Quality uncertainty mitigates product differentiation

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Basic Idea

Common economic theory suggests that competition is higher in markets with more homogeneous products; firms have an incentive to avoid head-on competition by differentiating their products. It’s “maximum differentiation”.

In this paper, the author combines the idea that prices signal product quality with the theory of spatial competition. He found that imperfect information about the (vertical) quality characteristics of goods reduces the firms’ incentives for horizontal product differentiation. The “quality premium” may be high enough to reduce a firm’s incentive to locate far from its rivals.

The equilibrium outcome may be characterized by “minimum differentiation”. This implies that firms tend to choose head-on competition by agglomerating at the same location and provide effectively homogeneous goods.
Model Setup 1

One unit mass of consumers whose locations are uniformly distributed over the market area $A=[0,1]$. The consumers will make at most $\tau > 1$ times of purchases of the same good.

2 firms, $i=1,2$, who choose locations $x_i \in A$. ($x_1 < x_2$)

Firm $i$ chooses the quality $q_i \in \{q_l, q_h\}$, which is the vertical quality characteristic of good. $q_l < q_h$.

Firm’s unit cost is $c(q_i)$, where $c_h = c(q_h) > c(q_i) = 0$.

In summary, the firm’s market decision is described by $(x_i, q_i, p_i)$, which is assumed fixed over the time interval in which consumers make repeat purchases of good.
Model Setup 2

The firms offer experience good, which means when the consumer make his first purchase, he only observes the locations and prices that firms choose but can’t know the quality. He forms inference of quality from the prices of the two firms and decides whether to buy and which to buy. Upon experiencing high quality, he will make his future $\tau - 1$ purchases. Otherwise, he may decide either to switch to other sellers or quit the market.

We define $\gamma = \frac{\tau - 1}{\tau}$, the significance of repeat purchases.

When the consumer buys the good from firm $i$, his utility depends on his location $a \in A$,

$$U(a, p_i, q_i, x_i) \equiv q_i - p_i - t(a - x_i)^2$$

If the consumer don’t buy from the two firms, he receives the net benefit $\bar{u} > 0$. 
**Assumption 1**

\[ q_h - u > 2(c_h + t) \quad ; \quad u > q_l \]

The first part requires that the net surplus from producing high quality is sufficiently high.

The second means a consumer will never purchase low quality. By the second part, we only need to focus on the equilibrium where sellers find choosing high quality optimal.

Then we have

\[ t < \frac{q_h - u}{2} / (2 - c_h) \]
Demand

The consumer at location \( a \), who anticipates the qualities \( q_1 \) and \( q_2 \), will purchase from firm \( i \), if \( a \in A_i(p_1, q_1; p_2, q_2) \), where

\[
A_i(p_1, q_1; p_2, q_2) \equiv \{ a \in A \mid U(a, p_i, q_i, x_i) \geq \max[U(a, p_j, q_j, x_j) \cup] \}
\]

And firm i’s demand, \( D_i(p_1, q_1; p_2, q_2) \) is the measure of the set \( A_i(p_1, q_1; p_2, q_2) \),

\[
D_1 = \frac{p_2 - p_1 + t(x_2^2 - x_1^2)}{2t(x_2 - x_1)}, \quad D_2 = 1 - D_1
\]

Then we can get firm i’s profit

\[
\pi_i(p_i, q_i, q_{ie}; p_j, q_j, q_{je}) =
\]

\[
\begin{cases} 
[p_i - c_h] \tau D_i(p_i, q_{ie}; p_j, q_{je}), & \text{if } q_i = q_h, q_j = q_h \\
p_i D_i(p_i, q_{ie}; p_j, q_{je}), & \text{if } q_i = q_l, q_j = q_h 
\end{cases}
\]
Price-quality equilibrium

We define \((p_1^*, q_1^*, p_2^*, q_2^*)\) as price-quality equilibrium if there exist \((q_{ie}^*(\cdot), q_{2e}^*(\cdot))\) such that for each \(i\),

\[
(p_1^*, q_1^*) \in \text{arg max } \pi_i(p_i, q_i, q_{ie}^*(p_i, p_j));
\]

\[
p_j^*, q_j^*, q_{je}^*(p_i, p_j))
\]

And

\[
q_{ie}^*(p_1^*, p_2^*) = q_i^* = q_h
\]

We can see that this equilibrium forms a Nash equilibrium. The consumer’s beliefs are confirmed in equilibrium.
Lemma 1.

In equilibrium, prices must include a “quality premium” of at least $c_h / \gamma - c_h$. Without the quality premium, the seller would have no incentive to offer high quality.

Assumption 2

$$\pi_i(p_i, q_h, q_{ie}; p_j, q_j, q_{je}(p_i, p_j))$$

$$\pi_i(p_i, q_l, q_{ie}; p_j, q_j, q_{je}(p_i, p_j))$$

for $q_{ie} = q_h$ implies that $q_{ie}(p_i, p_j) = q_h$, $q_{je}(p_i, p_j) = q_{je}(p_i, p_j)$

The firm $i$ is better off by offering high quality rather than low quality in combination with the price. So the consumers respond by anticipating high quality.
Lemma 2

In any price-quality equilibrium, \( q_{ie}^*(p_i, p_j^*) = q_h \) for all \( p_i \) such that \( p_i > c_h / \gamma \) and \( D_i(p_i, q_h; p_j^*, q_h^*) > 0 \).

This means that sufficiently high prices are signals of high quality.
And the location has no effect on the consumer’s belief, the expectation of the quality.

Proposition 1.

For any location pair \((x_1, x_2)\), there exists a unique price-quality equilibrium such that each firm choose high quality
And the firms’ equilibrium prices are given by the solution of

\[
p_1^* = \max \left[ \frac{c_h + p_2^* + t(x_2 - x_1)(x_2 + x_1)}{2}, \frac{c_h}{\gamma} \right]
\]

\[
p_2^* = \max \left[ \frac{c_h + p_1^* + t(x_2 - x_1)(2 - x_2 - x_1)}{2}, \frac{c_h}{\gamma} \right]
\]
Location Equilibrium

A location pair \((x_1^*, x_2^*)\) is a location equilibrium if the firm’s choice of locations constitutes a Nash equilibrium.

\[
\pi_1^*(x_1^*, x_2^*) \geq \pi_1^*(x_1, x_2^*) \\
\text{and} \quad \pi_2^*(x_1^*, x_2^*) \geq \pi_1^*(x_1^*, x_2)
\]

There are two opposing effects of the locations on the profits. First, when one of the sellers moves closer to his competitor’s location, his market share is increased, which increases the profit. Second, when two firms move closer, pricing behavior becomes more competitive, which decreases the profit.

Therefore, we get two different equilibriums as following:
Proposition 3 ("Maximum differentiation")

\[ x_1^* = 0, x_2^* = 1 \] constitutes a location equilibrium iff
\[ \gamma \geq 2c_h / (2c_h + t) \]
and
\[ p^* = c_h + t \]

Proposition 4 ("Minimum differentiation")

\[ x_1^* = x_2^* = 1/2 \] constitute a location equilibrium iff
\[ \gamma \leq 72c_h / (72c_h + 25t) \]
and
\[ p^* = c_h / \gamma \]