

Price competition in a differentiated products
duopoly under network effects

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Information Economics and Policy, 23 (2011)

- ~> We characterize the set of equilibria in a duopoly model where firms, selling horizontally and/or vertically differentiated products, compete in product prices under network effects.
- ~> The emphasis is given on consumers' expectations formation.

main questions

- How is the equilibrium affected if firms can influence consumers' expectations?
- Is it possible that products of lower quality obtain a higher market share?
- What conditions give rise to a multiplicity of equilibria?

Literature review

↪ Our analysis is related to the product differentiation and the network effect literatures

- product differentiation

Hotelling (1929), d'Aspermont, Gabszewicz and Thisse (1979), Shaked and Sutton, (1982)

- network effects

Katz and Shapiro (1985), Grilo et al. (2001)

Expectations formation - fulfilled in equilibrium (rational)

- We examine the case where consumers expectations cannot be affected by the prices set by firms (Katz and Shapiro, 1985)
- We examine the case where consumers' expectations **can** be affected by the prices set by the firms (this should be the case where firms can commit to their prices)
- We provide a refinement that limits the number of equilibria.

Key insights

- For firms to share the market asymmetrically when the expectations are not influenced by prices, the qualities of the products have to be different.
- When prices can influence the equilibrium we can have asymmetric equilibria even without quality differences.
- When expectations are influenced by the prices, the firms tend to compete with greater intensity, leading to lower equilibrium prices and profits.
- In both scenarios it is possible that the market is shared, with the high-quality firm obtaining a larger share than its rival.
- When the expectations are influenced by prices, the high-quality firm is favored more and its market share increases.
- Continuity of expectations is shown to have a dramatic effect, reducing the equilibria that one obtains.

Basic model

- 2 firms located at the two extremes of a $[0, 1]$ linear city, quadratic transportation cost
- horizontally and vertically differentiated products (Hotelling model with different qualities, where $q_A = 0$ and $q_B = q \geq 0$)
- network effect $\beta > 0$ through expected market sizes
- unit demands
- the indifferent consumer is located at x if

$$p_A + tx^2 - \beta x^e = p_B + t(1-x)^2 - \beta(1-x^e) - q,$$

where x^e is the expected market share of firm A. An indifferent consumer exists if $x \in (0, 1)$, otherwise corner solution.

$$x = \frac{p_B - p_A + \beta(2x^e - 1) + t - q}{2t}. \quad (1)$$

Equilibrium with expectations not influenced by prices

$$x^*(x^e) = \begin{cases} 1 & \text{if } \beta(2x^e - 1) \geq 3t \\ \frac{1}{2} + \frac{\beta(2x^e - 1)}{6t} & \text{if } -3t < \beta(2x^e - 1) < 3t \\ 0 & \text{if } \beta(2x^e - 1) \leq -3t, \end{cases}$$

- \rightsquigarrow when consumers' expectations are that the market shares are not extreme, both firms will indeed make positive sales
- \rightsquigarrow if consumers expect that the market share differences exceed a given threshold, then the firm expected to have a larger market share indeed captures the entire market
- \rightsquigarrow next step: examine what market shares can be supported when expectations about these shares are fulfilled in equilibrium

Equilibrium with expectations not influenced by prices

There are three cases to consider. Case 1: For relatively weak network effects ($\beta < 3t$)

$$x^* = \begin{cases} \frac{1}{2} - \frac{q}{2(3t-\beta)} & \text{if } 0 \leq q < 3t - \beta \\ 0 & \text{if } q \geq 3t - \beta. \end{cases}$$

Case 2: For relatively strong network effects ($\beta > 3t$)

$$x^* = \begin{cases} \{0, \frac{1}{2}, 1\} & \text{if } q = 0 \\ \{0, 1\} & \text{if } 0 < q < \beta - 3t \\ 0 & \text{if } q \geq \beta - 3t. \end{cases}$$

Case 3: For $\beta = 3t$: when $q = 0$, any $x^e = x^* \in [0, 1]$, while when $q > 0$ we necessarily have $x^* = 0$,

Equilibrium with expectations affected by prices

We start by substituting $x^e = x$ in expression (1) to obtain

$$x = \frac{p_B - p_A - \beta + t - q}{2(t - \beta)}$$

This expression corresponds to the location of the indifferent consumer (if one exists) when the prices are p_A and p_B **and when all the consumers believe that the market share of firm A is indeed given by this expression.** Since firms can influence consumers' expectations via their prices, these prices should be used when deriving the expected market shares

- if $t > \beta$, a higher price by a firm is associated with a lower market share for that firm
- if $t < \beta$, an increase in a firm's price is associated with an increase in its market share

weak network effects: $t > \beta$

$$x = \begin{cases} 0 & \text{if } p_B - p_A \leq \beta - t + q \\ \frac{p_B - p_A - \beta + t - q}{2(t - \beta)} & \text{if } \beta - t + q \leq p_B - p_A \leq t - \beta + q \\ 1 & \text{if } p_B - p_A \geq t - \beta + q. \end{cases}$$

In equilibrium, we obtain:

- If $0 \leq q \leq 3(t - \beta)$ there is a unique equilibrium where both firms have positive market shares ($x^* = \frac{1}{2} - \frac{q}{6(t - \beta)}$) and the high quality firm captures a larger market share than its rival
- If $q \geq 3(t - \beta)$, there is a unique equilibrium where the high-quality firm captures the entire market

strong network effects: $\beta > t$

$$x = \begin{cases} 0 & \text{if } p_B - p_A \leq \beta - t + q \\ \frac{p_B - p_A - \beta + t - q}{2(t - \beta)} & \text{if } t - \beta + q \leq p_B - p_A \leq \beta - t + q \\ 1 & \text{if } p_B - p_A \geq t - \beta + q. \end{cases}$$

- the network effects play a dominant role in driving the equilibrium behavior
- a number of different consumers' expectations about the firms' market shares may become self-fulfilled
- multiple equilibria exist

Refinement of equilibria

- the more restrictive we become as to how the expectations are formed, the smaller the set of equilibria we can obtain
- we impose the restriction on the formation of expectations that expectations move "continuously" when this is possible: small changes of the equilibrium prices lead to small changes in the expectations about the market shares.
- a reasonable restriction if one believes that consumers do not alter their expectations drastically when they observe a small change in some price.
- under strong network effects, by adding this continuity requirement we can only have an equilibrium where one of the firms captures the entire market.

Conclusions

- We consider two scenarios of the (rational) formation of expectations about market shares, depending on the possible commitment of the prices that firms set and find that the results are qualitatively different.
- The market outcomes crucially depend on whether the environment is such that it forces or allows firms to commit to the prices they set or not. In the former case, prices can be used to influence the consumers expectations and tend to be in equilibrium lower than in the latter case.
- It is also crucial if expectations tend to respond in a smooth manner to changes in the announced prices (in which case the market will tend to be dominated by a single firm, possibly the lower quality one) or if they can be drastically manipulated by small price changes (in which case multiple equilibrium exist and the eventual outcome will be harder to predict).

Extensions

- alternative product differentiation structures
- endogenous differentiation (location or quality)
- dynamic competition