Quality Provision in a Search Engine Environment

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Introduction

- Search engine organic results are the main sources for traffic in websites (Jerath, Ma and Park, 2013 and Baye, Santos and Wildenbeest, 2014)
- Every prominent rank position in the search engine results in a higher clickthrough rate (Glick, Richards, Sapozhnikov and Seabright, 2014)
- The ranking of the firms in the search engine is determined by an algorithm which is multidimensional, including Search Engine Optimization (SEO) and product quality)
- In contrast to the auction approach of the paid placement, firms which wish to gain prominence in organic results should comply with the requirements of the algorithm

Objectives

- Evaluate the impact of the search engine algorithm for prominence on firms' optimal allocation of investments between Search Engine Optimization (SEO) and quality
- SEO (white-hat) varies from developing site design and content quality as well as brand awareness and representation
- We investigate whether and under what conditions the SEO investment leads to a distortion in the level of quality and if yest, its impact on consumer surplus and total welfare

Model: Players

- Consumers of mass 1 type a query in a search engine. Preferences:

$$U = \begin{cases} v - p & \text{if consumer matches and purchases} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

- Consumer learns his valuation when he actually buys the good: $v \in [\underline{v}, \overline{v}]$, $0 \leq \underline{v} < \overline{v}$, $G(v)$ and $g(v) > 0$

- Two firms that compete for prominence in a search engine by choosing their level of SEO and product quality

- A search engine ranks the two firms based on its algorithm that takes into account firms' characteristics such as the investments on quality and SEO

Timing

1. Firms compete and maximize their payoff functions with respect to quality and investments on SEO
2. Firms choose their pricing behavior (monopolistic competition)
3. The search engine ranks the firms
4. Consumers observe the ranking and then they decide which firm to visit and whether they will purchase or not

Equilibrium Strategies

- Consumers will choose to go firstly on the firm that is ranked first. If they match they purchase and the game stops. Otherwise, they visit the second firm by incurring a relatively low search cost μ. If they match they purchase. Otherwise, they exit the market.

- Based on the implemented algorithm, the search engine ranks the firms based on both the SEO and quality investment outcome

- Firms in equilibrium charge the monopoly price and earn:

$$p^* = \frac{1 - G(p)}{g(p)}, \qquad \Pi^* = \frac{[1 - G(p)]^2}{g(p)} \tag{2}$$

Payoff Functions

$$\Pi_i = \Pi^* \left(\Phi_i(x_i, x_{-i}, S_i, S_{-i}) x_{-i} x_i + (1 - x_{-i}) x_i\right) - C(x_i) - K_i(S_i)$$

where $i = A, B$ and

- $\Phi_i(x_i, x_{-1}, S_i, S_{-i})$: firm i's probability of being ranked first
- x_i: matching probability of firm i with a randomly chosen consumer
- S_i: firm i's investment on SEO
- $C(\cdot)$, $K_i(\cdot)$: Associated costs

Benchmark: Search engine does not exist

Proposition

When a search engine admits the ranking randomly and firms are symmetric ($\Phi = \frac{1}{2}$), there exists a symmetric Nash equilibria in pure strategies where the investment on SEO is zero while the quality is given by:

$$x^r = \begin{cases} 2\frac{\Pi^* - C_x}{\Pi^*} & \text{if } 0 < \frac{\Pi^* - C_x}{\Pi^*} < \frac{1}{2} \\ 1 & \text{otherwise} \end{cases} \tag{4}$$

Quality and SEO in the short-run

- Qualities are fixed
- Firms optimize with respect to SEO: Symmetric Nash equilibrium
- How does search engine's algorithm perceives SEO and quality?
  1. Independent: $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_i} = 0$ and $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_{-i}} = 0$
  2. Complements: $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_i} > 0$ and $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_{-i}} < 0$
  3. Substitutes: $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_i} < 0$ and $\frac{\partial^2 \Phi_i}{\partial S_i \partial x_{-i}} > 0$

Quality and SEO in the short-run (2)

- Independent: even if there is asymmetry in offered qualities, firms select the same SEO in equilibrium
- Complements: The firm that offers higher quality, also sets greater SEO
- Substitutes: The firm that offers higher quality, sets lower SEO

Quality and SEO in the long-run

Proposition

If $C(\cdot)$ is sufficiently convex, there exists a symmetric pure Nash equilibrium which is defined by:

$$\Pi^* \left(\frac{\partial \Phi}{\partial x} x^2 + 1 - \frac{1}{2} x \right) = C_x, \qquad \Pi^* \frac{\partial \Phi}{\partial S} x^2 = K_S \tag{5}$$

Proposition

At such Nash equilibrium, if quality and SEO are:

- *independent: No quality distortion*
- *complements: firms are offering higher quality when SEO is allowed*
- *substitutes: firms are offering less quality when SEO is allowed*

Short-run welfare implications by the precense of the search engine

Proposition

The impact of the existence of search engine on the short-run consumer surplus and total welfare depends on correlation between quality and SEO. Specifically, if they are

- *independent: Consumer expected surplus is weakly increased by the presence of the search engine. Total welfare is also increased, but, only when the probability Φ_i for the high quality firm is sufficiently high*
- *complements: Same (qualitatively) conclusions as in the independent case*
- *substitutes: The impact on consumer surplus and total welfare is ambiguous. Positive impact requires further restrictions on Φ_i of the high quality firm.*

Long-run welfare implications by the precense of the search engine

Proposition

The impact of the existence of search engine on the short-run consumer surplus and total welfare depends on correlation between quality and SEO. Specifically, if they are

- *independent: Consumers are indifferent while total welfare decreases*
- *complements: Consumer surplus increases while the impact on total welfare is ambiguous*
- *substitutes: Consumer surplus and total welfare are reduced*

Discussion

- Complementarity between quality and SEO can be welfare improving
- What are the incentives of the search engine?
- Could we derive any regulatory implications (for example, about the disclosure of the algorithm)?
- Competition among search engines?