Learning, entry and competition with uncertain common entry costs

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Learning in market entry games

Penguin effect

Me-too

Wait-and-see

Learning in market entry games

- Entry into new market
  - Market research to learn about demand and investigation of production and distribution alternatives.
- R&D race
  - Often firms build small prototype, run small-scale experiments before investing in large-scale project.
- At times, after observing entry by one rival, others follow suit within a short timeframe. At times, they don't.
- Often, firms introduce new products at predetermined dates (trade fairs, but also firm-specific dates). Why?
- **Interplay between learning and entry timing.**
  - *How much time to spend on learning about one's entry cost before deciding whether and when to enter?*

Learning in market entry games

- When Mark Zuckerberg and Eduardo Saverin first launched Facebook, it was very early in the innovation cycle. They
  - neither knew exactly what the product was supposed to be,
  - nor what the cost of entry into the market for online social networks would be.
- Zuckerberg did know that there was a competing team and decided to pre-empt their entry.
- No competing entry for a long time.
- Google entered the market with Google+ only after long experimentation and learning (with Buzz, the Smartphone OS Android, about privacy issues Facebook faced, ...).

Learning in market entry games

- When Apple launched the iPhone, it was relatively late in the innovation cycle.
  - They had experimented with handwriting recognition technology and PDAs (Newton);
  - They had experimented with MP3 players (iPod);

  $\rightarrow$ They knew a lot and their competitors (kind of) knew they knew.
- Competitors in the smartphone market, e.g., Samsung et al., almost immediately copied Apple's entry into the market with me-too products.

Learning in market entry games

- In many industries, firms introduce new products only at specific, pre-determined dates, e.g., trade fairs.
- At times, they don't introduce the product at these dates and wait for the next one.
- E.g., Phones at MWC Barcelona, IFA Berlin.

Learning in market entry games

- Model market entry game with learning between two firms;
  - initially, firms do not know the cost of entry; can experiment (wait) and learn the cost before deciding to enter or they can enter without learning the cost first;
  - firms face optimal timing problem: have to decide when to enter;
  - **Previously**: have looked at private value version of that problem with private and public learning (Bloch, Fabrizi & Lippert, ET 2014);
  - **Here**: *model common values version of that problem and study private learning*.

Insights

- There are many equilibria, including those with strategic entry delay by firms who learned good news to manipulate their competitor's beliefs.
  - Informed firm would delay entry until t at which uninformed firms enter with sufficiently high probability if that causes the opponent to believe that entry was by uninformed firm and following suit is unprofitable.
  - **Necessary**: Entry before having learned the entry cost. Part of equilibrium strategy if sufficiently early, firms sufficiently impatient, learning not too fast.
- **Four possible inefficiencies**: (1) excess momentum, (2) entry cost duplication, (3) rent dissipation, (4) excess delay.
- **Less excess momentum than if costs are uncorrelated**:
  - there is always a waiting equilibrium, which does not always exist for the private values case; and,
  - the preemption equilibrium exists for a smaller parameter range than in the private values case.

Related literature

- **Patent race literature** (Loury 79, Reiganum 82, Harris & Vickers 85; with private information: Spatt & Sterbenz 85, Choi 91).
- **Technology adoption and innovation timing with preemption or waiting** (Fudenberg & Tirole 85, Katz & Shapiro 87; Weeds 02, Mason & Weeds 10).
- **Information revelation and strategic delay** (Chamley & Gale 94, Décamps & Mariotti 04, Lambrecht & Perraudin 03). Add post-entry competition.
- **Preemption games with private information** (Hopenhayn & Squintani 11, Bloch, Fabrizi & Lippert 14). *Modify our framework to account for perfectly correlated entry cost.*

The model: main parameters

- Two firms in entry game;
- Fixed entry cost of each firm denoted θ;
  - Initially unknown by the firms;
  - Takes one of two different values, $\theta = \underline{\theta}$ and $\theta = \overline{\theta}$, with equal probability; expected value: $\widetilde{\theta} = \frac{\underline{\theta}+\overline{\theta}}{2}$;
  - perfectly positively correlated across firms (common values model).

Experimentation

- Discrete time with periods $t = 0, 1, 2, \ldots, \infty$; length of period Δ;
- In every period, each firm receives costless signal about the cost;
- With probability $\lambda\Delta$, signal says $\underline{\theta}$ or $\overline{\theta}$, with probability $1 - \lambda\Delta$, it says $\widetilde{\theta}$;
- The signals are *private* information (private learning).
- Timing 'within periods': (i) Entry decision (ii) Result from experimentation.

Market

- In any period $t = 0, 1, 2, \ldots$, a firm can choose to make an irreversible, publicly observable investment to enter the market;
- Entry involves the immediate payment of fixed cost θ, it allows to receive product market profits (gross of the entry costs), Δv_m per period if monopoly and Δv_d per period if oligopoly;
- Take $r > 0$ to denote the firms' common rate of time preference, defining $\delta = e^{-r\Delta}$ as their common discount factor.
- We can thus define formally the discounted sum of monopoly and duopoly profits, respectively, as: $\pi_m = \frac{\Delta v_m}{1-e^{-r\Delta}}$ and $\pi_d = \frac{\Delta v_d}{1-e^{-r\Delta}}$;

Assumptions on the main parameters

Assumption

$$\underline{\theta} \leq \pi_d \leq \widetilde{\theta} \leq \pi_m \leq \overline{\theta}.$$

→ With low cost, firms have an incentive to enter, even if they compete;

→ With high cost, firms do not have an incentive to enter, even if they were a monopoly;

→ Firms that do not know the cost have an incentive to enter if they were a monopoly but not if they were a duopoly in the market.

Assumption

$$v_m > 2v_d$$

→ It is never jointly optimal for both firms to enter.

Cooperative Benchmark

- In the cooperative benchmark, firms experiment if and only if $\pi_m - V_{EC} < \widetilde{\theta}$ and they enter without experimentation otherwise.
  - **By assumption**: Select one project, either before or after learning. Learn from two projects in parallel.
  - Payoff from entry without learning: $\pi_m - \widetilde{\theta}$.
  - Payoff from waiting and learning:

$$V_{EC} = \sum_{t=1}^{\infty} (1 - \lambda\Delta)^{2(t-1)} \delta^t \left[(1 - \lambda\Delta)\lambda\Delta + \frac{(\lambda\Delta)^2}{2} \right] [\pi_m - \underline{\theta}]$$

or, for $\Delta \to 0$,

$$V_{EC} = \frac{\lambda}{2\lambda + r} (\pi_m - \underline{\theta}).$$

Strategies

- Firms that learned the entry cost is high never enter;
- Relevant choices are those to be made by firms that do not know the entry cost and by firms that learned the entry cost is low;
- Strategies specify after every possible history a probability with which firm enters when it does not know its cost and when it knows the entry cost is low.

Entry timing

- **Entry costs perfectly correlated** $\rightarrow$ decision to enter may carry information;
- Uninformed firms enter purely because they observe the other firm has entered;
- Firms may want to avoid "me-too" entry by manipulating their rival's beliefs.

Plan

- Will look at
  1. Waiting equilibrium.
  2. Preemption equilibria in which firms with good news enter without delay.
  3. Preemption equilibria in which firms with good news delay their entry strategically.

Waiting equilibrium

Waiting equilibrium

Proposition

There always exists an equilibrium where firms only invest after they learn that the cost is low.

- **Strategies** and **beliefs**:
  - Firms observing entry at t believe $\underline{\theta}$;
  - $\widetilde{\theta}$ firms enter with probability 1 if they observe entry by the other firm and with probability 0 otherwise;
  - $\underline{\theta}$ firms enter immediately after learning the entry cost.
- For $\widetilde{\theta} < \pi_m - V_{EC}$, there is excess delay.
- If we rule out the (consistent, but implausible) belief that a firm at date zero enters if and only if it knows $\underline{\theta}$, then the waiting equilibrium exists if and only if $V_L - \widetilde{\theta} < V_E$.

Preemption equilibria in which firms with good news enter without delay.

Preemption equilibrium without delay by $\underline{\theta}$ firms

- Consider entry by $\widetilde{\theta}$ firms at one date t without delay by $\underline{\theta}$ firms.

Lemma

There is no equilibrium, in which $\widetilde{\theta}$ firms enter with positive probability at one date $t > 0$ and all $\underline{\theta}$ firms enter immediately following their learning of the entry cost.

- Entry by $\widetilde{\theta}$ firms is only viable if it is NOT met by "me-too" entry.
- However, if entry by $\widetilde{\theta}$ firms is not met with "me-too" entry, there will be firms that learn $\underline{\theta}$ sufficiently close to date t that will delay their entry to avoid entry by their rival.
- The only date at which there is no such delay is $t = 0$.

Preemption equilibrium without delay by $\underline{\theta}$ firms

- Assume a first firm has invested. If the second firm (the follower) only follows suit if it learns that its cost is low, then its expected value is given by

$$V_F = \frac{\delta\lambda\Delta[\pi_d - \underline{\theta}]}{2(1-\delta(1-\lambda\Delta))}.$$

- If the second firm (the follower) only follows suit if it learns that its cost is low, then gross of the fixed cost, a leader firm that does not know its cost has an expected payoff of

$$V_L = \pi_m - \frac{\delta\lambda\Delta[\pi_m - \pi_d]}{2(1-\delta(1-\lambda\Delta))},$$

- If no firm has entered and the first firm to learn that the entry cost is low invests and is immediately followed by "me-too" entry of the other firm, the expected profit of each firm is

$$V_E = \sum_{t=1}^{\infty}(1-\lambda\Delta)^{2(t-1)}\delta^t \left[(1-\lambda\Delta)\frac{\lambda\Delta}{2}[\Delta v_m + \delta\pi_d - \underline{\theta}]\right.$$
$$\left. +(1-\lambda\Delta)\frac{\lambda\Delta}{2}\delta[\pi_d - \underline{\theta}] + \frac{(\lambda\Delta)^2}{2}[\pi_d - \underline{\theta}]\right]$$

Preemption equilibrium without delay by $\underline{\theta}$ firms

- For $\Delta \to 0$, these simplify to

$$V_F = \frac{\lambda}{2(\lambda + r)}(\pi_d - \underline{\theta}),$$

$$V_L = \pi_m - \frac{\lambda}{2(\lambda + r)}(\pi_m - \pi_d),$$

and

$$V_E = \frac{\lambda}{2\lambda + r}[\pi_d - \underline{\theta}].$$

Preemption equilibrium without delay by $\underline{\theta}$ firms

Proposition

An equilibrium, in which $\widetilde{\theta}$ firms enter with positive probability at $t = 0$ and all $\underline{\theta}$ firms enter immediately following their learning of the entry cost exists if and only if $V_L - \widetilde{\theta} \geq V_E$.

- **Strategies**
  - Firms that do not know the entry cost ($\widetilde{\theta}$ firms) enter with probability $p_0 \in]0, 1[$ at $t = 0$;
  - $\widetilde{\theta}$ firms enter immediately following entry by their rival at any $t \neq 0$ ("me-too" entry) and with probability 0 otherwise;
  - $\underline{\theta}$ firms enter immediately after learning.
- $V_L - \widetilde{\theta} \geq V_E$: sufficiently impatient firms and sufficiently slow learning.
- $\pi_m - V_{EC} < \widetilde{\theta} \leq V_L - V_E$: excess momentum.
- **Generalizes**: There is an equilibrium for similar conditions ($V_L - \widetilde{\theta} \geq V_E$) in which $\widetilde{\theta}$ firms enter continuously up to some $\widehat{t}$ and firms that learned $\underline{\theta}$ do not delay entry.

Preemption equilibria in which firms with good news delay their entry strategically.

Entry by $\widetilde{\theta}$ firms with delay by $\underline{\theta}$ firms

- Informed firm's entry decision transmits information, inducing a competitor to enter before it has learned the entry cost;

$\rightarrow$ $\underline{\theta}$ firm would have an incentive to avoid such entry if had the opportunity;

- Equilibria with dates at which $\widetilde{\theta}$ firms enter with sufficiently large probability that no uninformed firms that did not enter have an incentive to engage in "me-too" entry when they observe entry at those dates;
- Informed firms wait with their entry until those dates.

Avoiding "me-too" entry with one entry date for $\widetilde{\theta}$ firms

- Consider an equilibrium, in which there is one date $\widetilde{t}$ such that
  - leader $\widetilde{\theta}$ firms enter (only) at date $\widetilde{t}$ with a probability strictly between 0 and 1,
  - firms that learned $\underline{\theta}$ before $\widetilde{t}$ wait until $\widetilde{t}$, firms that learned $\underline{\theta}$ after $\widetilde{t}$ enter immediately
  - $\widetilde{\theta}$ firms do not engage in "me too" entry at $\widetilde{t} + \Delta$, and
  - $\widetilde{\theta}$ firms engage in "me too" entry at $t + \Delta$ if they observe entry at $t \neq \widetilde{t}$.

Avoiding "me-too" entry with one entry date for $\widetilde{\theta}$ firms

Proposition

For sufficiently impatient firms and sufficiently slow learning, there exist equilibria in which $\widetilde{\theta}$ firms invest with positive probability at small $\widetilde{t} > 0$, firms that learned $\underline{\theta}$ before $\widetilde{t}$ invest at $\widetilde{t}$ to conceal their knowledge, and $\widetilde{\theta}$ firms that have not entered at $\widetilde{t}$ do not engage in "me-too" entry.

- **(Relevant) constraints**:
  - $\widetilde{\theta}$ firms that haven't entered at $\widetilde{t}$ must find "me-too" entry unprofitable; holds for any λ and r if $\widetilde{t}$ small and for no λ and r if $\widetilde{t}$ is large;
  - $\widetilde{\theta}$ firms must be indifferent between entering and not entering at $\widetilde{t}$; holds for r sufficiently large (impatient firms), λ sufficiently small, and $\widetilde{t}$ sufficiently small;
  - $\underline{\theta}$ firms must find delaying their entry until $\widetilde{t}$ profitable; holds for any λ and r if $\widetilde{t}$ is sufficiently small.
- There is both excess delay (firms that learn $\underline{\theta}$ should enter immediately) and excess momentum (firms that enter with $\widetilde{\theta} > \pi_m - V_{EC}$ should experiment).

Avoiding "me-too" entry with two entry dates for $\widetilde{\theta}$ firms

- We also show that an equilibrium exists, in which
  - (i) leader $\widetilde{\theta}$ firms enter (only) at $\widetilde{t}_1$ with probability $p_1 \in]0,1[$ and at $\widetilde{t}_2$ with probability $p_2 \in]0,1[$, (ii) firms that learned $\underline{\theta}$ before $\widetilde{t}_1$ enter at $\widetilde{t}_1$ and firms that learn $\underline{\theta}$ between $\widetilde{t}_1$ and $\widetilde{t}_2$ enter at $\widetilde{t}_2$, (iii) $\widetilde{\theta}$ firms do not engage in "me too" entry at $\widetilde{t}_1 + \Delta$ and at $\widetilde{t}_2 + \Delta$, and (iv) $\widetilde{\theta}$ firms engage in "me too" entry at $t + \Delta$ if they observe entry at $t \notin \{\widetilde{t}_1, \widetilde{t}_2\}$.

  for r large, λ small, and $\widetilde{t}_1$ and $\widetilde{t}_2$ small.
- Constraint that $\underline{\theta}$ firms must find delaying their investment profitable is less restrictive than with one entry date.

Summary

- We build a model of market entry with **uncertain common entry costs** and **learning**.
- There are many equilibria, including those with strategic entry delay by firms who learned good news to manipulate their competitor's beliefs.
  - Informed firm would delay entry until t at which uninformed firms enter with sufficiently high probability if that causes the opponent to believe that entry was by uninformed firm and following suit is unprofitable.
  - **Necessary**: Entry before having learned the entry cost. *Part of equilibrium strategy if sufficiently early, firms sufficiently impatient, learning not too fast.*
- **Four possible inefficiencies**: (1) excess momentum, (2) entry cost duplication, (3) rent dissipation, (4) excess delay.
- Less excess momentum than if costs are uncorrelated:
  - there is always a waiting equilibrium; and,
  - the preemption equilibrium exists for a smaller parameter range than in BFL ET2014.