Entry and Welfare in Search Markets

Yongmin Chen and Tianle Zhang

May 2013
Introduction

- Extensive economic literature on markets with consumer search. (e.g., Stigler, 1961; Stahl, 1989; Wolinsky, 1986).

- Virtually all these studies take the number of sellers in the market as exogenously given.

- New technologies and new market institutions such as the Internet can substantially reduce entry costs and increase the number of sellers.

- This paper: how does entry affect the performance of search markets?
There are also extensive studies on the effects of entry.

What makes entry in search markets potentially different?

Consumers need to incur search costs to find out whether a seller’s product matches their needs, the value of the product, and/or its price.

More active sellers will increase the options available to a consumer.

But they can also reduce search efficiency if the marginal entrant lowers the expected product quality in the market.

Entry can thus affect price and welfare by affecting both the scope and efficiency of consumer search.
Introduction

Main Findings:

- When sellers are vertically (and horizontally) differentiated ex ante, consumer welfare is an inverted-U function of the expected number of entrants, or equivalently, of entry cost.
  - In the existing literature, entry generally *increases* consumer welfare, with ambiguous effects on total welfare (consumer gain vs. business stealing)
- When a consumer’s matched sellers are also horizontally differentiated ex post, market price is *lower* when the expected quality of sellers is *higher*.
  - Usual intuition suggests that price is *higher* with higher product quality.
The Model

- Unit mass of consumers, each demanding one unit of a product.
- $n$ potential entrants can choose to become active sellers, and the entry cost for each seller is $c > 0$. No production cost.
- With probability $\beta_i$, potential entrant $i$’s product matches a consumer’s need. $\beta_i$ follows distribution function $G$.
- A consumer derives utility $u$ from a matched product. $u$ is an independent draw from distribution $F$. Zero utility if no match.
  - following several recent papers on consumer search (e.g., Athey and Ellison, 2011; Chen and He, 2011; Eliaz and Spiegler, 2011).
  - one interpretation: sellers may carry multiple brands, and a seller that offers more brands will have a higher $\beta_i$.
- Firms differ both vertically and horizontally. Higher $\beta_i$ means higher quality.
  - if all $\beta_i$ were ex ante identical, only horizontal differentiation.
Timing of the model:

- First, $\beta_i$ of each potential entrant $i$ is realized and is known privately by $i$.
- Second, each potential entrant decides whether to enter the market, based on her $\beta_i$. Entry decisions are made simultaneously.
- Third, the market structure is determined, with $k \geq 0$ (active) sellers. Focus on situations where $k \geq 1$.
- Fourth, (active) sellers simultaneously and independently set prices.
- Fifth, each consumer can choose sequential search to discover whether any particular seller offers a matched product, her $u$, and the seller’s price.
- Each search costs $s$. At least one search is needed for purchase.
The Model

- Assume that \( G \) and \( F \) satisfy the monotonic hazard-rate condition:

\[
\frac{d}{d\beta} \left( \frac{g(\beta)}{1-G(\beta)} \right) \geq 0; \quad \frac{d}{du} \left( \frac{f(u)}{1-F(u)} \right) \geq 0.
\]

(1)

- Let

\[
p^o = \arg \max_p \{ p \cdot [1 - F(p)] \}; \quad \pi^o = p^o \cdot [1 - F(p^o)].
\]

(2)

- We consider symmetric perfect Bayesian equilibrium of this game.

- For a given entry cost \( c \), there will be a unique threshold match probability \( t \), such that \( i \) will enter iff her \( \beta_i \geq t \).

- We then consider the effects of changes in \( t \), as well as the underlying exogenous parameters, \( c \) and \( n \).
Market Equilibrium

- Given $t$, the expected match probability (quality) of an active seller is

$$\gamma \equiv \gamma(t) = \frac{\int_t^1 xg(x) \, dx}{1 - G(t)},$$

(3)

where $\gamma > t$ for all $t \in [0, 1)$ since $\int_t^1 xg(x) \, dx > t [1 - G(t)]$.

- From standard argument, equilibrium price will be $p^o$, independent of the number of the sellers, $k$, and consumers will search if

$$\gamma \int_{p^o}^1 (u - p^o) f(u) \, du - s \geq 0.$$  

(4)

- Assume $s$ is small enough to ensure a search equilibrium.
Market Equilibrium

- In equilibrium, seller $i$'s expected profit is
  \[
  \pi_k (\beta_i) = \beta_i p^o \left[1 - F (p^o)\right] \phi_k, \tag{5}
  \]
  where
  \[
  \phi_k = \frac{1 - (1 - \gamma)^k}{k \gamma}
  \]
  is the number of consumers who come to seller $i$ for the first time (after sampling $j \in \{0, 1, \ldots, k - 1\}$ other sellers).

- A seller’s expected profit is increasing in $\beta_i$. Thus, given $c$, only sellers with $\beta_i \geq t$ will become active.
Market Equilibrium

- To determine $t$, we consider the decision of seller $i$ with $\beta_i$. The post-entry expected profit for seller $i$ is

$$
E(\pi|\beta_i) = \sum_{k=1}^{n} \delta_k(t) \pi_k(\beta_i),
$$

where

$$
\delta_k(t) = \binom{n-1}{k-1} [1 - G(t)]^{k-1} G(t)^{n-k}
$$

is the probability that $k - 1$ other sellers are active.

- $\pi_k(\beta_i)$ is the expected profit for seller $i$ if she chooses entry simultaneously as $k - 1$ other sellers do.

- An increase in the marginal entrant’s quality ($t$) will raise the average quality of all entrants ($\gamma$), but the increase in $t$ exceeds that in $\gamma$. 

Market Equilibrium

- The expected profit for the marginal entrant is higher if it has a higher match probability. Therefore, \( E(\pi|t) \) is increasing in \( t \).

- For \( c \in (0, \pi^o) \), there exists a threshold \( t \equiv t(c) \in [0, 1) \) that satisfies
  \[
  E(\pi|t(c)) = c. \tag{7}
  \]

\( t(c) \) increases in \( c \), with \( t(0) = 0 \) and \( t(\pi^o) = 1 \).

Proposition

For any given \( c \in (0, \pi^o) \), there exists a unique symmetric equilibrium where: (i) potential seller \( i \) will enter the market if and only if \( \beta_i \geq t(c) \), where \( t(c) \) is an increasing function, and each (active) seller will charge price \( p^o \); (ii) consumers will search sequentially and purchase from the first matched seller, provided that \( u \geq p^o \).
The study of entry effects typically considers how the number of entrants affects conduct and performance.

In our model, the number of entrants is uncertain, depending on the number of potential entrants \( n \), the realizations of \( \beta_i \), and entry cost \( c \).

For our model, a proper measure of entry is the expected number of entrants, determined by the match probability of the marginal entrant, \( t \).

Given \( t \), the expected number of active sellers is \( n \left[ 1 - G(t) \right] \). Hence a lower \( t \) corresponds to a higher expected number of active sellers in the market.

Furthermore, since \( t \) is an increasing function of \( c \), the effects of \( t \) also correspond to the effects of entry cost.
For a given $t$, consumer welfare can be written as

$$V = [1 - M(t)^n] \left( \Phi - \frac{s}{\gamma} \right),$$

(8)

where

$$\Phi = \int_{p^o}^{1} (u - p^o) f(u) \, du; \quad M(t) = 1 - \gamma [1 - G(t)].$$

(9)

- The probability that a match will occur for the consumer is $1 - M(t)^n$.
- Since $\Phi$ is the expected surplus to a consumer from a matched seller and $s/\gamma$ is the search cost adjusted by the expected match probability, $\Phi - \frac{s}{\gamma}$ reflects the expected net benefit from a search.
- Consumer welfare is the expected net benefit from the entry of firms.
Effects of Entry: Consumer Welfare Decomposition

**Proposition**

*Consumer welfare is an inverted-U function of $t$, first monotonically increasing and then monotonically decreasing.*

\[
\frac{dV}{dt} = -nM(t)^{n-1} (\gamma\Phi - s) g(t)
\]

\[
+ \frac{1}{\gamma} \left[ \frac{1 - M(t)^n}{\gamma} s + nM(t)^{n-1} (\gamma\Phi - s) (1 - G(t)) \right] \frac{d\gamma}{dt}.
\]

- **Positive variety effect**: a lower $t$ leads to a larger expected number of entrants, increasing search opportunities.

- **Negative quality effect**: a decrease in $t$ reduces the average match probability of sellers in the market, lowering consumer search efficiency.
Effects of Entry: Consumer Welfare

- As $t$ decreases (as entry cost decreases), more sellers choose to be active, but the marginal entrant has a lower quality (match probability).

- Holding other things constant, an increase in the number of sellers is beneficial to consumers (the variety effect).

- However, the addition of low-quality sellers reduces the average quality, which harms consumers due to reduced search efficiency (the quality effect).

- When $t$ is high, the marginal entrant has a relatively high quality, so the variety effect from a decrease in $t$ dominates.

- When $t$ is low, the quality of marginal entrants is low, and the benefit from more search opportunities also diminishes. Thus the quality effect dominates.
Effects of Entry: Total Welfare

Total welfare can be written as

\[ W = [1 - M(t)^n] \left[ \left( \Phi - \frac{s}{\gamma} \right) + \left( 1 - \frac{t}{\gamma} \right) p^o \left[ 1 - F(p^o) \right] \right]. \]

**Proposition**

(i) Industry profit decreases in t. (ii) Total welfare decreases in t when s is sufficiently small or t is sufficiently high.

- An increase in the expected number of sellers raises industry profit.
  - higher probability of sales without lowering price.
  - This benefit outweighs the increase in total entry cost.

- When t is large, more entry (lower t) raises consumer welfare, so total welfare is higher.

- For small t, since lower t reduces consumer welfare, total welfare may be lower with more entry.
Example

Suppose that \( n = 3 \), \( s = 0.05 \), and both \( \beta_i \) and \( u \) are uniformly distributed on \([0, 1]\).

solid curve- \( V \); dash curve- \( \Pi \); dot curve- \( W \).
Welfare Effects of Entry

Effects of Entry Cost ($c$):

Corollary

For $c \in (0, \pi^0)$: (i) consumer welfare is an inverted-U function of $c$, first increasing and then decreasing. (ii) total welfare decreases in $c$ when $c$ is sufficiently large.

Effects of the Number of Potential Entrants:

- Consumer welfare $V$ depends on both $t$ and $n$.
- $n$ affects $V$ both directly and indirectly via $t$ — holding $t$ constant, $V$ increases in $n$, but changes in $n$ also affect $t$, which in turn affects $V$.
- In examples, when $n$ is relatively small ($n \leq 10$), as $n$ increases, both $t$ and $V$ increase; but $\Pi$ and $W$ first increase and then decrease.
Welfare Effects of Entry

Example

Suppose that $s = 0.05$, $c = 0.03$, and $\beta_i$ and $u$ are uniformly distributed on $[0, 1]$. Figure 2 shows the impact of $n$ on $t$ and welfare.

$t$ changes in $n$

solid curve-$V$; dash curve-$\Pi$; dot curve-$W$. 
The direct effect of more potential entrants is to benefit consumers.

Indirectly, an increase in $n$ leads to more potential competition, which decreases the expected profit of entry.

Hence, $t$ increases, which leads to a higher $V$ when $t$ is relatively small.

When $n$ is relatively small, $t$ is also small, so $V$ tends to increase in $n$.

But $\Pi$ and $W$ first increase and then decrease in $n$.

- an increase in $n$ has a direct positive impact on industry profit, and hence also on total welfare.
- This effect dominates the rise in aggregate entry cost and the possible fall in consumer welfare when $n$ is relatively small.

Contrasting the effects of entry cost $c$: $\Pi$ and $W$ monotonically decrease in $c$. 
We also consider an alternative setting where a consumer has heterogeneous values for products that match her needs.

There is product differentiation among matched sellers. Everything else is the same as in the main model.

Following Wolinsky (1986), a consumer’s value for a matched seller $i$’s product, $u_i$, is independently drawn from distribution $F$.

A key difference in the alternative framework is that entry will now also affect market price.

This alternative model serves two purposes:

- reveal the relationship between product quality and price in search markets;
- show that the inverted-U relationship between consumer welfare and entry holds beyond the main model.
Alternative Model: Differentiated Matched Sellers

Equilibrium in the Alternative Model:

- Suppose that the market has \( k \leq n \) active sellers.
- Consumers’ optimal search strategy is to sample sellers sequentially, with reservation value \( a(\gamma) \) that satisfies

\[
\gamma \int_{a}^{\bar{u}} (u_i - a) f(u_i) \, du_i = s. \tag{11}
\]

- The market is active only when sellers are expected to charge \( p_k \leq a \).
- A consumer stops searching when she finds a product with \( u_i \geq a \); if no such product is found, she buys the product with the highest \( u_i \geq p_k \), and she buys nothing if \( u_i < p_k \) for all matched sellers.
- If only one seller is active \( (k = 1) \), then he optimally charges \( p_1 = p^o \). So suppose that \( k \geq 2 \) sellers are active.
Equilibrium price $p_k$ is given by

$$p_k = \frac{[1 - F(a)] \varphi_k + \int_{p_k}^a [1 - \gamma + \gamma F(u_i)]^{k-1} f(u_i) \, du_i}{f(a) \varphi_k - \int_{p_k}^a [1 - \gamma + \gamma F(u_i)]^{k-1} f'(u_i) \, du_i},$$

where

$$\varphi_k = \frac{1 - [1 - \gamma + \gamma F(a)]^k}{k \gamma [1 - F(a)]}$$

is the number of consumers who come to seller $i$ for the first time.

For a given entry cost, there exists an equilibrium analogous to the one in the main model. For any $c \in (0, \pi^0)$:

(i) Only sellers with $\beta_i \geq t \equiv t(c)$ are active, each of whom charges $p_k$ defined as in (12) if $k$ sellers are active;

(ii) Consumers will search sequentially with reservation value $a$ satisfying (11).
Proposition

In the alternative model: (i) given $k$ active sellers, an increase in $\gamma$ leads to a decrease in $p_k$; (ii) given $\gamma$, an increase in $k$ leads to a decrease in $p_k$.

- An increase in the expected quality of sellers increases consumers’ incentive to search.
- Consequently, consumers raise their reservation (net) value ($v - p$).
- This increased search intensity motivates firms to lower prices.
In our main model, consumer welfare is an inverted-U function of entry cost.

In the alternative model, changes in entry cost affect consumer welfare also through the price effect, in addition to the variety and quality effects.

Numerical examples indicate that the inverted-U relationship between consumer welfare and entry cost still holds for the parameter values we have considered.
In search markets, entry expands consumer search choices, but it can also reduce search efficiency.

In a model with both vertical and horizontal differentiation, consumer welfare has an inverted-U relationship with entry cost.

Higher average product quality in a search market can benefit consumers by lowering prices through increasing search incentives.

A policy application: consumer privacy protection.

The entry cost under some medium level of privacy protection could be most beneficial to consumers.