DEAR DON: "WELFARE EFFECTS OF GLOBAL PATENT PROTECTION"

SINGLE INVENTION IN A SINGLE COUNTRY

BASIC SETUP:

\[ K = \text{RESEARCH COST} \quad c = \text{MARGINAL COST OF PRODUCTION} \]

If an inventor spends \( K \) dollars, it obtains a new product that can be produced by anyone at a MC of production \( c \).

Assume \( N \) identical consumers. If individual demand is \( p = a - b q_i \) for consumer \( i \),

the market demand is:

\[ p = a - \frac{b}{N} q \quad \text{(where} \quad q = \sum q_i = \text{MARKET PRODUCTION}) \]

CASES:

(A) NO PATENT GRANTED TO FIRST INVENTOR \( \Rightarrow \text{COMPETITIVE PRODUCTION} \)

We calculate fixed industry output

\[ p = MC \quad \Rightarrow \quad a - \frac{b}{N} q = \frac{c}{MC} \]

\[ q^* = \frac{c}{b} \left( \frac{a - c}{b} \right) \quad p \]

\[ S^* = \text{CONS. SURPLUS UNDER P. COMPETITION = OPTIMAL CONS.SURPLUS:} \]

\[ = \text{CONS. SURPLUS AT} \quad q^* = \text{AREA BELOW DEMAND CURVE & ABOVE} \quad c = \]

Using (3)

\[ \frac{\text{AREA OF}}{= \frac{\text{TRIANGLE}}{2}} \]

\[ = \frac{\left( a - c \right) q^*}{2} = \frac{(a - c)^2}{2} \eta \]
-2-

Since the inventor will earn zero profits, the invention will not be undertaken.

(B) Patent granted to inventor

\[ \Rightarrow \text{Inventor will act as a monopoly} \]

We calculate total industry output:

\[ MA = MC \Rightarrow a - \frac{b}{2} + 2p = q = c \]

(6) \[ q^m = \frac{1}{2} \gamma \left( \frac{a-c}{b} \right) \]

(7) \[ p^m = \frac{a+c}{2} \]

(8) \[ \pi^m = \frac{1}{2} \gamma \left( \frac{a-c}{b} \right) \]

Comparing (4) and (8) we have

\[ S^m = \text{Area below demand curve & above } p^m = \text{Area Rectangle } S^m \]

(9) \[ = \frac{a - p^m}{2} \cdot q^m = \frac{1}{8} \gamma \left( \frac{a-c}{b} \right) \]

Comparing (4) and (9) we have

Benefit for society of monopoly in this case:

\[ S^m = \pi^m + S^m = \frac{3}{4} S^o \]

\[ \Rightarrow \text{deadweight loss to society because of} \]
MONOPOLY PRICING:

\[ T_1 = S_1 - 6m = S_0 - \frac{3}{4} S_0 = \frac{1}{4} S_0 \]

Will the monopolist undertake the invention?

Yes: if \( T_1 > R \)

No: if \( T_1 < R \)

Invention should be undertaken from society's point of view if:

\( S_0 > R \)

Since \( T_1 = \frac{1}{2} S_0 \) even with a patent some worthwhile inventions (from society's point of view) will not be undertaken.

Conclusion: patents are an imperfect method to deal with inventions.

Why? Because: not all worthwhile inventions (from society's point of view) will be undertaken.

\( \theta \) monopoly pricing produces a deadweight loss (4).
MULTIPLE INVENTIONS
SINGLE COUNTRY

INVENTIONS ARE INDEXED (RANKED) BY THE PARAMETER $z$

DEFINITION:

OPTIMAL CONSUMER SURPLUS FOR INVENTION $k$ NORMALIZED BY ITS RESEARCH COST

$$\left(\begin{array}{c}
\tilde{z}^k(2) \\
\tilde{z}^k(3) \\
\tilde{z}^k(4)
\end{array}\right) = \frac{S^k(z)}{R(z)}$$

ASSUME WE ORDER THE MANY INVENTIONS
ACCORDING TO THEIR $\tilde{z}^k$'S (LOWER NUMBERS IDENTIFY INVENTIONS WITH HIGHER $\tilde{z}^k$'S)

Suppose $n$ inventions $1, 2, 3, \ldots, n$ are undertaken in a country.

Question: What is the total investment in research in the country?

$$\hat{Z}^k(n) = \text{TOTAL INVESTMENT \text{IF} \text{LAST INVENTION IS } \tilde{z}^k, \text{TOTAL COST OF = \text{RESEARCH}} = R(1) + R(2) + \ldots + R(n)}$$
If this function is "nice" we can write

\[ z_0 = \text{LAST INVESTMENT} \]

as a function of

\[ z_0 = \text{TOTAL INVESTMENT} \]

and

\[ (8') \text{ in page } 4 \]

Therefore \( z_0 \) can be written now as

**A function of** \( \bar{z} \):

\[ z_0(\bar{z}) = \text{OPTIMAL CONSUMER SURPLUS PER DOLLAR OF RESEARCH OBTAINABLE FROM THE LAST} \]

\[ \text{(or MARGINAL) DOLLAR OF RESEARCH INVESTMENT.} \]

Using our previous work on single

\[ \text{INVENTION} \]

\[ (\text{PAGE } 2) \]

we use Equations \( (8') \) and \( (9') \) to define

the following:

\[ (15) \]

\[ J^{m}(\bar{z}) = \text{MONOPOLY PROFITS PER DOLLAR OF RESEARCH OBTAINABLE FROM THE LAST DOLLAR OF RESEARCH INVESTMENT} \]

\[ (16) \]

\[ z^{m}(\bar{z}) = \text{CONSUMER SURPLUS PER DOLLAR OF RESEARCH UNDER MONOPOLY OBTAINABLE FROM THE LAST DOLLAR OF RESEARCH INVESTMENT} \]

\[ = \frac{1}{4} \left( z_0(\bar{z}) \right) \]

(See diagrams next page when we assume linear function for \( z_0(\bar{z}) \))
Assume there is a large number of inventions ("one as close to the next as possible") so we can assume that \( R^o(I) \) is a negative sloped line:

\[
R^o(I) = \eta \begin{pmatrix} f \end{pmatrix} - \eta g I
\]

\# consumers

Optimal Consumer Surplus per unit of research obtained from the last dollar of research investment.

\[
\Xi = \text{value of } I \text{ when } R^o = 0
\]

\[
\Xi = \frac{f}{g}
\]

I have drawn \( R^m(I) \) & \( R^m(I) \)

No Patent Protection:

(This is perfect competition if an invention is available)

P. C. \( \Xi I = 0 \) so no invention takes place

i.e. \( \Xi = 0 \) \( \Rightarrow R^c(0) = 0 \)

Optimal Invention

Invest as long as optimal consumer surplus or invention \( \geq \) larger than research cost or invention \( \geq \) (i.e. \( R^o(I) \geq 1 \)).

In other words, stop when \( R^o(I) = 1 \)

We call the optimal level of research
INVESTMENT: \( I^0 \), see diagram:

\[ S^0 = \text{total consumer surplus when optimal amount of research investment is undertaken} \]

\[ S^0 = \text{area below } R^0(I) \text{ from } 0 \text{ to } I^0 \]

\[ \text{Profit granted to inventor (monopoly), invest as long as profit of invention larger than research cost of invention } \]

\[ \pi^m(I) > 1 \]

In other words, stop when

\[ \pi^m(I) = 1 \Rightarrow \frac{1}{2} R^0(I) = 1 \]

Using (15) in page 5

\[ \Rightarrow 2^0(I^m) = 2 \]

(see diagram above)

Total research investment by monopolist.

\[ \pi^m = \text{total monopoly profit per dollar of research investment} \]

\[ Z \to I^m = \frac{1}{2} \]
\[ S^m = \text{total consumer surplus} = \text{area below } 2^m(t) \text{ from zero to } t^m = \frac{1}{2} t^m \]

\[ N = \text{net gain for society} \]

\[ \text{research cost} \]
OPTIMAL:

\[ N^0 = S^0 + \Pi^0 - I^0 = \frac{1}{2} [I \times A - \text{AREA of rectangle base } I_0 \text{ height of } 0] \]

MONOPOLY

\[ N^m = S^m + \Pi^m - I^m \]

DEADWEIGHT LOSS OF MONOPOLY:

\[ N^0 - N^m \]

\[ N^m = S^m + \Pi^m - I^m = \Pi_1 + \Pi_3 \]

\[ N^0 = S^0 - I^0 = \Pi_1 + \Pi_3 \]

\[ \text{DWL} = I^0 - \Pi_3 \]
III  TWO COUNTRIES
MULTIPLE INVENTIONS
COUNTRY A: ALL INVENTIONS TAKE PLACE HERE
COUNTRY B: NO INVENTIONS / ONLY CONSUME GOODS
ASSUME COUNTRY B IS SMALLER THAN COUNTRY A.
WE WILL STUDY 2 REGIMES:
④ RESTRICTED PATENT PROTECTION
PATENTS ARE ONLY GRANTED IN COUNTRY A.
SINCE COUNTRY B DOES NOT HAVE PATENTS
LEVEL OF PRODUCTION IS AT p=mc
② EXTENDED PATENT PROTECTION
BOTH COUNTRIES GRANT PATENTS
(=> MONOPOLY PRICING IN BOTH COUNTRIES)

① RESTRICTED PATENT PROTECTION (IN)
SINCE PROFITS FROM COUNTRY B ARE
ZERO, THE INVENTOR DECIDES HIS INVESTMENT
LEVEL LOOKING ONLY AT ΠA.
\[
\Pi_A(I^*) = \Pi_{A_{IN}}(I^*)
\]
THE SAME AS IN THE CLOSED ECONOMY CASE

COUNTRY: NET GAIN FOR SOCIETY:
\[
\sum_{A}^{A_{IN}} = S_{A_{IN}}^A(I^*) - I^*\]
See Fig. 3
\[
= \mu_1 + \frac{\mu_1 + \mu_2 + \mu_3}{\mu_1 + \mu_2}
\]
= \mu_1 + \mu_3

COUNTRY: ONLY CONSUMES \Rightarrow
NET GAIN FOR SOCIETY:
\[
\sum_{B}^B = S_{B}(I) = \mu_1 + \mu_2 + \mu_3
\]
2 \( \textbf{Extended Patent Protection} \)

Now the innovator decides on his investment level looking at \( \Pi_A + \Pi_B \).

\[ \text{Profit Max} \Rightarrow \Pi_A(I^e) + \Pi_B(I^e) = 1 \]

So extending patent protection to country B increases research investment since the new equilibrium investment level \( I^e \) is larger than \( I^a \).

\[ \text{Country A: Net Gain for Society:} \]

\[ \Delta N_A^e = S \cdot \Pi^A(I^e) + \Pi^A(I^e) + \Pi^B(I^e) - I^e \]

\[ = \mu_1 + \mu_2 + \mu_3 + \mu_4 + \mu_5 + \mu_8 \]

This is larger than \( N_{A^a} \) (see page 7) since \( N_{A^a} = \mu_1 + \mu_3 \).

So country A gains when patent protection is extended.

\[ \text{Country B: Net Gain for Society:} \]

\[ \Delta N_B^e = S \cdot \Pi^B(I^e) = \mu_1 + \mu_4 \]

Comparing \( \Delta N_B^e \) with \( \Delta N_{B^a} \) (see page 7), we see that

\[ \Delta N_{B^a} = \mu_1 + \mu_2 + \mu_3 > \Delta N_B^e = \mu_1 + \mu_4 \]

Since \( \mu_2 + \mu_3 > \mu_4 \) (looking at the diagram)

So country B loses when patent protection is extended.
How about world welfare?

Need to compare gains for A: \( w_1 + w_5 + w_8 \)

with

losses for B: \( n_y - (n_2 + n_3) \)

The result depends on the relative size of the countries. If country A is huge & B very small, extending patent protection to welfare.

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**FIGURE 3.** Welfare effects in two countries of inventions in one, with restricted and extended patent protection.