumers
- Product dimensions: down payment, interest rate, price
- Observable credit scores, but also hidden risks
- Changing required down payment affects in two ways
  - 1 Reduces chance of default directly by reducing debt
    - Just like many incentive problems we have been dealing with
  - 2 Cash-strapped borrowers less likely to repay
    - ⇒ Down-payment requirements sort for good risks
- Einav et al. measure looking at variation in requirement
  - Sticker price counter-productive, as it translates into debt
  - ⇒ Raises chance of default

# Einav et al. results



# Other applications of heterogeneous contributions

Basic logic applies in very wide range of contexts:

- 1 Optimal media slant also depends on politics of rich
- 2 Soap operas appeal to melodrama-loving women
- 3 Credit card "points" useful if frequent users may leave
  - And travel benefits useful to attract
- 4 Insurers may hold down coverage to drive away sick
  - If they drive them to other insurer, this is externality
  - "Skim the cream" of healthy clients (problem set)
  - Called "Rotschild-Stiglitz Cream Skimming distortion"
- 5 Colleges make facilities to attract right types of students
- 6 Goldman Sachs makes like hell to scare off wimps
- 7 Intellectual property more valuable to good products
- 8 Industrial policy valuable if it targets infra-marginal surplus

Basic logic applies very broadly!