Full Appropriation and Intellectual Property

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Introduction

Ostroy [1980, 1984] and Ostroy and Makowski [1984, 2001]

- focus one idea of marginal contribution of an individual to society
- if everyone is able to fully appropriate their individual contribution to social surplus, perfect competition and efficiency are obtained

  Our answer is that a perfect competitor is a full appropriator: whatever quantities the perfect competitor supplies, the amounts he extracts from the rest of the economy in exchange are such that others are indifferent between trading with the perfect competitor or not trading with him at all. [2001, p. 498]

Innovation

following Ostroy and Makowski

if copyrights and patents enable creators and innovators to appropriate (most of) the surplus created by their ingenuity, it should lead to efficient outcomes

implicit in conventional view of innovation as due to monopoly power based upon intellectual property, for example: Barro and Sala-i-Martin [1999]

> *It would be efficient ex post to make the existing discoveries freely available to all producers, but this practice fails to provide the ex ante incentives for further inventions. A tradeoff arises between restrictions on the use of existing ideas and the rewards to inventive activity.*

Opportunistic Behavior

Ostroy and Makowski [2001, p. 479-480] "game-theoretical considerations"

conventional view is problematic: What happens when competitive actors in the model instead of taking price as given choose what to do in an opportunistic and forward-looking fashion?

> *Portraying the individual as a pricetaker was extremely useful for displaying the new equi-marginal principle underlying individual choice. But it had the unfortunate consequence of suppressing the entrepreneurial side of competition.*

We follow the invitation by Makowski and Ostroy

> *Our image of the perfect competitor is someone who is active and innovative. Rather than dealing with an impersonal market, perfect competitors interact with one another in an environment involving intense rivalry. A perfect competitor will do whatever he can to increase his gain: bargaining vigorously with others for a better deal, innovating new products if he sees a profit to doing so, ...*

The Bertrand Case

after a discovery by innovator copies of new good may be produced by anyone at a common constant marginal cost and without a capacity constraint

market for copies is extremely competitive: there is Bertrand competition so that each agent tries to beat the other one by lowering the asking price so as to capture the whole market

in the market for copies, as soon as a single competitor 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, as Barro and Sala-i-Martin and many other assert, *ex ante* nobody would be willing to pay the fixed cost of creation suppose that competitors copying the innovator's product face some small fixed cost of entering the market

- reverse engineering the new product
- setting up a production line
- building a website to distribute copies

may be considerably smaller than that of the original creator

each potential rival knows the moment they enter the market for new good, Bertrand price determination forces the price to drop to marginal cost

they too face the prospect of zero profits – and will be unwilling to enter the market

so: the original creator should innovate if – with the share of social surplus generated by a monopoly – she can cover her fixed costs even in limiting case where fixed cost of entry is zero there are two equilibria under the assumption that the discovery is made freely available to everyone *ex post*

in the usual one there is no discovery and if creator steps off equilibrium path and innovates faced by the immediate entry of imitators

in the limit of fixed cost goes to zero the creator innovates if a monopoly covers the fixed cost – the rivals, being indifferent, choose not to enter

no need for intellectual property to appropriate the (share of the) social surplus the innovator needs to find motivation for her creative effort.

The Role of Intellectual Property

to what extent is intellectual property useful, or even *necessary*, in appropriating surplus?

move beyond improbable assumption of instantaneous Bertrand competition with unlimited capacity

strictly speaking Makowski-Ostroy full appropriation condition necessary only for marginal discoveries and marginal inventors

“high quality” discoveries – tied to “high quality” innovators – for which the social surplus greatly exceeds the fixed cost of creation require only limited appropriability to guarantee that they are produced

it is “marginal” discoveries – and “marginal” innovators – for which the social surplus only barely exceeds the fixed cost of creation that require a high degree of appropriability to guarantee they are produced

Why More Appropriation for Marginal Innovations?

the “free” market produces more competition over goods for which social surplus is great than over those for which social surplus is small

for given ability to extract a share of social surplus, and given fixed cost of entry, expect more entry – and more competition – over “high quality” discoveries

government guarantees of monopoly treat marginal and high quality discoveries alike – or, since the rich have better access to government favors, favor the high quality over the marginal quality

competition by its nature is more generous to the marginal discoverer

moreover, the marginal discoverer is the one whom, when aiming at social efficiency, we most need to encourage

The Model

single good to be created

demand for that good linear

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.

Cournot Competition

as Kreps and Scheinkman [1983] – firms choose capacity before entering market and competing over prices

Timing:

1. creator decides whether or not to innovate
2. if the creator innovates she produces initial run of q_0
3. 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 $\overline{q}$ units of output
4. output is sold in the market

N imitators creator's profit $2v(1-q_0-N\overline{q})q_0-AF$

imitator producing q_i profit $2v(1-q_0-(N-1)\overline{q}-q_i)q_i-F$.

symmetric subgame perfect equilibrium

- given number of entrants N individual imitators optimally choose the identical output level $\overline{q}$
- given the initial production run by innovator, q_0 and dependence of $\overline{q}$ on N decision of imitators to enter is optimal
- specifically: N chosen so that imitators' profit is non-negative, and so that any larger number of entrants $N' > N$ yields non-positive profits
- allow N to take on non-integer values to simplify computation so that it is the unique number that leads to zero profit for entry
- creator decides to create only if it is possible to earn a non-negative profit, and must choose q_0 optimally, given that the number of imitators and their output will follow the equilibrium response

Solving the Model

Backwards induction

final stage with N entrants and initial production run q_0

representative imitator first order condition

$$\bar{q} = \frac{1}{N+1}(1 - q_0).$$

free entry condition

$$2v\left(\frac{1}{N+1}\right)^2 (1 - q_0)^2 = F$$

solves to give

$$\frac{1}{N+1} = \frac{1}{(1 - q_0)}\sqrt{\frac{F}{2v}}, \quad N = (1 - q_0)\sqrt{\frac{2v}{F}} - 1$$

total market output of imitators

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

Note that $1 - q_0 > \sqrt{F/2v}$ is required to guarantee that there is entry with positive output produced

total industry output addsoutput of innovator

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

provided greater than the monopoly output of ½

otherwise optimal for the creator to bring industry output up to ½ when output is at least ½ unit profit margin in the industry ignoring fixed cost is

$$\sqrt{2vF}.$$

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

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

note: $v\le 2F$ target industry output is below ½, so innovator preempts market by setting $q_0=1/2$, earns profit margin of v and a total profit of $v/2$; since less than or equal to F it is certainly less than AF, so the innovator would not choose to enter in this case

Welfare Analysis

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

in equilibrium

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

so social surplus is less than v, but increasing in v

social surplus at the equilibrium is the integral under demand curve (net of marginal cost) between 0 and $1-\sqrt{F/2v}$, that is

$$\left(1-\sqrt{\frac{F}{2v}}\right)\left(1+\sqrt{\frac{F}{2v}}\right)v =$$
$$\left(1-\frac{F}{2v}\right)v = v-\frac{F}{2}$$

when $v \to \infty$ the innovation always takes place as $v \geq v^{\pi} = (1+A)^2 F/2$

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

a legal monopolist will supply just ½ units of output degree of appropriability: ratio of profits (gross, before fixed costs) versus total social surplus

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

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

if $v > 2F$

necessary for innovation

so appropriability by innovator decreases as social surplus of the innovation increases monopolists profit is $v/2$

marginal monopoly innovating firm $v^m = 2AF$

social surplus generated by monopoly $(3/4)v$

as $v \to \infty$ monopoly does approximately 25% worse than competition

under legal monopoly all innovations better than $2AF$ are implemented

under (Cournot) competition those better than $(1+A)^2 F/2$ implemented

always more innovations under legal monopoly

costly legal monopoly

additional fixed cost of bF required

hiring lawyers to enforce a copyright or patent claim, for example

profits under monopoly exceed those under Cournot competition by $v/2 - \sqrt{2vF} + F$

worth the additional fixed cost if

$$v/2 - \sqrt{2vF} + F - bF \geq 0.$$

The most marginal firm willing to invest in a legal monopoly $v^C = 2F\left(1 + \sqrt{b}\right)^2$.

v^C versus v^π

if $4b > (A-1)^2$ marginal firm in market will not choose monopoly

in this case copyright/patent does not effect which innovations are implemented – it serves merely to enrich the already wealthy.

Uncertain Success

uncertainty about the market value of a given innovation

innovators must pay fixed cost under conditions of uncertainty

imitators can wait to see if an innovation is a success or failure before deciding whether or not to imitate assume information between creators and imitators is symmetric

at the time initial creation decision is made – at the time AF must be committed – social value v is uncertain and is drawn from a commonly known distribution

after innovation takes place, but before imitation and the decision to pay F is undertaken everyone learns true value of v affect appropriation.

v drawn from CDF G

Note: if the innovator creates, whatever the value of v that is drawn (provided it is non-negative) the inventor will always choose to enter

imitator may decide to stay out once uncertainty is resolved

in symmetric Cournot imitation and linear demand inventor only produces if $v \geq v^{\pi} = (1+A)^2 F/2$. *Ex post* after the fixed cost AF has been paid it is a sunk cost, and the inventor should enter as long as $v \geq 0$.

summarize situation by means of a private appropriation function

$$g(v)=\begin{cases} v/2 & v\le 2F \\ \sqrt{2Fv}-F & v\ge 2F \end{cases}.$$

degree of expected appropriability

$$\Phi_G=\frac{\int g(v)dG(v)}{\int vdG(v)}.$$

$\Phi_G v - AF \ge 0$ inventor chooses to innovate

does a G that places greater weight on smaller values of v have greater appropriability? Or equivalently, does Φ is decrease as G shifts to the right

General Appropriation Functions

drop special assumption of Cournot competition and linear demand

$g(v)$ is strictly increasing

$g(v) \leq v$ can't appropriate more than social value

$g(v) \geq 0$

$g(v)$ concave

all satisfied in the linear-Cournot example concavity of $g(v)$ implies non-increasing appropriability without uncertainty

$$\phi(v) = \frac{g(v)}{v}$$

concavity implies $D\phi \leq 0$.

Does this generalize for non-degenerate distributions of social value G?

Conjecture: if H first order stochastically dominates G then $\Phi_H \leq \Phi_G$

False.

two point distribution

innovation success yielding v_1 with probability π

failure yielding v_0 with probability $1 - \pi$

$$\Phi_G = \frac{(1-\pi)g(v_0) + \pi g(v_1)}{(1-\pi)v_0 + \pi v_1}.$$

If $v_0 = 0$: failure results in no profit at all

$$\Phi_G = \frac{g(v_1)}{v_1}.$$

if G shifts to right by increasing probability of success π appropriability does not change

if G shifts to right by increasing the benefit of success v_1, then appropriability falls more generally

$D_\pi \Phi_G \leq 0$

when failure is worth something, increasing probability of success reduces appropriability

for small values of π $D_{v_0}\Phi$ is negative

if, as in linear Cournot model, $g(v)/v \to 0$ as $v \to \infty$ for sufficiently large v_1 and values of π near one, $D_{v_0}\Phi$ positive

Theorem 1: If H is a mean preserving spread of G then $\phi_H \leq \phi_G$.

Proof: Follows directly from the definition

$$\phi = \frac{\int g(v)dG(v)}{\int v dG(v)}$$

Define $\max_G v$ to be the essential maximum – that is the largest value in the support of G.

Theorem 2: Suppose that $E_H v > \max_G v$ and that $g(v)$ is not linear on $[\max_G v, E_H v]$. Then $\Phi_H < \Phi_G$.

Hollywood

two industries notorious much *ex ante* uncertainty: film industry and the pharmaceutical industry

for films have reasonable measure of *ex ante* expected social value and *ex post* social value

industry effectively operates under monopoly not competition

according to model should capture constant fraction of social value independent of how great that social value is

use observed profits as a proxy for social value

if the industry were instead to operate under competition, would appropriability be increasing or decreasing with social value?

measure of *ex ante* social value is the budget (BUDGET) of the film

assume all films with the same budget have the same G

budget is front money provided by investors not social cost of production

represents the expectation of the investors as to the expected return on the film much of the budget goes to rents above opportunity costs for such factors of production as big movie stars and directors,

big stars and great directors command huge rents above their opportunity cost – this component of the budget does not reflect social cost

higher budget films generally do involve higher costs such as more elaborate sets and more expensive locations

comparing salaries of top stars yesteryear when the market – and the rents – were much lower

hard to argue that such great stars as Charles Chaplin or Humphrey Bogart were in some way inferior to current stars

more direct method: examine the budgets of sequels to successful films – hard to argue the social cost of a sequel is greater than the original

Date	Film	Producer	Budget	US Gross	Wrld Grs
6/23/89	Batman	Warner	$35M	$251M	$413M
6/19/92	Batman Returns	Warner	$80M	$162M	$282M
5/25/77	Star Wars	20th C. Fox	$11M	$460M	$797M
5/21/80	Empire Strks Back	20th C. Fox	$23M	$290M0	$534M
7/14/99	Blair Witch Project	Artisan	$.035M	$140M	$248M
10/27/00	Blair Witch 2	Artisan	$15M	$26M	$47M
9/26/86	Crocodile Dundee	Paramount	$5M	$174M	$328M
4/20/01	Croc Dund in LA	Paramount	$25M	$25M	$39M
6/20/75	Jaws	Universal	$12M	$260M	$470M
6/16/78	Jaws 2	Universal	$20M	$102M	$208M
3/21/80	Mad Max	Filmways	$.2M	$8M	$99M
5/21/82	Mad Max 2	Warner	$2M	$24M	Unknown

measure of *ex post* social value is the U.S. box office gross of the film (REVENUE)

does BUDGET predict REVENUE?

OLS regression in millions for 2,204 films we see that

REVENUE = 12.59 + 1.082 * BUDGET ($R^2 = 0.3183$)

(1.488) (.00371)

standard errors are in parenthesis

high intercept term indicates lower budget films have higher rates of return than higher budget films

most likely explanation sample selection bias despite importance of several low budget high revenue outliers

[*Blair Witch Project* had budget of only $35,000 and a U.S. Box Office of $140,539,099]

never-the-less Theorem 2 applies

no film with a budget of less than $1.488 million [The budget of *Snow White*, 213 movies in the sample] ever earned revenues equal to $149,916,667 the average revenue of films with budgets of $142-160 million

high budget films do not simply increase the revenues relative to low budget films, they increase the probability and value of success as well examination of the revenues earned by the top 10% within a budget category

$1.8-2.1 million budget earned average $26.5 million

$10 million budget earned on average $74.6 million

$90-110 million budget earned $327 million.