Targeting in Advertising Markets: Implications for Offline vs. Online Media

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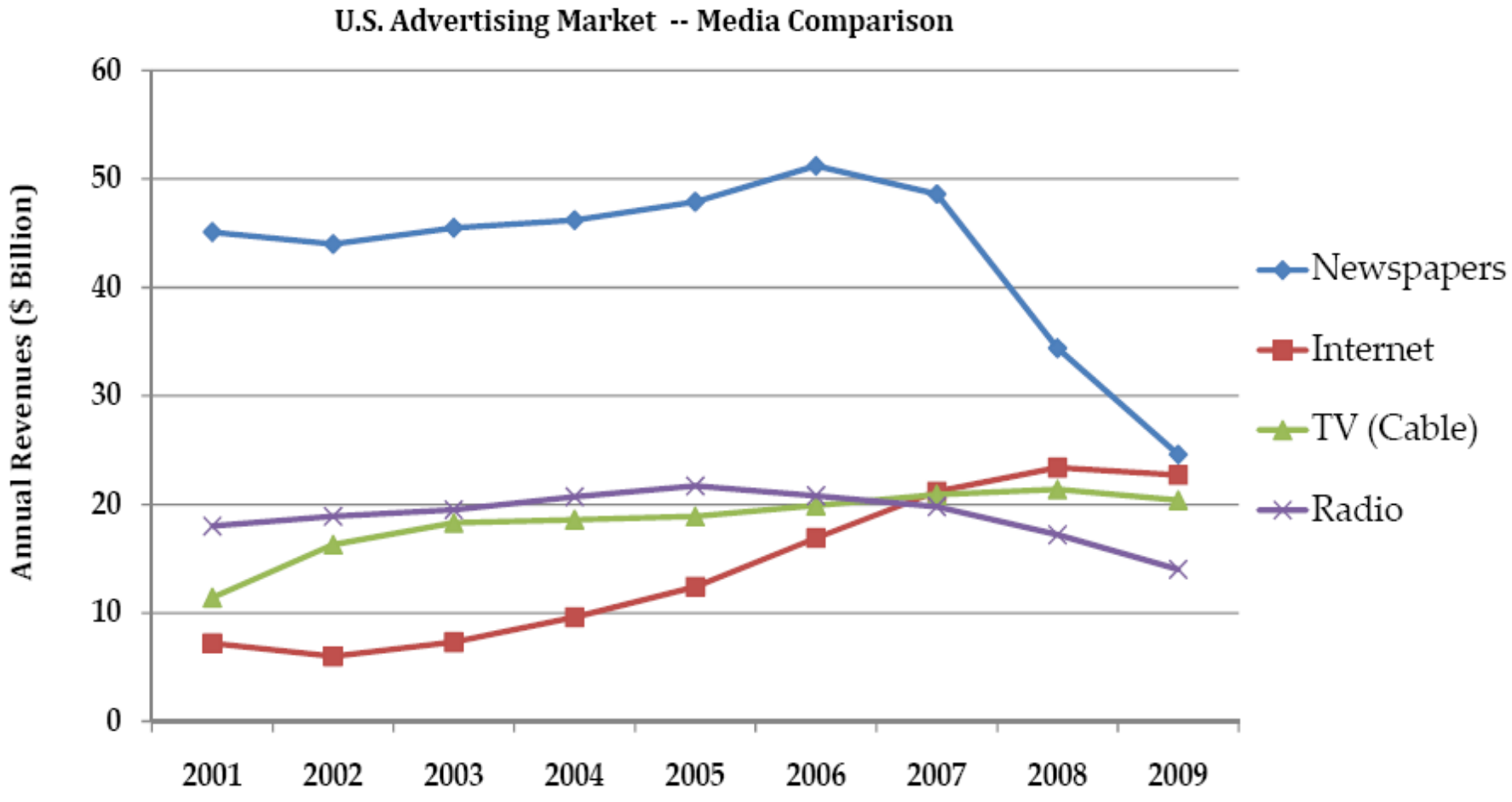
- "Recent" progress in advertising technology:
  - display advertising
  - sponsored search
  - social networks
  - mobile ads
  - addressable cable
  - ...
- Distinctive feature is the ability to target:
  - attribute, demographic targeting;
  - behavioral, contextual targeting.

Some Data


U.S. Advertising Market -- Media Comparison
Annual Revenues ($ Billion)
60
50
40
30
20
10
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
Newspapers
Internet
TV (Cable)
Radio

Targeting with Many Markets/Products

- to offer a model of targeting in advertising markets in the presence of
  - many distinct advertising markets
  - many distinct advertisers
- we trace out the implications of targeting for:
  - the allocation of advertisement messages;
  - the social value of advertising;
  - the equilibrium price of advertising;
  - the equilibrium revenues of new and old media.

A Model of Advertising as Matching

- Advertising matches a consumer and a product.
- An advertisement message turns a potential, interested consumer into an actual customer.
- Advertising markets operate under substantial frictions:
  1. messages may reach the wrong consumer;
  2. messages may reach the same consumer repeatedly.
- Targeting reduces matching frictions.

Advertising and Product Markets

- A continuum of distinct advertising markets

$$a \in [0, \infty),$$

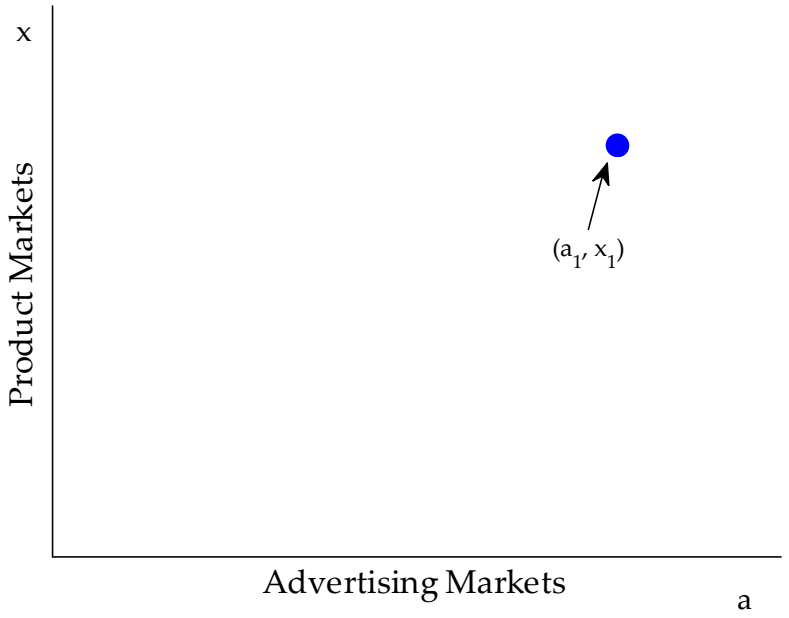
  representing outlets, channels, websites, searches.
- A continuum of distinct products (= firms),

$$x \in [0, \infty).$$

- A unit mass of consumers with two-dimensional type (a, x):
  - each consumer is located in a specific advertising market a;
  - each consumer is interested in a specific product x.

Consumer Characteristics...

- A consumer is characterized by (a, x):
  1. his location in a specific advertising market a,
  2. his preference for a specific product x



- market structure: joint density $s(a, x)$ over (a, x) :

$$\int_0^\infty \int_0^\infty s(a, x)\, dadx = 1.$$

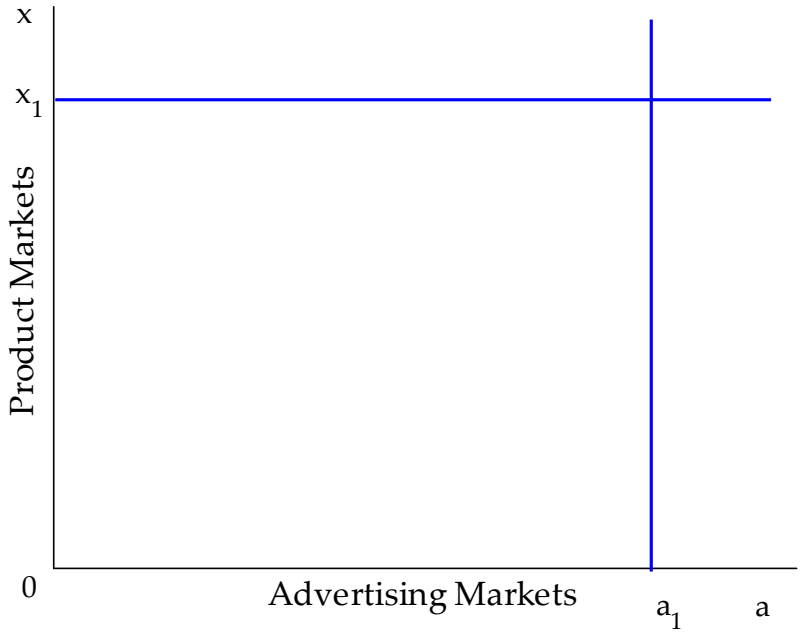
... and Market Characteristics

- advertising market a : distribution over consumer preferences

$$s\left(x\,|a\right) = \frac{s\left(a,x\right)}{\int_0^\infty s\left(a,x'\right)dx'}$$

- firm x: distribution of its consumers over advertising media:

$$s\left(a\,|x\right) = \frac{s\left(a,x\right)}{\int_0^\infty s\left(a',x\right)da'}$$



- we maintain the distribution over consumer preferences:

$$s(x) = \int_0^{\infty} s(a', x)\, da',$$

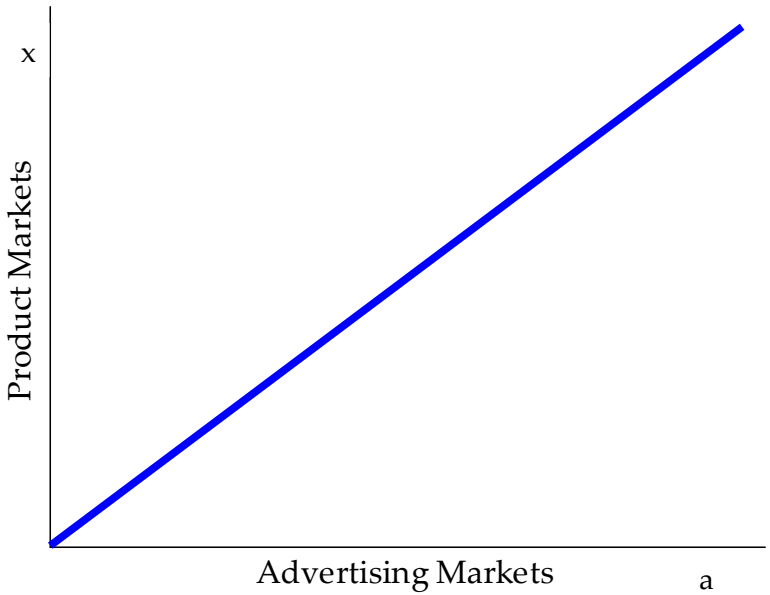
  the share $s(x)$ of each product in the consumer market
- we order x (without loss of generality) so that:

$$s'(x) < 0,$$

- there are products with a broad audience $x \approx 0$ and products with a narrow audience $x \approx \infty$ (the long tail of Anderson (2006))

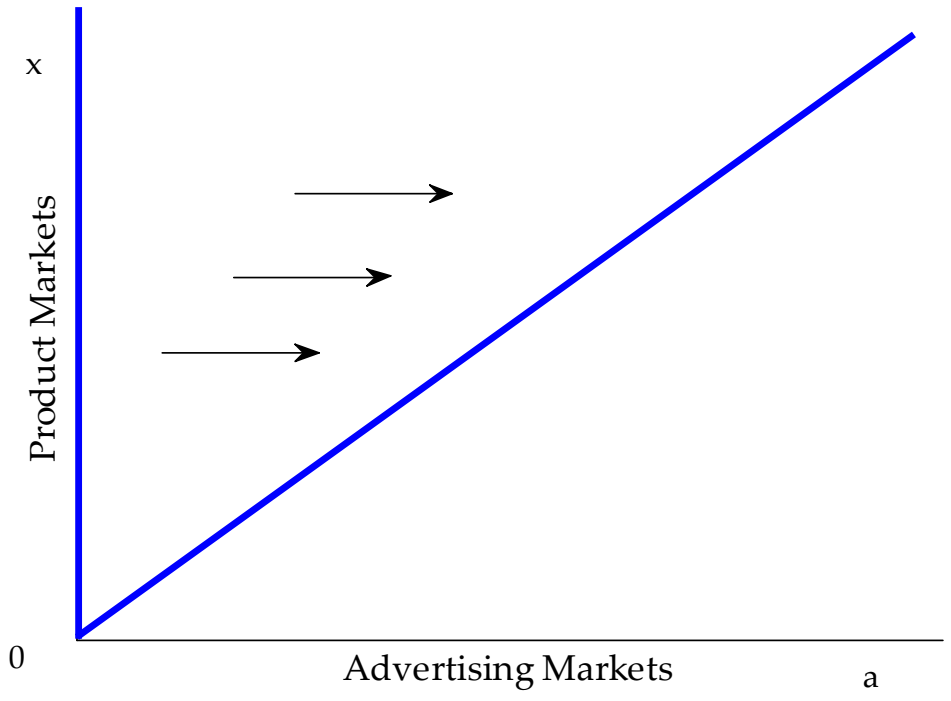
...and Targeting

- we investigate the impact of different distributions of consumers across advertising markets..
- the distribution of consumer across advertising markets range
  - from perfect targeting
  - to zero targeting
- and ask how does an increase in targeting impact the allocation and the price of advertising across media markets



Impact of Targeting

- an increase in targeting then has two effects:
  1. consumers move from mass market publications to more specialized, narrower media
  2. in every media market, the naturally targeted audience has a larger relative population share



Distribution in Product Markets

- Exponential distribution of consumers' interests:

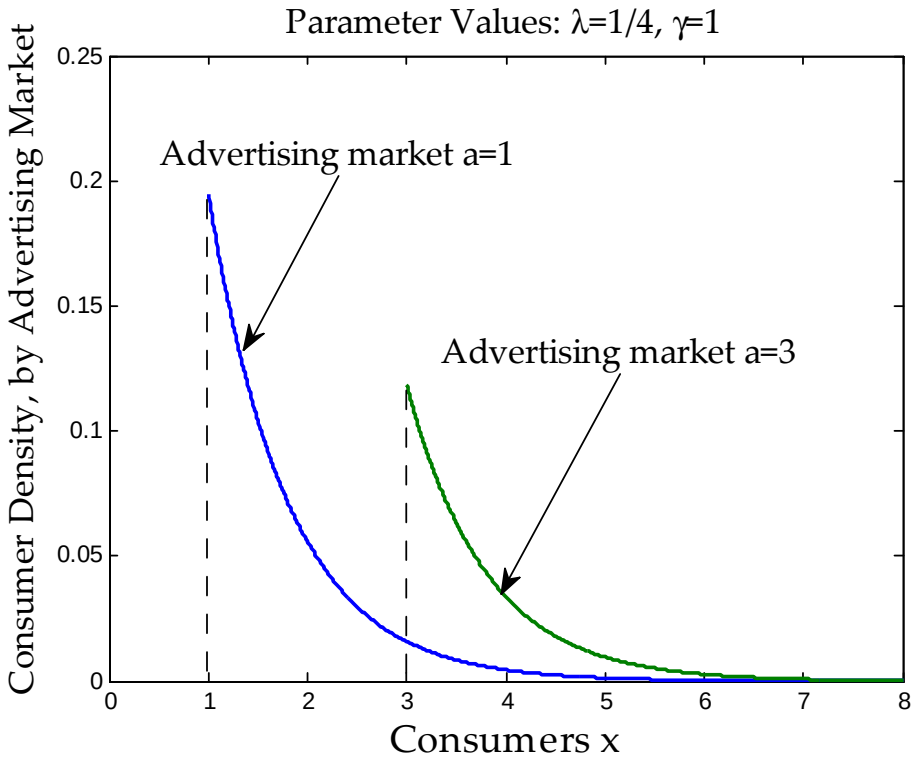
$$s_x := \lambda e^{-\lambda x}.$$

- λ measures concentration of consumers in product markets.
- Market shares s_x are declining in x.
- Hierarchical structure of products:
  - popularity: bicycles, music, watches, travel destinations;
  - mass vs. niche products, mainstream vs. fringe firms.

Distribution in Advertising Markets

- Conditional distribution of consumers x in markets a:

$$s(x|a) = \gamma e^{-\gamma(x-a)}, \qquad \text{for all } 0 < a \leq x.$$

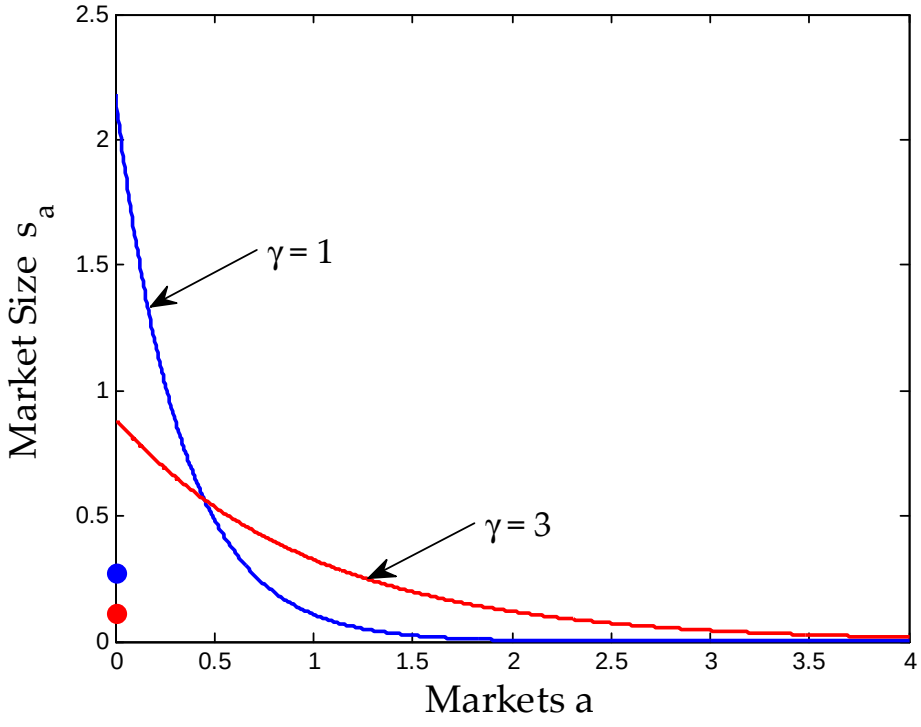


- Distribution across markets is upper triangular (stationary):

$$s(x|a) = 0 \quad \text{for all } x < a,$$

Size of Advertising Markets

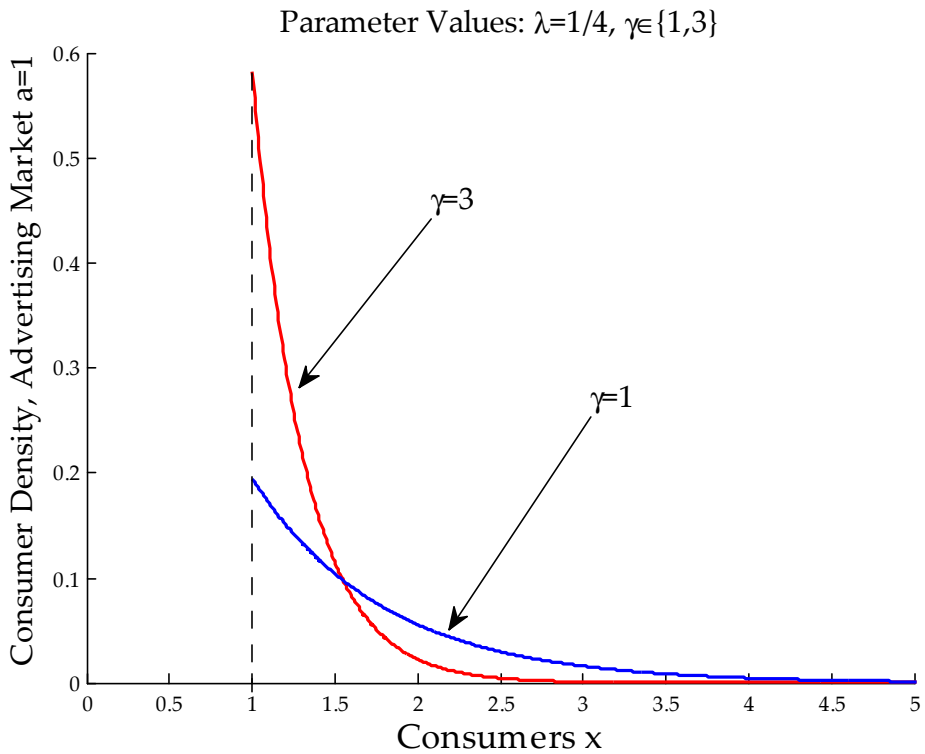
- an increase in the targeting technology γ has a size effect...:



- γ measures consumer concentration in advertising markets.
- high $\gamma \Rightarrow$ the consumers of x move to nearby markets $a \approx x$.

Composition of Advertising Markets

- ... and an increase in targeting γ has a composition effect:



- γ measures consumer concentration in advertising markets.
- high $\gamma \Rightarrow$ most consumers in a have nearby preferences $x \approx a$.
- a higher γ facilitates targeting.

Advertising as Random Matching

- Each consumer reads/views/processes M messages
- A consumer with preference for product x purchases if and only if she receives a message from firm x
- Firm x sends $m_{a,x}$ messages to consumers in market a.
- Each message is received with **uniform probability** by one of the consumers in advertising market a:
- It follows that a consumer in advertising market a receives at least one message from firm x with probability

$$f\left(m_{a,x}, s_a\right) = 1 - \exp\left(-m_{a,x} \,/\, s_a\right).$$

Advertising Policy

- an advertising policy of firm x:

$$\left\{m_{a,x}\right\}_{a=0}^{x}$$

- advertising intensity in advertising market a:

$$\frac{m_{a,x}}{s_a}$$

- the gross revenue of $m_{a,x}$ is given by

$$s_{a,x} \cdot f\left(m_{a,x}, s_a\right) = s_{a,x} \cdot \left(1 - \exp\left(-m_{a,x} / s_a\right)\right)$$

- an optimal advertising policy seeks to minimize the role of:
  1. irrelevant messages: $1 - s_{a,x}$
  2. duplicating messages: $\exp\left(-m_{a,x} / s_a\right)$

Competitive Equilibrium

- price of message in advertising market a is competitive equilibrium price

$$p_a$$

- M is time/attention of consumer devoted to advertisments
- supply of messages M_a in advertising market a is given by:

$$M_a = s_a \cdot M$$

- competitive price p_a equilibrates demand and supply:

$$\int_0^\infty m_{a,x}\left(p_a\right) dx = M_a.$$

The Firms's Problem

- Each sale generates revenue \$1, firms only differ in size $s(x)$.
- Firm x chooses $m_{a,x}$ to maximize profit:

$$\pi_{a,x} = \max_{m_{a,x}} \left[s_{a,x} \cdot \left(1 - \exp\left(-\frac{m_{a,x}}{s_a} \right) \right) - p_a \cdot m_{a,x} \right].$$

- advertising policies are separable across advertising markets:

$$m_{a,x} = s_a \left(\ln \frac{\gamma + \lambda}{p_a} - (\gamma + \lambda)(x - a) \right)$$

for all $x \geq a$.

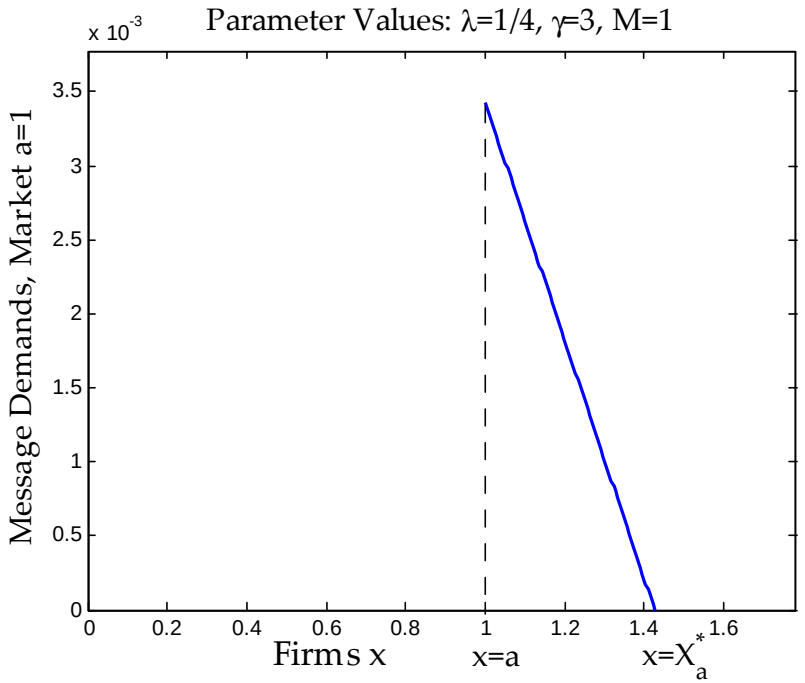
Competitive Equilibrium

- marginal advertiser in advertising market a is X_a^*
- The number of active firms is constant across markets a:

$$X_a^* - a = \sqrt{\frac{2M}{\lambda + \gamma}}.$$

- The equilibrium demands are

$$m_{a,x}^* = \gamma \lambda e^{-a\lambda} \left(X_a^* - x \right).$$



Competitive Equilibrium Price

- Equilibrium prices p_a^* are equalized across advertising market:

$$p_a^* = p^* = (\lambda + \gamma)\, e^{-\sqrt{2(\lambda+\gamma)M}}, \quad \text{for all } a.$$

- For any $\gamma > 0$, all firms advertise somewhere
- positive targeting $\Rightarrow$ "long tail".

The Social Value of Targeting

- an improvement in targeting technology as increase in γ
- what is the impact in terms of the social welfare?
  - less irrelevant messages are received
  - more messages are sent by smaller firms

Proposition (Targeting and Social Welfare)

As targeting improves the social value of advertising increases.

- the total number of matches between advertisers and consumers increases
- even, the number of matches of each firm (product) increases

Targeting and the Profile of Demand

- as the social value of advertising increases, how does the composition in the demand for advertising change?

Proposition (Targeting and Demand)

As targeting improves:

1. *the large firms purchase less, the small firm purchase more messages (across all markets);*
2. *the number of participating firms $X_a^* - a$ decreases in every advertising market;*
3. *The number of messages per capita $m_{a,x}^* / s_a$ increases for all $x < (a + X_a^*)/2$.*

- conversely, every firm is present in fewer advertising markets

Targeting and The Price for Advertising

- as the social value of advertising increases, can (a share of) the increase in value be captured by the media?

Proposition (Targeting and Price)

As γ increases, the equilibrium price per message p_a^* increases if and only if $\lambda + \gamma < 2/M$.

- the equilibrium price is initially increasing in the targeting ability but eventually decreasing
- main trade-off: the messages become more relevant yet eventually to a smaller set of firms and thus the risk of duplication (saturation)
- in hedonic terms: the price per consumer reached is decreasing everywhere.

Related Empirical Evidence

- Chandra and Kaiser (2010) “Target Advertising in Magazine Markets":
  - advertiser value more homogenous groups of readers (in subscriber characteristics of age, gender, income, etc.)
- Rutz and Bucklin (2010): "From Generic to Branded: A Model of Spillover Dynamics in Paid Search Advertising,” compare generic (e.g., “Hotels LA”) and branded (e.g., “Hilton Hotels LA”) searches
  - find that branded keywords have lower prices than generic keywords "Sheraton Hotel NYC" vs "Hotel NYC;
  - find that long, narrower keywords “Hotels LA Westwood” have lower prices than shorter ones “Hotels LA"

Media Competition

- allow for multi-homing of consumer and thus multiple opportunities for advertiser to match with a customer
- online versus offline media, targeted vs. non-targeted medium
- total exposure to advertising, given by M, is now divided between media, A and B :

$$M_A + M_B = M$$

- suppose firm x reaches a fraction a_x of its consumers on medium A, and a fraction b_x on medium B.
- the total fraction of s_x reached is

$$a_x + b_x - a_x \cdot b_x.$$

Online vs. Offline Media

- general (offline, A) and perfectly targeted (online, B) advertising $\left(m_x^A, m_{a,x}^B\right)$.
- supply in the (single) offline market is M_A.
- supply in online market a is $M_{B,a} := s_a \cdot M_B$.
- perfectly targeted advertising online: $\gamma = \infty$
- the relevant online advertising market for firm x is $a = x$.

- large firms ($x < X^*$) are present online and offline
- small firms ($x > X^*$) are present only online

Proposition (Equilibrium Prices)

1. *The equilibrium price on the offline medium is given by:*
$$p^* = \lambda \exp(-M_B - \sqrt{2\lambda M_A}).$$
2. *The equilibrium prices on the online markets are given by:*
$$p_a^* = \begin{cases} \exp(\lambda a - M_B - \sqrt{2\lambda M_A}), & \text{for} \quad a \leq X^*, \\ \exp(-M_B), & \text{for} \quad a > X^*. \end{cases}$$

The Emergence of the Internet

- the attention/time allocated to online media, M_B, is increasing; conversely the attention to offline media, M_A is decreasing
- the segment of firms advertising offline is shrinking as $x < X^*$:

$$X^* = \sqrt{\frac{2M_A}{\lambda}}$$

- the price of advertising offline is decreasing faster, linear rather than square root, with an increase in the online media:

$$p^* = \lambda \exp(-M_B - \sqrt{2\lambda M_A}).$$

- in particular, relative to the introduction of competing offline medium where it would be:

$$p^* = \lambda \exp(-\sqrt{2\lambda \left(M_A + M_B\right)})$$

Related Empirical Evidence

- Goldfarb and Tucker (2010): " Search Engine Advertising: Channel Substitution when Pricing Ads to Context" use natural experiment - ambulance-chaser regulations across states.
- when lawyers cannot contact clients by mail, advertising prices per click for search engine advertisements are 5-7% higher. Therefore, online advertising substitutes for offline advertising
- consistent with Chandra and Kaiser (2010) who document the positive valuation of homogenous, targeted audiences; and hence imply differential revenue across media with differential targeting abilities

Concluding Remarks

- A model of targeting in competitive advertising markets.
- Hierarchical framework for product and advertising markets.

Extensions and future directions:

1. revenue maximization, strategic interaction;
2. platform competition;
3. congestion, consumer preferences over for different ads;
4. ad exchanges.