10th CREA-Barcelona Economics Lecture

Market Structure, Property Rights and Innovative Activivity

Michele Boldrin

Washington University in Saint Louis

Barcelona, May 17, 2007

Overview

1. *Appropriation* links market structure to innovative activity

2. Three approaches to appropriation

3. Bertrand competition => monopolistic appropriation

4. Replacing Bertrand with Cournot =>competitive appropriation

5. Competitive Entrepreneurial Equilibrium

6. Open issues.

1.

Appropriation and Innovation

Appropriation => Incentives => Efficiency

Market structure & property rights => degree of appropriation

Question:

Which share of the Social Value created by the innovation ***should*** *(or* ***does****) the creator appropriate?*

2.1

Schumpeter (1942) & Arrow (1962): innovation = public good; large cost of creation, small cost of imitation, very small cost of replication.

Dominant paradigm.

Increasing returns unavoidable => competition cannot work

“New” Growth Theory builds on its premises, introducing dynamic setting and external effects.

Growth is due to monopoly power, as this allows appropriation.

Competition => No innovation.

Tradeoff between “static” and “dynamic” efficiency

2.2

Schumpeter (1911),Plant (1934), Stigler (1956): innovation= private good, capacity constraints binding, sequential entry, costly imitation

Marshallian theory of a competitive industry: competitive entrepreneurs appropriate value through competitive rents

It turns into a dynamic GE model by adding it to a von-Neumann & McKenzie growth model with constant return to scale and endogenous technology

Controversial: I will argue it overcomes logical and empirical limits of the dominant approach, while retaining the key insights.

2.3

Hirshleifer (1971): innovation implies foreknowledge, innovator may appropriate more than social value; threat of outside option allows competitive innovator to appropriate substantial share.

Innovator has informational advantage that allows price manipulation

Monopolistic appropriation obtained via the threat of competition.

Threat of competition is credible because innovator is always allowed to reveal (make public) the content of discovery

Recent revival, Anton and Yao (1994, 2000), Baccara and Razin (2003), Marimon and Quadrini (2006), …

3.

Bertrand without Capacity Constraint

After a discovery copies of new good may be produced by anyone at a common constant marginal cost and <u>without a capacity constraint</u>

Market for copies: <u>Bertrand competition</u>

As soon as a single imitator enters, price is forced to marginal cost and profits to zero – no surplus left over to pay the fixed cost of the creator

Conclude that, *ex ante*, nobody would be willing create

Suppose imitators face small fixed cost of entering the market

Each one knows the moment they enter the market, Bertrand price determination forces the price to drop to marginal cost

Consider the (unique) sub-game perfect equilibrium of this game: innovation without imitation.

Imitators too face the prospect of negative profits – and will be unwilling to enter the market.

The THREAT of competition supports monopolistic appropriation!

Limiting case where fixed cost of entry is zero:

There are two equilibria

(i) usual one: no discovery. If creator steps off equilibrium path he is faced by the immediate entry of imitators

(ii) limit of earlier one as fixed cost goes to zero: creator innovates if monopoly covers the fixed cost – the rivals, being indifferent, choose not to enter

4.

Cournot without Capacity Constraint

single good to be created

linear demand

q the quantity of good – number of copies consumed

margin between price and (constant) marginal cost of making copies for creator and imitators alike $p = 2v(1-q)$

$v > 0$ social value of the discovery

to make discovery innovator pays fixed cost AF, $A \geq 1$

imitators or copiers pay only F to reverse engineer the discovery and enter the market.

Timing:

a. creator decides whether or not to innovate

b. if the creator innovates she produces initial run of q_0

c. before creator's output hits market, imitators – of which potentially there are an unlimited number – choose whether or not to enter, with the representative imitator producing $\bar{q}$ units of output. Number N of imitators determined

d. output is sold in the market

Solving by backward induction

Final stage with N entrants and initial production run q_0

total market output of imitators

$$N\overline{q} = \frac{N}{N+1}(1-q_0) = 1 - q_0 - \sqrt{\frac{F}{2v}}.$$

total industry output

$$q = 1 - \sqrt{\frac{F}{2v}}$$

(if greater than the monopoly output of ½)

If innovator wishes to enter, optimal to preempt imitators by producing the entire market output; innovator profit is

$$\sqrt{2Fv}\left(1-\sqrt{\frac{F}{2v}}\right)-AF$$

Zero profit yields the "marginal innovative firm" v^{π} such that creators with higher values enter, and those with lower values stay out

$$v^{\pi} = (1+A)^2 F / 2$$

Welfare Analysis

After fixed cost of innovating has been sunk socially optimal output is $q^* = 1$ and social surplus is v

In "Cournot-competitive" equilibrium

$$q = \max\left\{\frac{1}{2}, 1 - \sqrt{\frac{F}{2v}}\right\} < 1$$

Fraction of social surplus recovered by the simple Cournot-competitive mechanism approaches one

A monopolist will supply just ½ units of output

Appropriability

Ratio of gross profits versus total social surplus

$$\phi(v) = \frac{\sqrt{2Fv} - F}{v}.$$

$$\phi'(v) < 0$$

Appropriability by innovator decreases as social surplus increases.

Competition is stronger when social surplus is higher.

It is at its lowest for the marginal innovators.

5.

Bertrand with limited capacity

World with standard “ladder structure” over consumption and capital goods

$$U = \int_0^\infty e^{-\rho t} \log\left[\sum_j \lambda^j d_{jt}\right] dt$$

Continuum of homogeneouos agents that are consumers, workers (labor supplied inelastically) and potential entrepreneurs.

In this setting, “Bertrand” implies price taking competition

1. Ladder corresponds to qualities of knowledge (capital) k_j and consumption d_j

2. One unit of labor. Consumption needs labor and capital

3. Knowledge has two uses: more knowledge and consumption

4. More knowledge = increasing own type or creating new type

5. Same type produced at a fixed rate $b > \rho$, <u>widening</u>

6. New type $j+1$ needs $a > 1$ units of quality j, <u>deepening</u>

7. Deepening is costlier than widening, $\lambda / a < 1$.

8. Law of motion:

$$\dot{k}_j = b(k_j - d_j) - h_j + \frac{h_{j-1}}{a}.$$

This is an ordinary diminishing return economy, CE is efficient

Production uses at most two adjacent qualities of capital $j, j+1$

Full employment of labor:

$$d_j + d_{j+1} = 1.$$

Consumption grows, when it grows, at a rate $b - \rho$

You innovate only when when $d_{j+1} = 1$

Equilibrium path cycles between widening and deepening

Widening

At the beginning of this phase $d_j = 1$ and $d_{j+1} = 0$.

Consumption during widening is $\lambda^j d_j + \lambda^{j+1} d_{j+1}$

It increases as labor shifts from old to new capital

This continues until $d_j(\tau_1) = 0$ and $d_{j+1}(\tau_1) = 1$

At which point widening ends.

Length of widening

$$\tau_1 = \frac{\log \lambda}{b - \rho}.$$

Deepening

How much capital of new quality should we pile up before starting the new widening phase?

Full employment and optimization implies that consumption is constant for the length of deepening

$$\tau_0 = \frac{\log a - \log \lambda}{b - \rho},$$

Because there is no fixed cost, the same flow of consumption service can be obtained through many innovation processes

Hence there is a continuum of payoff equivalent equilibria.

Focus on the one in which innovation is done at end of deepening by investing F^* all at once.

In this equilibrium it is *as if* there were a fixed cost

Fixed Cost

Assume that there is a technologically determined fixed cost F that gets you $\bar{k} = F/a$ units of new capital.

Once the fixed cost is incurred, it is possible to convert additional units of old capital to new capital at the same rate a.

If j is introduced for the first time at t_j then $j+1$ cannot also be introduced at time t_j.

We are interested in

$F \leq F^*$ *small fixed cost,*

$F > F^*$ *large fixed cost.*

Behavioral economics: who innovates?

Competitive ⇔ no one has monopoly power.

May someone affect prices by innovating?

May he/she take this into account?

When everybody believes nobody can affect equilibrium prices

competitive equilibrium with small innovators

When somebody believes it possible to affect prices

entrepreneurial competitive equilibrium

Small Innovators

A *competitive equilibrium with small innovators* E consists of:

(i) a non-decreasing sequence of times $(t_0, t_1, \ldots, t_j, \ldots)$ at which innovations take place;

(ii) paths $k_j(t)$, $c(t)$, $q_j(t)$, $p(t)$ satisfying

- utility maximization
- profit maximization
- feasibility and boundedness.

.

Theorem 1:

In the economy with a ***small fixed cost****, for given initial conditions, there exists a unique competitive equilibrium with small innovators. This equilibrium is efficient.*

Theorem 2:

In the presence of a ***large fixed cost*** *the competitive equilibrium of the economy without fixed cost is no longer feasible.*

- *There is large number (continuum?) of competitive equilibria*

- *The equilibrium at which innovations occur the earliest, Pareto dominates all other equilibria. It is not first best.*

- *There are also equilibria with* $\Delta k_j = 0 \ for \ j > J^*$

Entrepreneurial Innovators

Fix one competitive equilibrium with small innovators, $\hat{E}$.

A j-*innovation* is a pair $(\tilde{t}, \tilde{k}_j(\tilde{t}))$ composed of the time $\hat{t}_{j-1} < \tilde{t} < \hat{t}_j$ at which *a single agent* purchases $\tilde{F}$ units of capital of quality $j-1$ and turns them into $\tilde{F}/a$ units of capital of quality j.

We say that a j-innovation $(\tilde{t}, \tilde{F})$ is *profitable* with respect to a feasible continuation $\tilde{E}$ if

$\tilde{q}_j(t_j) \geq a\tilde{q}_{j-1}(t_j)$, and

$\tilde{q}_j(t_j) > a\hat{q}_{j-1}(t_j)$.

An *entrepreneurial competitive equilibrium* is defined as a competitive equilibrium with small innovators that

(1) does not admit innovations that are profitable with respect to feasible Markov continuations,

(2) does not stop innovating, that is, $t_j < \infty$ for all j.

Theorem 3:

There exists a unique entrepreneurial competitive equilibrium: it is the earliest competitive equilibrium with small innovators.

6.

Open issues:

a. The need for more empirical work

b. Regulation of Intellectual Property

c. Growth inducing policies

d. Trade Policies