Perfectly Competitive Innovation

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Conventional Logic of Intellectual Monopoly

- information, ideas are a “public good” means zero marginal cost of distribution ➔ increasing returns to scale
- increasing returns to scale

  fixed cost plus

  constant marginal cost (nothing essential about zero) plus

  marginal cost pricing ➔ ***the firm loses money***
- conclusion: intellectual monopoly is necessary for the production of ideas and creations

Ordinary Economics of Scarcity

- a new drug created by a team of (12) biomedical researcher over a period of time (1 year)
- at the end of the year the knowledge is *embodied in the researchers* (and possibly some of their writing) – no one can produce the drug unless the researchers tell them how to do it
- it is socially valuable to have other people know how to produce the drug
- for example: a second team of 12 expert biomedical researchers could set up a production line in Europe, while the original team sets up production in the U.S.
- transfer of knowledge is not costless – how long would it take them to explain to a group of inexpert economists how to produce the new drug? (huge literature on the problem of technology transfer…no mystery here)

- two methods by which second team can obtain knowledge
- one: reinvent the wheel (1 year of team time)
- two: have the first team teach them (1 month of time for both teams, for example)
- second method minimizes team time (1 yr. 2 months), but production starts after 1 year 1 month
- first method: maximizes team time (2 yrs) but production starts after 1 year
- beginning production one month earlier has social value – this implies that the FIRST team can sell their knowledge into a competitive market and earns a ***positive return*** not zero as in the conventional story

What Went Wrong in the Conventional Story

- Build a shoe-factory, face constant mc of using it: same story; why is this not an issue?
- Shoe factories have a capacity constraint – leads to a positive return
- As we saw, transmission of ideas is similarly limited by scarcity of current set of people and/or products embodying the idea
- In the shoe factory case, capacity is chosen small enough that the competitive rent covers the cost of building the factory
- With ideas there is the problem of *indivisibility*
- Indivisibility has similar implications to fixed cost, but not the same
- In the example: no guarantee that the positive return is sufficient to compensate the research team for its time

- it may be that (say) the team would have to produce ¾ of an idea to be able to recover costs – but this is not feasible because of indivisibility
- on the other hand, the social optimum might be such that saving a month in the start of production has social value exceeding a year of team time – in this case the costs of the first team are necessarily covered by the competitive rent
- an immediate implication – growth reduces need for intellectual monopoly as it reduces the importance of the indivisibility
- so do innovations that reduce the size of the indivisibility, of course

Overview

- ♦ We argue copyrights, downstream licensing and patents play harmful role in the innovation process

So this doesn’t seem completely crazy, a fact:

"During the nineteenth century anyone was free in the United States to reprint a foreign publication, and yet American publishers found it profitable to make arrangements with English authors. Evidence before the 1876-8 Commission shows that English authors sometimes received more from the sale of their books by American publishers, where they had no copyright, than from their royalties in [England]" where they did have copyright.

Arnold Plant [1934] "The Economic Aspects of Copyright in Books," *Economica*, 167-195

Innovation Under Competition

- To understand whether an innovation will take place or not in a competitive environment, we must understand how much the new good/process is worth after it is created
- Focus on the extreme case where every subsequent item produced using the template is a perfect substitute for the template itself - that is, what is socially valuable about the invention is entirely embodied in the product.

$k > 0$ initial units available

$0 < c \leq k$ units allocated to consumption

$(k - c)$ units produce $\beta(k - c)$ copies next period (+ ζc if durable)

representative consumer: $u(c)$ strictly increasing, concave, and bounded below, discount factor $0 \leq \delta < 1$, feasible present value utility is bounded above

Optimization problem characterized by concave value function $v(k)$

$$v(k) = \max_{0 \le c \le k} \{u(c) + \delta v(\beta k - (\beta - \zeta)c)\}$$

Solution of this problem may decentralized as a competitive equilibrium,

price of consumption

$p_t = u'(c_t)$ [note: if ζ near β we hit boundary]

price of the durable good

$$q_t = v'(k_t) = p_t \frac{\beta}{\beta - \zeta}$$

[boundary case, Quah's 24/7 model]

$$q_0 = \sum_{t=0}^{\infty} \delta^t u'((1+\beta)^t)(1+\beta)^t$$

Observations

p_t, q_t decreases at rate $1/\beta$ per period of time

rental rate is p_t

with durability, sale price q_t is higher, possibly much higher

pricing can be easily understood using capital theory

The Problem of Competitive Innovation

- Innovator has $k_0 = 1$ he must sell into a competitive market
- It sells for q_0, which accrues to the fixed factor $k_0 = 1$
- Introducing first unit of the new good, entails some cost $C > 0$
- Innovation produced if and only if $C \leq q_0$

What happens as β increases?

Conventional wisdom suggests that in this case rents fall to zero, and competition must necessarily fail to produce innovations

Conventional wisdom fails for two reasons:

- ♦ it ignores the impact of limited capacity, in all periods
- ♦ it ignores the delay in reproduction

The rent to the fixed factor may INCREASE as β increases.

Notice:

$$\frac{dq_0}{d\beta} = u''(c_0)\frac{dc_0}{d\beta} - u'(c_0)\frac{\zeta}{(\beta - \zeta)^2}$$

Hence:

rent increases with β if initial period consumption falls with β!

Is consumption between time periods substitutes or complements?

$\zeta = 1$ (no depreciation) and CES utility $u(c) = (1/\theta)c^{-\theta}$, $\theta > -1$

Inelastic demand $\theta > 0$; little substitutability between periods $\beta \to \infty$ then $c_0 \to \overline{c} < 1$

Elastic demand $\theta \leq 0$; high elasticity of intertemporal substitution in consumption ($\theta = -1$ linear utility and perfect substitutability)

Utility becomes unbounded above as $\beta \to \delta^{(1/\theta)}$; as this limit is approached $c_0 \to 0$, $p_0 \to \infty$, rents to innovators becomes infinite

(general equilibrium: approaches income of consumers)

Note: the behavior of u' near zero is largely irrelevant; for CES it is unbounded. If we truncate the utility function so total and marginal utility are bounded at zero, that tends to shift consumption from the present to the future, so increases the tendency of increased β to raise revenue [think of the boundary case where $c_t = (1+\beta)^t$]

On the other hand: the behavior of u' near infinity is crucial; for example if u' falls to zero for finite levels of consumption, then eventually for β large enough, initial price must fall to $u'(1)$

Note that reducing the length of time it takes to reproduce a single unit (or changing the discount factor) has an effect similar to reducing $u'(1)$

so we can understand the traditional case as one in which there is satiation; reproduction time is very short, and the reproduction rate is very high

for patents this limit makes exactly no sense whatsoever for copyrights it could be argued that modern technology is increasing β and lowering reproduction time

As it happens

- ♦ this has ambiguous consequences for price q_0
- ♦ the same technological change has unambiguous consequences for the cost C - it is getting smaller
- ♦ and of course as a practical matter, it ignores any collateral uses of the creation that is not subject to reproduction cost reduction – paper books; live performances and so forth

Innovation Chains

Innovations generally build on existing goods, that is on earlier innovations

Consider a situation where each innovation creates the possibility of further innovation

Many different producible qualities of capital, beginning with quality zero capital of quality i denoted k^i, depreciates at rate $1-\zeta$

capital i yields γ^i units of consumption, $\gamma > 1$,

capital i reproduces $\beta > 1$ units of itself

capital i produces $\rho < \beta$ units of capital $i+1$

ρ technology subject to an indivisibility of $\underline{h}$

assume $\rho\gamma > \beta$ and $\delta(\beta - \zeta) > 1$

Convex Production Possibilities

Consider first $\underline{h} = 0$

Because $\rho\gamma > \beta$ the β activity dominated by innovation using ρ technology

Several qualities of capital available at a moment of time (because of depreciation), but irrelevant which one is used to produce consumption because all have the same intertemporal tradeoff

Assumption on preferences: coefficient of relative risk aversion is bounded above.

Then, from

$$u'(c_t) = \delta(\rho\gamma - \zeta)u'(c_{t+1})$$

one gets

$$(c_{t+1} - c_t)/c_t > \Delta > 0$$

and c_t grows without bound

Repeated innovations take place because rents are high enough to provide an incentive for entrepreneurs to undertake innovative activity

Growth with Indivisibility

If the indivisibility is large enough competitive equilibrium in the usual sense may not exist.

But if it is small enough it may not bind at all – and the previous analysis continues to hold

Apply analysis of one-shot model.

What happens to investment in the newest technology over time?

If it declines to zero, then regardless of how small $\underline{h}$ the indivisibility must eventually bind

If it grows or remains constant, then a sufficiently small $\underline{h}$ will not bind

For any finite time horizon, since consumption is growing over time, investment is always positive, so a small enough $\underline{h}$ will not bind over that horizon

What happens asymptotically to investment in the newest quality of capital?

Assume for large enough c the utility function $u(c)$ has approximately the CES form $u(c) = -(1/\theta)c^{-\theta}$, $\theta > -1$.

Explicitly solve the first order condition to find the growth rate of consumption g

$$g = \frac{c_{t+1}}{c_t} = (\delta(\rho\gamma - \zeta))^{1/(1+\theta)}$$

With the indivisibility it is no longer true that when there are several qualities of capital available it does not matter which is used for consumption; the constraint may bind with some plan but not other

Concentrate on the special class of production plans in which depreciated old capital is used only to produce consumption

<u>Necessary and sufficient condition</u> for physical investment to be non-decreasing asymptotically:

$g - \left(\frac{\rho\gamma - g}{\rho\gamma - \zeta}\right)\left(\frac{g - \zeta}{\rho\gamma - \zeta}\right) \geq \gamma$, satisfied if: $g - \zeta / 4 \geq \gamma$

Notice possibility for (complicated) growth cycles when condition is not satisfied.

Does Monopoly Innovate More than Competition?

Complications of modelling dynamic monopoly in the setting of innovation chains: commitment, timing and the number of players matter in a game played between a long-run monopolist and atomistic consumers or innovators

We make the following assumptions

Commodities and activities as before + transferable commodity m

Assume transferable utility: $m + \sum_{t=0}^{\infty} \delta^t u(c_t)$

Utility of monopolist is m

Consumer endowed with a large amount $\bar{m}$ of transferable commodity, while the monopolist is endowed with none

At the beginning of each period, monopolist chooses a particular production plan, price for consumption subsequently determined by consumers' willingness to pay

Beside owning the stock of capital the monopolist has also been awarded full patent protection over the β, ρ, γ activities that use that capital as an input

Leads to a “traditional” model of monopoly: consumers completely passive, unique equilibrium in which precommitment makes no difference

Will consider case in which monopolist does not control the ρ activity later

Show that a monopolist who has complete downstream rights has an incentive to suppress innovation in circumstances where a competitive industry would innovate

Use a simple example of an innovation chain. Point is actually trivial.

For some $\theta_1 < 0, \theta_2 > 0$ period utility function is

$$u(c) = \begin{cases} -(1/\theta_1)c^{-\theta_1} & c \le 1 \\ 2 - (1/\theta_2)c^{-\theta_2} & c > 1 \end{cases}$$

elastic CES below $c = 1$, inelastic CES above

Consider competition:

no indivisibility and no depreciation $\zeta = 1$, initial capital stock $k_0^0 = 1$

competitive growth rate

$$g = (\delta(\rho\gamma - 1))^{1/(1+\theta_2)}$$

investment grows over time provided

$$g - \left(\frac{\rho\gamma - g}{\rho\gamma - 1}\right)\left(\frac{g - 1}{\rho\gamma - 1}\right) \geq \gamma$$

for example $\theta_2 = 0.10$, $\rho = 2.20$, $\gamma = 1.05$, $\delta = 0.98$

Consider the monopolist

utility function is designed so that the global maximum of revenue $u'(c)c$ takes place at $c = 1$

the monopolist starts with a unit of capital that does not depreciate, so can produce a unit of consumption each period

because he can't get more profit than this better than this, this is the optimum for the monopolist, more or less regardless of modelling details for timing and commitment

monopolist chooses not to innovate because any investment to do so would necessarily reduce current period revenues below the maximum, while it cannot increase future revenue.

Similarly, the monopolist will not allow anyone else to innovate.

Call it James Watt who refused for the 31 years of his monopoly to allow innovation in the steam engine

The significance of inventions that build on previous inventions is old to the IP literature: Scotchmer (1991) for example; but has not taken account of the possibility that adequate returns can be generated even without intellectual monopoly

Note significance of durability of the capital good: others, such as Fishman and Rob (2000), have emphasized the role of durability in reducing the incentive of monopolists to innovate

In the presence of an indivisibility (the condition usually thought least conducive to competition), a monopolist may fail to innovate, even with depreciation

Specifically, what is required is that the depreciation rate be small enough that the amount of capital required to invest to replace the depreciated old capital be less than the threshold for producing a single unit of new capital via the ρ technology

This may be the case even if the indivisibility is small enough that it would not bind for the competitive industry

In other words – indivisibility can have worse consequences with intellectual monopoly than with competition

Different incentives to innovate under the two market regimes

Competitive industry has incentive to produce additional output that goes over and above the need for replacing the depreciated goods; as long as the consumer marginal valuation is high enough to cover the cost of production, a competitive industry will increase output as entrepreneurs try to maximize their rents

Competitive pricing leads to continuous attempts to increase the overall size of the capital stock, and is more likely to reach the threshold requirement at which innovation becomes possible

Conclusions

Competition = good

Monopoly = bad