Perfectly Competitive Innovation

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- Compelling logic of fixed cost and perfect competition: fixed cost plus constant marginal cost plus marginal cost pricing means the firm loses money?
- A firm builds a factory, faces constant mc of using it: same story; why is this not an issue in capital theory?
- “Fixed costs”? Generally what is involved is a sunk cost and an indivisibility

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- We argue: innovation is little different than any other investment
- We examine invention and adoption of new goods and techniques of production under perfect competition; argue copyrights, licensing and patents play harmful role in innovation process

Pricing of Ideas

- Economic innovation has two phases
- *FIRST*: R & D or invention step, developing new good or process
- *SECOND*: mass production, making copies of initial prototype
- First stage subject to minimum size requirement: at least one prototype must be manufactured. Note: prototype may be a good (e.g. a CD) or a process (e.g. a chemical plant).

Are Ideas non-Rivalrous?

- Most people argue they are: Our use of the fundamental theorem of calculus cannot prevent innumerable other people from using the same theorem at the same time.
- True, but irrelevant for the economics of innovation
- What is economically relevant is our specific knowledge of the fundamental theorem of calculus
- Only knowledge of ideas embodied in people or machines has economic value – ideas that are not embodied in some good or person are of no economic value
- It is always costly to transmit ideas

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 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

$$p_t = u'(c_t)$$

price of the durable good (for $c < k$)

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

Observations

when $\zeta = 0$ (full depreciation) p_t, q_t decreases at rate $1/\beta$ per period of time

rental rate is p_t; with durability, sale price is higher, possibly much higher – since eliminating downstream licensing eliminates rental market, prices may jump significantly (effect of Napster on CD prices?)

Quah argues that in many cases ζ is close to β

The Problem of Competitive Innovation

- Innovator has $k_0 = 1$ he must sell into a competitive market
- It sells for q_0, accruing 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 $C \leq q_0$

As the Reproduction Rate Increases

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)

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

In competitive equilibrium,

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

Regularity assumption on preferences: coefficient of relative risk

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

so c_t growth 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. Lotteries/contracts (… results to be proved)

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

Necessary and sufficient condition 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.

Entrepreneurship, Profits and Competition

Does this lead to an interesting theory of innovation?

Basic ingredients: fixed factors, indivisibilities, rents and sunk costs

A single entrepreneur contemplating an innovation, anticipates the prices at which he will be able to buy inputs and sell his output, and introduces the innovation if, at those prices, he can command a premium over alternative uses of his endowment

Owns the rights to his innovation, meaning that he expects to be able to collect the present discounted value of downstream marginal benefits

Does Competition Always Work?

We do not argue that competition is the “best” mechanism in all circumstances

Rents to a fixed factor may fall short of the cost of producing new good, even when the total social surplus is positive: indivisibility constraints may bind, invalidating the analysis of the previous sections

We do not yet have an adequate theory of competitive equilibrium when indivisibility constraints bind

- If indivisibility constraints bind in one period, they may not bind in subsequent periods when more of the investment good is acquired
- Taking contingent orders in advance
- Selling tickets to a lottery involving innovation as one outcome
- Treating initial innovation as a public good

Entrepreneurs have adopted exactly such methods for many centuries in markets where indivisibilities have posed a problem

What is the positive and normative theory for these situations?

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

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

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 Bell … (or James Watt)

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

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

Conclusion

Competition = good

many examples of thriving innovation under competition

- produce niche ideas (McDonalds, immigration)
- financial securities
- pornography

Monopoly = bad

examples of thriving innovation under monopoly?

- turning television series and comic books into movies?
- Microsoft = “freedom to innovate”?