Intellectual Property and the Scale of the Market

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What is IP?

- Intellectual property: patents and/or copyrights
- Economically relevant good: copies of ideas
- Provides a time-limited monopoly
- Economic rationale for IP: first copy subject to indivisibility or “fixed cost,” followed by distribution at zero marginal cost
- Goods with fixed cost + constant marginal cost will not be produced under competition. Hence government “should” create time-limited monopoly

Problems with IP

- Not necessary for production of ideas; competitive rents due to short-run capacity constraints, first-mover advantages
- May reduce rather than increase innovation when innovations build on existing innovations (downstream innovation problem)
- Impact on secrecy and other private rent-seeking ambiguous
- Problems of rent-seeking when government gives away monopolies
- High transaction costs involved in controlling copies of ideas

Suppose IP is necessary – how much?

- Gilbert & Shapiro, Gallini – length versus breadth in a one-good world
- Can “breadth” be legislated easily?
- Grossman and Lai – optimal size of protection independent of market size

U.S. law

- Copyright is life of author plus 70 years for individual works, 95 years for works for hire
- Design patents are 20 years
- Ornamentation patents are 14 years

Do these terms make sense?

Optimal IP Length

- Trade off between monopoly distortion on inframarginal ideas versus discouragement/encouragement of marginal ideas
- How does this depend on the scale of the market?
- G7 nations about 2/3rds of world GDP; so WTO can potentially expand market size by 50%, even without income growth
- World real GDP has risen about 80 times during the 20th century
- We argue that IP length should decrease with the size of markets.
- <u>Rule of thumb:</u> roughly in inverse proportion (double the market, halve the length of protection)

The Model

characteristics of ideas $\omega \in \Omega$, topological space

minimum labor $h(\omega) \geq 0$ to produce, create or invent idea with characteristics ω; $h(\omega)$ a continuous function

measure $\eta(\omega)$ the "number" of ideas with characteristics ω in an economy of unit size

Individual ideas are small relative to size of economy

Consider the size of some very, very, very big ideas:

Manhattan Project (1942-1945): $7 billion per year in 1996 $;

GDP in 1944-1945 about $1700 billion per year in 1996 $

Manhattan Project cost approximately 0.4% of GDP

NASA (1962-73) about $15 billion per year in 1994 $; Apollo project about 1/3 of it

1968 GDP, in 2000 $, about $3,700 billion

Moon landings cost approximately 0.15% of GDP

Privately financed ideas

"The Titanic" cost $200 million in 1997

DiMasi et al [1991] estimate average cost of bringing a new drug to market at $231 million 1987 $

Privately financed ideas at most 1/10,000 of US GDP

The Model (continued)

Continuum population of agents of size λ (the scale of the economy)

Total number of ideas with characteristics ω available in an economy of size λ is $\eta(\omega)g(\lambda)$

$g(\lambda)$ is assumed non-decreasing in λ; $g(1) = 1$

Production

Amount of labor input $y(\omega)$ must overcome the indivisibility $h(\omega)$

$x(\omega)$ consumption of a "representative" idea with characteristics ω

$y(\omega) < h(\omega)$ then $x(\omega) = 0$

$y(\omega) \geq h(\omega)$ then $x(\omega) \geq 0$

Per capita consumption is $z(\omega) = x(\omega)/\lambda$.

Consumption

Representative individual has Dixit-Stiglitz utility over goods with different characteristics

Consuming z units of a good with characteristics ω gives utility $v(z,\omega)$

$v(z,\omega) \geq 0$ continuous in ω, non-decreasing, and at least up to a limit z^*, smooth and strictly increasing

$\lim_{z\to\infty} v(z,\omega) = v^C(\omega) < \infty$, $v(0,\omega) = 0$

$zv_z(z,\omega) \to 0$ as $z \to \infty$

(this just means: competitive rents are zero)

$zv_z(z,\omega)$ has a unique maximum at $z^M(\omega)$

Utility ℓ from leisure $0 \leq \ell \leq L$, where L is the individual endowment of time; leisure = all activities that take place outside of the idea sector

Individual Utility

$$g(\lambda)\int v(z(\omega),\omega)\eta(d\omega)+\ell$$

Labor Demand=Labor Supply

$$\lambda(L-\ell)=g(\lambda)\int y(\omega)\eta(d\omega).$$

Where:

either $y(\omega)=h(\omega)$ when the good is produced,

or $y(\omega)=0$ otherwise.

Patent Equilibrium

Hart (1979), Makowski (1980), Acemoglu and Zilibotti (1996)

Fixed length ϕ of patent protection for all ideas.

- a fraction ϕ of total time occurs under monopoly,

- a fraction $(1-\phi)$ of total time occurs under competition

Potentially many individuals can produce or make use of any particular idea.

A particular individual is awarded a “patent” for a particular idea.

When patent expires, output and consumption jump to infinity, price and revenues to zero

A type of good is produced if, given the patent length ϕ, the prospective monopolist finds it profitable to overcome the indivisibility; in this case $h(\omega)$ units of labor.

Market for innovation equilibrated through the wage rate w.

Higher w => fewer ideas produced

When labor demand is strictly less than λL, then wages $w = 1$

Otherwise w chosen to reduce demand for labor to the point where the amount of leisure is 0

Problem of the Monopolist

Consider a monopolist for good with characteristics ω

Sells z units to each of λ consumers at price $v_z(z,\omega)$

Revenues per unit of time $\lambda z(\omega) v_z(z(\omega),\omega)$.

Assume have a unique maximum at $z^M(\omega)$

Cost faced by the monopolist is $wh(\omega)$

$$\rho(\omega) = z^M(\omega) v_z(z^M(\omega),\omega)/h(\omega)$$

Private Value per unit of indivisibility of a good with characteristics ω

Monopolist introduces good if

$$\phi\lambda\rho(\omega)h(\omega) \geq wh(\omega), \text{ or } \rho(\omega) \geq w/\phi\lambda \equiv \underline{\rho}$$

Note: $\underline{\rho}$ strictly decreasing in $\phi\lambda$; “lower quality” ideas introduced.

Per-Capita Social Welfare in the Patent Equilibrium

$$g(\lambda)\int_{\rho(\omega)\geq\underline{\rho}}[\phi v(z^M(\omega),\omega)+(1-\phi)v^C(\omega)-h(\omega)/\lambda]\eta(d\omega)+L$$

Reformulation in terms of ρ

Measure $h(\omega)\eta(\omega)$: quantity of ideas in terms of the labor needed to produce them

Restrict $h(\omega)\eta(\omega)$ to the σ-subalgebra of the Borel sets of Ω on which $\rho(\omega)$ is constant; make the regularity assumption that this measure is represented by a continuous density function $\mu(\rho)$

For any measurable function $f(\omega)$ define "conditional value" $\overline{f}(\rho)$ in much the same way as a conditional expectation is defined, that is $\overline{f}(\rho)$ is defined μ-almost everywhere by the condition that

$$\int_B \overline{f}(\rho)\mu(d\rho) = \int_B f(\omega)\eta(d\omega)$$

for every B in σ-subalgebra of Borel sets of Ω on which $\rho(\omega)$ is constant

Then, define:

$$\nu^M(\omega) \equiv v(z^M(\omega), \omega)/h(\omega)$$
$$\nu^C(\omega) \equiv v^C(\omega)/h(\omega)$$

Use "conditional value" formulation to rewrite per capita social welfare

$$g(\lambda)\int_{\underline{\rho}}^{\infty} [\phi\overline{\nu}^M(\rho) + (1-\phi)\overline{\nu}^C(\rho) - 1/\lambda]\mu(\rho)d\rho + L$$

Further (and final!) simplification

Let

$\sigma(\rho) \equiv \overline{\nu}^M(\rho)/\rho$: ratio of social surplus to private revenue

$\Delta(\rho) \equiv (\overline{\nu}^C(\rho) - \overline{\nu}^M(\rho))/\overline{\nu}^M(\rho)$ distortion introduced by monopoly

Per capital social welfare

$$g(\lambda)\int_{\underline{\rho}}^{\infty} [\phi\rho\sigma(\rho) + (1-\phi)\rho\sigma(\rho)(1+\Delta(\rho)) - 1/\lambda]\mu(\rho)d\rho + L$$

Example: Quadratic utility and linear demand

$$v(\omega, z) = b(\omega)\left(Z(\omega)^2 - [z - Z(\omega)]^2\right) \text{ for } z \leq Z(\omega)$$

$$v(\omega, z) = b(\omega)Z(\omega)^2 \quad \text{for } z > Z(\omega)$$

then

$\sigma(\rho) = 1.5,\ \Delta(\rho) = 0.5$

Assumptions and Definitions

(1) For any $\underline{\rho} > 0$

$$L^D(\underline{\rho}) = g(\lambda)\int_{\underline{\rho}}^{\infty} \mu(\rho)d\rho < \infty,$$

(2) $M(\rho) = \int_{\rho}^{\infty} \mu(\rho')d\rho'$

(3) $\Upsilon(\rho) = -\rho M'(\rho) / M(\rho),$

Assume $\Upsilon(\rho)$ is differentiable

Quality neutrality

Three different measures of quality

1) private value ρ,

2) public value of monopoly output $\overline{\nu}^M(\rho)$,

3) public value of competitive output $\overline{\nu}^C(\rho)$

Quality neutrality: three measures are independent of characteristics

$$\sigma(\rho) = \sigma\,,\ \Delta(\rho) = \Delta$$

$$\overline{\nu}^M(\rho) = \sigma\rho\,, \qquad \overline{\nu}^C(\rho) = (1+\Delta)\sigma\rho$$

Proposition:

Suppose quality is neutral. If, for some $\tilde{\rho}$***,*** $\Upsilon'(\rho) \neq 0$ ***for*** $0 \leq \rho \leq \tilde{\rho}$***, then there exists*** $\tilde{\lambda}$ ***such that*** $\hat{\phi}(\lambda)$ ***is unique and strictly decreasing for*** $\lambda > \tilde{\lambda}$***. If*** $\Upsilon'(1/\lambda\hat{\phi}(\lambda)) > 0$ ***then*** $\hat{\phi}(\lambda)$ ***is unique and non-decreasing.***

Relation between the elasticity of total monopoly revenue with respect to ρ and the fact that the "mass of ideas" declines rapidly or not with quality.

When the elasticity of total monopoly revenue is increasing with ρ, loss of new ideas is more than compensated by inframarginal gains of reduced monopoly distortions

In the other case (elasticity of monopoly revenue declining) then as the scale of the economy grows, the demand for labor grows even more rapidly (more on this later)

Relation with Production Function Approach

Q is quantity of ideas (they are assumed to be all of the same quality)

$Q = f(\ell)$ for production function of ideas

wage is one

$\ell = f^{-1}(Q)$; corresponding marginal cost $1/f'(\ell)$

Then

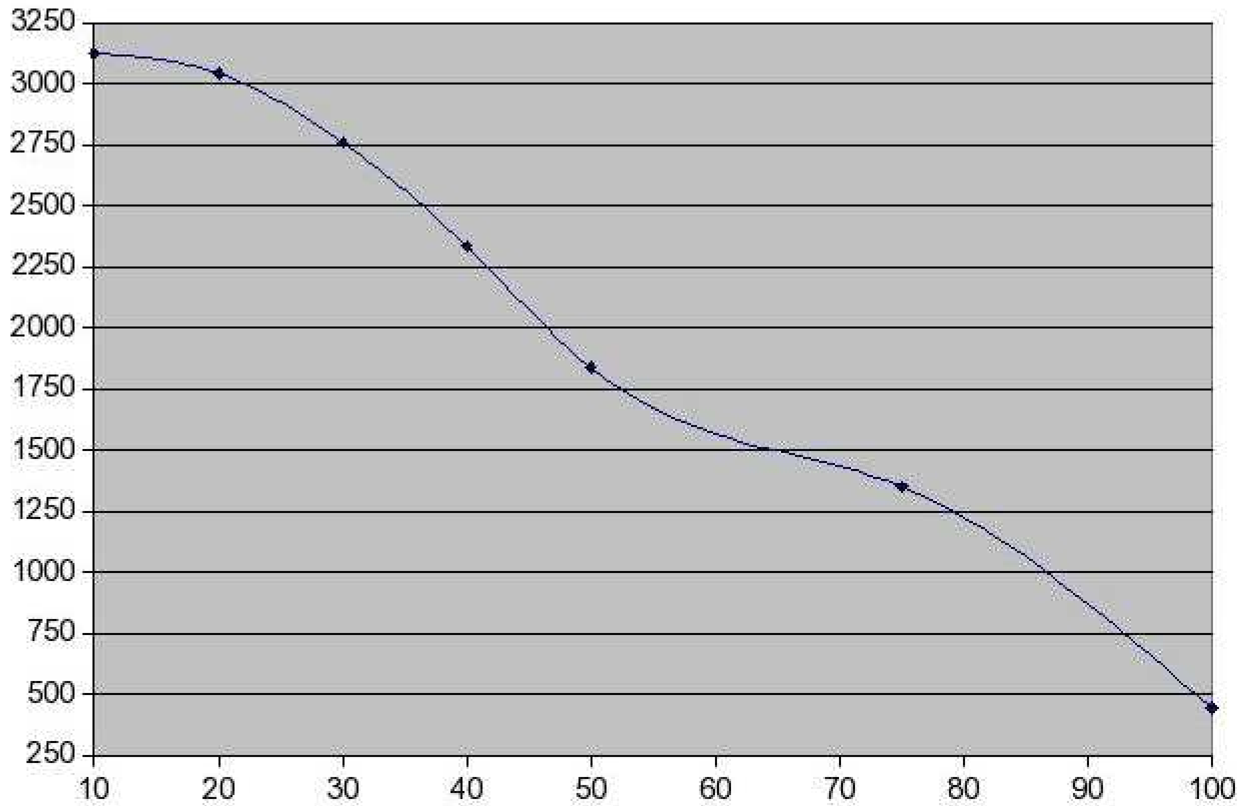
$$M(\rho) = f\left([f']^{-1}(\rho)\right)$$

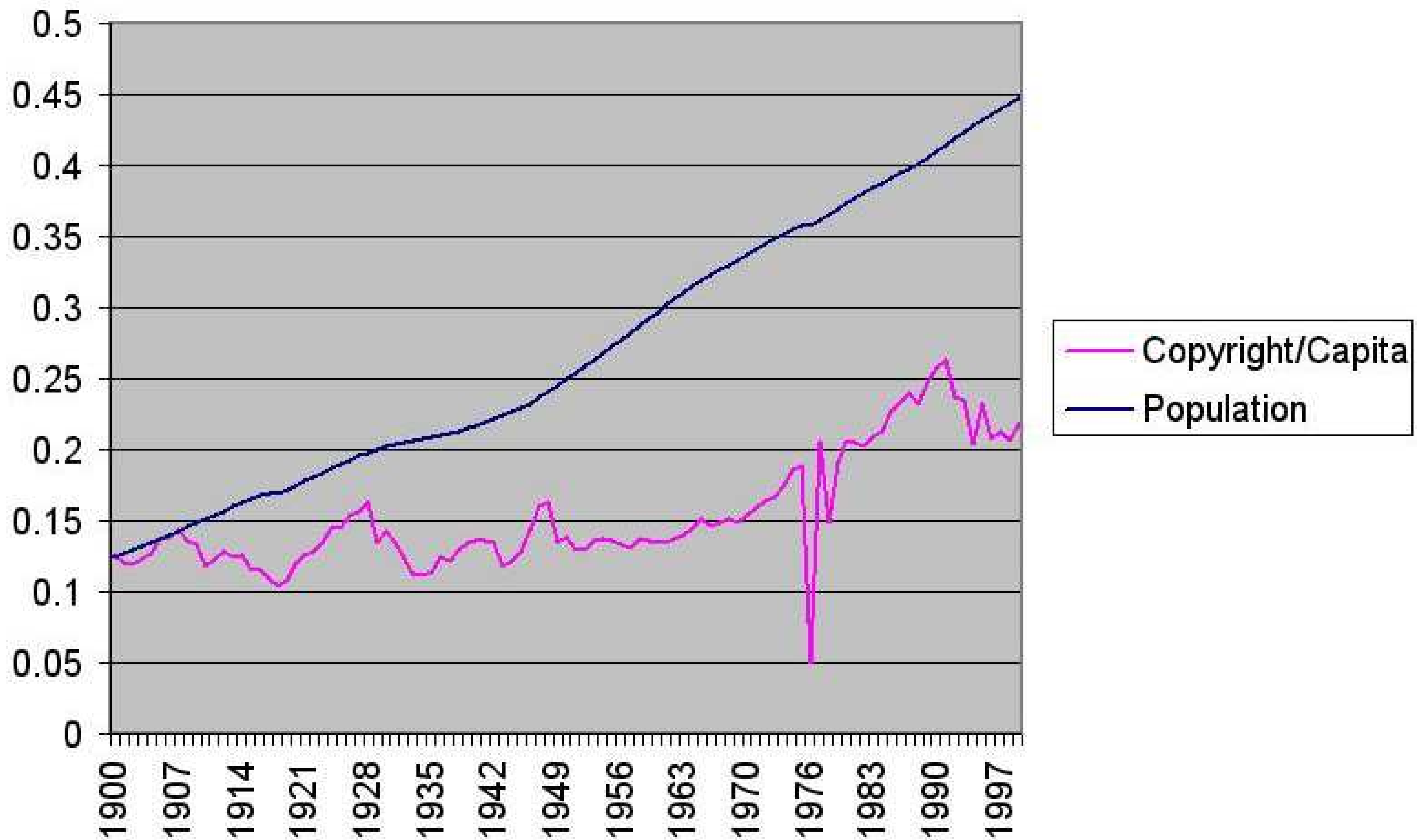
So elasticity of M, Υ is elasticity of research output w.r.t. labor

Cobb-Douglas implies constant elasticity of $M(\rho)$ implies Pareto tail

--also implies if $g(\lambda) = \lambda$ that per capita labor goes up linearly with the scale of the economy

U.S. Income Distribution





0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1900
1907
1914
1921
1928
1935
1942
1949
1956
1963
1970
1976
1983
1990
1997
Copyright/Capita
Population

Digression on labor constraint binding

Interesting practical case is that in which $g(\lambda)/\lambda$ is an increasing function. Number of ideas increases faster than size.

Super-optimal protection can drive up the wage rate for the relevant supply of labor when the labor constraint is binding

Lobbyist groups point to the high cost of producing new goods (movie, music, drugs) as reason for strong copyright protection

Much of the high cost is due to paying a few “stars” large salaries. Social opportunity costs for these stars is often small. The observed current cost is, mostly, monopoly rents.

Reducing IP protection lowers rents earned by these stars, reduces costs of producing ideas of a given quality

Quality Nonneutrality

- Goods with lower private quality have even lower social value $\sigma'(\rho) > 0$ and/or $\Delta'(\rho) > 0$: obviously optimal protection should show even greater decline with scale of market

- $\sigma'(\rho), \Delta'(\rho) < 0$, i.e. private and social values go the opposite direction. In this case optimal protection may increase with the size of the market. But, notice what this means: what's socially valuable is not privately valuable, so huge distortions need to be introduced to create incentive for private production of socially valuable goods. System of awarding private monopolies loses much –might be better to have the government pick winners

Competitive Rents

To obtain competitive rents, just assume that a capacity constraint binds for a while, that is: after patent expires it takes a while to enter and build productive capacity. Let this constraint be $\bar{z}$, which determines the level of the competitive rents.

Simple case: <u>competitive rents proportional to monopoly revenue</u> ρ.

In this case, it is easy to show that

- extent of optimal protection is generally lower
- optimal protection goes to zero at a finite size of the economy.

Optimal patent length is zero in large economies

Harmonization

When countries have the same size, this model explains the harmonization approach: in the unconstrained protection game countries underprotect.

Let θ_i be the share of country i in world market and ϕ_i its level of protection. Effective protection then is

$$\phi = \sum_{i=1}^{K} \phi_i \theta_i$$

Each country max its own welfare

$$g(\lambda)\int_{\underline{\rho}}^{\infty} [\phi_i \rho\sigma(\rho) + (1-\phi_i)\rho\sigma(\rho)(1+\Delta(\rho)) - 1/\lambda]\mu(\rho)d\rho + L_i$$

Note that $\underline{\rho} = 1/\phi\lambda$ is determined at the world level, but national distortion is determined by choice of local protection.

Assume labor constraint is not binding (if it were, protection already too high)

Consider first symmetric equilibrium when countries have same size $\theta = 1/K$, so $\phi_i = \phi^K$. Compare ϕ^K with ϕ^1, from FOC it follows that

$$\phi^K < \phi^1$$

This is suboptimal in our setting, hence in principle harmonization is welfare improving.

Consider the same technology but with two groups of countries of unequal size. A large one (EU+US) and $k-1$ small ones.

For example, assume that $\theta_i = \dfrac{1-\theta_1}{K-1} < \theta_1$

Things change. From FOC one can show that large country protect too much and small countries protect too little. This inefficiency increases with number of countries

In particular, for large K we show that $\phi_i = 0$ for $i = 2,3,...,K$, and ϕ_1 is the one that would be optimal for a population of size $\theta_1\lambda < \lambda$.

Harmonization requires that the level of IP protection chosen be more than the existing level in the poor countries, but less than the existing levels of protection in the large country.

Alternatives To Government Grants of Monopoly

- government award prizes for innovation
- financed by imposing a sales tax on sales of newly invented goods
- similar to Gilbert and Shapiro [1990] “breadth” measure, and therefore less distortionary than temporary monopolies
- prize money is simply paid back to same innovator - mandatory licensing
- mandatory licensing widely used - in copyright radio play of music and xeroxing of copyrighted materials; in patent, mandatory licensing widely used in Taiwan until forced to reform their patent system by the United States
- efficiency improvement from replacing unregulated monopoly with regulated monopoly

- no reason to pay proceeds of taxes on new goods to original innovator
- better that proceeds be used to defray the costs of producing innovations of high social value
- best to pay h the indivisibility rather than the social value because raising revenue is distortionary
- intellectual property system makes little use of social knowledge of h (exception of “non-obviousness” requirement of patents now largely defunct); rewards scaled to value not cost
- if social value poorly correlated with private value rewards based on other information about social value/cost likely to lead to better mix of innovations being produced
- public and private prizes have been widely used historically and are of demonstrated practicality
- historians of aviation argue that prizes played important role aviation innovation

Conclusion

Competition = Good

Monopoly = Bad