

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

In considering product design, two crucial considerations:

1 Goals:

- Keep costs low and price high
- Attract as many consumers as possible
- Attract most valuable (avoid most costly) customers
 - Either directly for the firm or for other customers

2 Tools or *instruments*:

- Price: not focus today
- Charges beyond basic: less focus today (discrimination)
- Range of products offered
- Product quality, ease of use, etc
- Product niche, market segment, etc.
- Advertising, marketing to consumers, placement, etc.
- Group of consumers for others to interact with: platforms

⇒ Today we'll learn how to use instruments for goals

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
 - θ is the consumer's *type*, ρ 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 ρ

- 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 ρ 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?

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

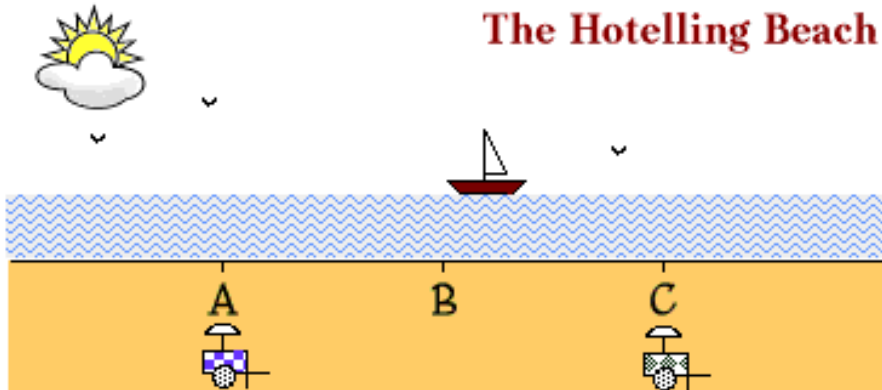
- Cater to *marginal not average*; called the *Spence distortion*
 - Quality too high (low) if marginals value more (less)
 - May be offset by other influence of infra-marginals: voice

The Hotelling line

One very simple example of this given by Hotelling

- Product characteristic along line, like consumers
 - Classic example horizontal, single-peaked, other spatial
- Location of store; consumers uniformly, travel to the store
- Consumers always buy one of two competing products
 - Technically not monopoly, but logic similar
- Each firm starts somewhere along the line
- Question: where do they move from there?
 - 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



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

The Median Voter Theorem

Perhaps most common application is electoral competition

- Two political parties competing, voters left to right
- Everyone votes, just a question of for whom
- Direct extension of Hotelling's logic is?

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"
- Subsidiary: if more competition, more towards center
 - One dominant party may be able to favor its own view more
- 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

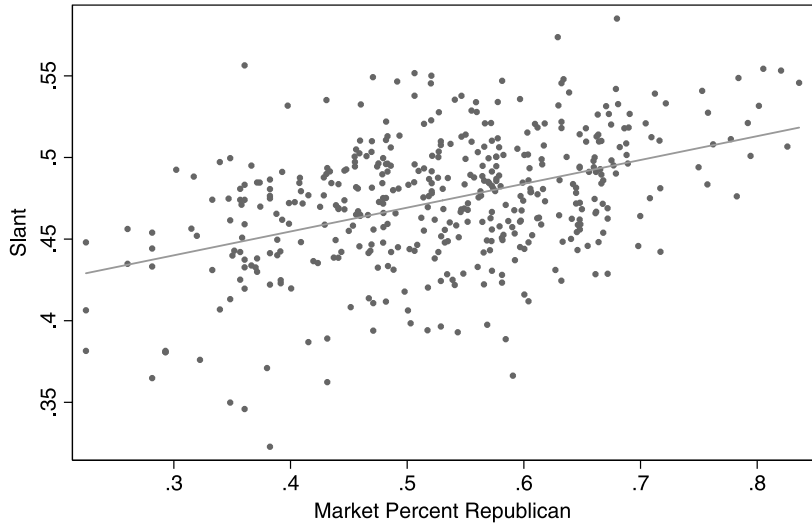
⇒ Much political science application of Spence

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



Switching costs, cities and tourists

Another application of Spence logic is “switching costs”

- Often consumers get “addicted” or locked-in
 - ① Customers at a bank or other recurring service
 - ② User of certain type of technology (Mac v. PC)
 - ③ People and companies living in cities
 - ④ Lawyers and other “client-based” services
- Firms have incentive to exploit those locked-in
 - But off-set by excessive catering to those not on board
 - Repeat custom, reviews, consumer anger act as check
 - But still this is major phenomenon, subject of famous joke
- Cities often cater to tourists rather than to residents
- David Ben-Gurion, heaven and hell
 - Then you were a tourist...
 - Spence distortion in action

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

A simple model of platforms

In simple model of platforms, only number matters

- Identity of consumers irrelevant: not relevant above
- Shows basic logic, generalizes, maybe for telecom network
- Users, like Spence, have utility for joining $u(N; \theta)$
- N now serves both the role of N before and ρ !

$\implies \frac{dP}{dN} = -\frac{1}{M} + \tilde{u}'$, may rise or fall!

- If cannot sell, might still avoid raising price (problem set)
 - Attracts in other customers (popular restaurants, theaters)
- For everything else, just combine ρ and N : $C(N)$
- Social value derivative $P - MC + N\tilde{u}' = 0$; $MC \equiv C'$
- Private value derivative $P - \frac{N}{M} - MC + N\tilde{u}' = 0$
 - Label $-\frac{N}{M} \equiv \mu = P'N$ market power/Cournot distortion
 - Formula exactly what you would think...

Platform pricing and the Spence distortion

Socially optimal is just Pigou?

$$P = MC - \underbrace{Nu'}_{\text{externality to average users}}$$

Monopolists distorts in two ways?

$$P = MC + \underbrace{\mu}_{\text{Cournot distortion}} - \underbrace{Nu'}_{\text{Spence distortion}}$$

- Just as in Spence, may go either way
 - Newspapers v. credit cards (two-sided markets, next slide)
- This effect may be bigger here...only one product
 - Interacts with market power: may be good or much worse

Multi-sided platforms

In many (most?) cases different distinct groups

- Usually called “sides of the market” $\mathcal{I} = A, B, \dots$
 - Readers and advertisers, card-holders and accepters, etc.
- A bit more more notation, math in deriving, but same idea
- Social optimum is Pigou:

$$P^{\mathcal{I}} = \underbrace{C_{\mathcal{I}}}_{\text{marginal cost}} - \underbrace{\sum_{\mathcal{J}} N^{\mathcal{J}} \overline{u_{\mathcal{I}}^{\mathcal{J}}}}_{\text{externality to average users}}$$

- Private optimum adds two distortions:

$$P^{\mathcal{I}} = C_{\mathcal{I}} + \underbrace{\mu^{\mathcal{I}}}_{\text{Cournot distortion}} - \sum_{\mathcal{J}} N^{\mathcal{J}} \cdot \underbrace{\widetilde{u_{\mathcal{I}}^{\mathcal{J}}}}_{\text{Spence distortion}}$$

Heterogeneity of contributions

Users care only about *number* not *composition* of other users

- But in many cases goal is to attract *right type of users*
 - ① “Soap” operas and selling soap
 - ② American Express travel services and merchant fees
- Also broader: insurance coverage, down payments
 - Different users make *heterogeneous contributions*

⇒ Instruments now serve additional role of *sorting* users

- 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]

Cov [preferences, contributions | margin]

More precisely?

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

- $\frac{dP}{dN} = -\frac{1}{M} + \widetilde{u}' \frac{dK}{dN}$ and $\frac{dK}{dN} = -M\widetilde{k} \frac{dP}{dN} + M\widetilde{u}'k \frac{dK}{dN}$
- ⇒ $\frac{dK}{dN} = \widetilde{k} + M \left(\widetilde{u}'k - \widetilde{u}'\widetilde{k} \right) \frac{dK}{dN}$
 - $\text{Cov}[x, y] = E[xy] - E[x]E[y]$ so $\widetilde{u}'k - \widetilde{u}'\widetilde{k} = \sigma$
- ⇒ $\frac{dK}{dN} = \widetilde{k} + M\sigma \frac{dK}{dN}$, $\frac{dK}{dN} = \frac{\widetilde{k}}{1-M\sigma}$, $\frac{dP}{dN} = -\frac{1}{M} + \frac{\widetilde{k}\widetilde{u}'}{1-M\sigma}$
 - Bringing in more people sorts for (or against) higher quality
 - Popular kids and losers v. telemarketers and grannies
 - This reinforces, infinite series, so multiplier
 - So derivative social value wrt N is $P - MC + \frac{N\widetilde{k}\widetilde{u}'}{1-M\sigma}$
 - Derivative of profits wrt N is $P - \mu - MC + \frac{N\widetilde{k}\widetilde{u}'}{1-M\sigma}$
 - Gives optimal pricing formula...

Pricing with heterogeneous contributions

Rearrangement yields simple rules:

1 Social:

$$S \equiv C' - P = \tilde{k} \frac{\overbrace{u'N}^{\text{direct externality}}}{\underbrace{1 - M\sigma}_{\text{infinite series formula}}}$$

2 Private:

$$D \equiv C' + \mu - P = \tilde{k} \frac{\tilde{u}'N}{1 - M\sigma}$$

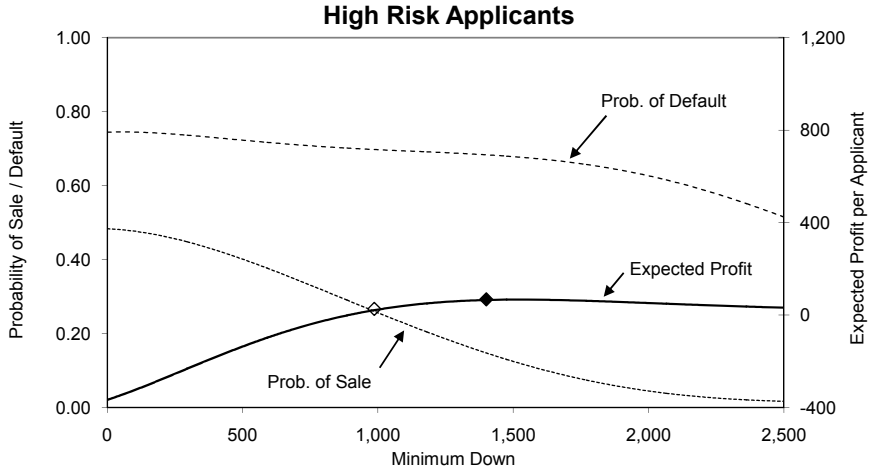
- Spence distortion can be magnified or mitigated
- Uncorrelated collapses to simple model with average
- Key feature is not contribution heterogeneity alone...
 - Key is covariance! Sorting effect of characteristic

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!