

Economics and Management of Intellectual Property  
HSE, Spring 2008

Lecture 4

**“Designing Optimal Intellectual Property Policy”**

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# Outline of Core Lectures

1. Basics of IP Law (Välimäki)
2. Use of IPRs (Välimäki)
3. Basic Economics of IP
4. Designing Optimal IP Policy
5. Network Industries, Competition Policy, IP
6. Microsoft Cases in the US and Europe (Välimäki)
7. Economic arguments used in legal cases (Välimäki)
8. Cumulative Innovation and IP
9. Basic IP Management
- 10-11. Industry studies: IP in Financial Services etc

# How to Model Innovation Process?

## Production function vs. ideas model

- We for brevity use production function approach, the book uses ideas model
- Here we assume that ideas, or their values ( $W$ ), are non-observable or at least non-verifiable by an outside party (government agency)

- Focus on the basic trade-off between ex ante and ex post considerations
- Generic view on IP in case of stand-alone inventions/creative works
  - Copyright
  - Patents (e.g. in pharmaceutical industry)
  - Trade secret
- Many insights apply more widely
- But leaves important issues out (as we will see later)

# Duration as a Policy Lever

**Duration** is rather clear-cut, measures the time-period the IP is in force

- after IP no longer in force, information (invention, works etc) in public domain
- Patent: 20 years (from application, conditional renewal fees)
- Copyright: often authors' life + 70 years (works for hire, 95 yrs after publication or 120 yrs from creation)
- Trade secret: forever (until becomes public)

- Statutory life usually differs from economic life
- E.g.
  - secret leaks out
  - patented invention becomes obsolete  $\Rightarrow$  renewal fees are not paid
    - less than 10% patents are kept force full period
- $\Rightarrow$  "patents as real options"
- Invalidity: Typically a firm that is sued for infringement claims that the patent is invalid
- copyrighted material becomes obsolete

## Designing Optimal Duration of an IPR

- Assume an IP is so broad that it is not possible to make a non-infringing substitute
- If innovation is successful, an IPR is awarded for  $\tau$  years
- $T$  = "discounted" duration of the IPR

$$T = \int_0^{\tau} e^{-rt} dt = \frac{1 - e^{-r\tau}}{r} \approx \sum_{t=1}^{\tau} \frac{1}{(1+r)^t}$$

- Clearly  $dT/d\tau > 0$  so we can focus on  $T$ .
- $\tau \rightarrow \infty \Rightarrow T \rightarrow 1/r$

- E.g.  $\tau=20$  years,  $r=0.1$



$$T = \frac{1 - e^{-0.1 \cdot 20}}{0.1} \approx 8.65$$
$$\approx \sum_{t=1}^{20} \frac{1}{(1.1)^t} \approx 8.51$$

- Discounted duration of "after IP" - life:

$$\int_{\tau}^{\infty} e^{-rt} dt = \frac{e^{-r\tau}}{r} = \frac{1}{r} - T$$

- Consider an inventor with an idea
- Cost of innovation  $C$
- If  $C$  is invested, probability of making an invention =  $\alpha$
- When the IPR is in force, a profit flow  $\pi^P$
- Eg with a zero MC and a linear inverse demand  $P=a-Q$ ,  
 $\pi^P = a^2/4$
- When the IPR expires, entry by rivals drive the profits down to  $\pi^C \in [0, \pi^P]$
- If imitation/entry costless,  $\pi^C = 0$

- Innovator's ex post profits as a function of the discounted IPR duration,  $P(T)$ :

$$P(T) = \int_0^{\tau} e^{-rt} \pi^p dt + \int_{\tau}^{\infty} e^{-rt} \pi^c dt = \frac{\pi^c}{r} + T(\pi^p - \pi^c)$$

- Assume free-entry  $\Rightarrow \pi^c = 0 \Rightarrow \mathbf{P(T) = T \pi^p}$
- The effect of IPR duration on the ex post profits:  
 $dP/dT = \pi^p > 0$ , i.e. the longer duration boosts incentives to innovate

NOTE:  $dP/d\tau < dP/dT$ , i.e. if  $\tau = 20$  and  $r = 0.1$  the marginal effect is only  $e^{-0.1 \cdot 20} \pi^p \approx 0.135 \pi^p$

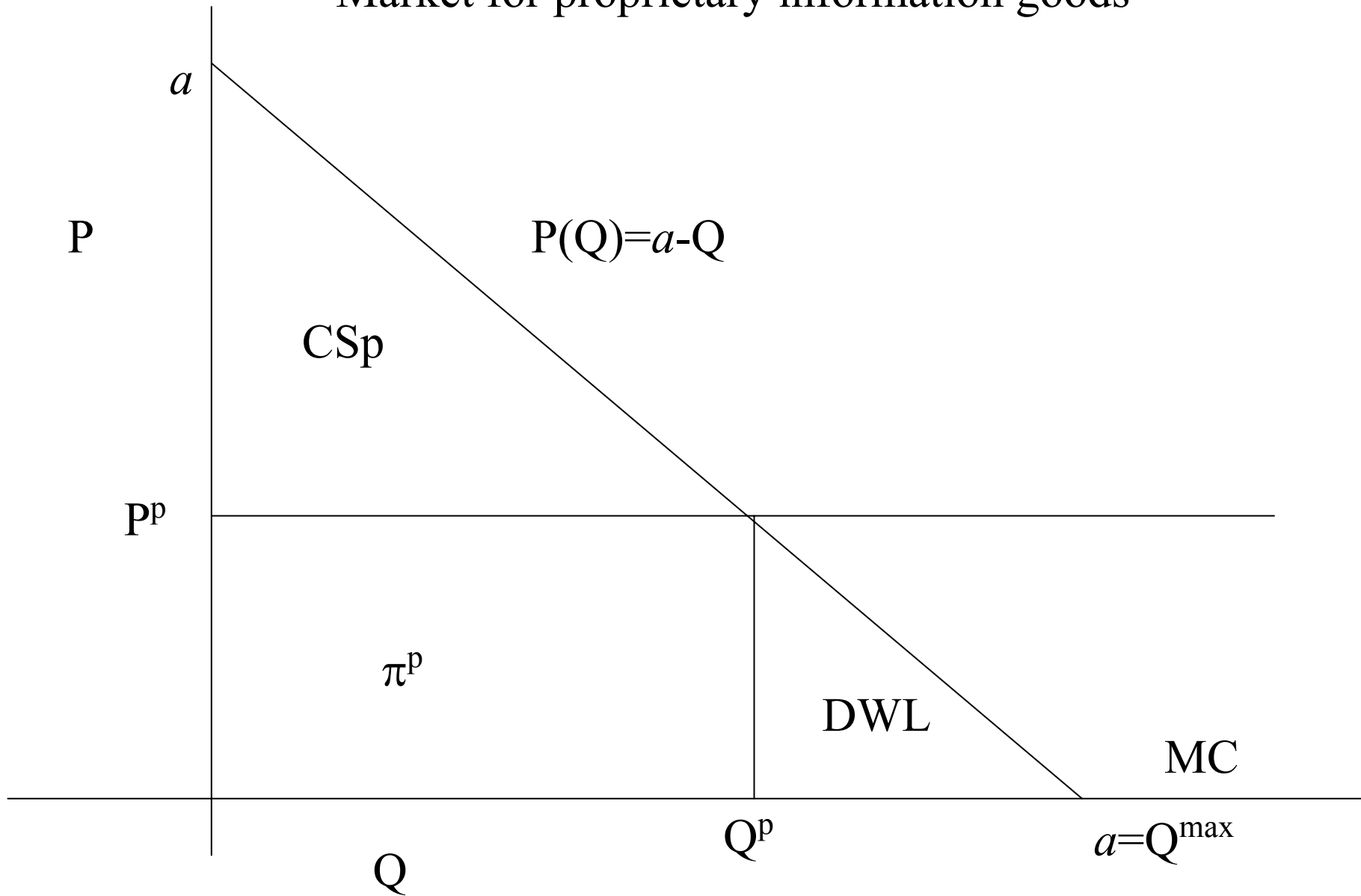
The innovator invests only if  $\alpha \mathbf{P}(T) \geq C$

$\Rightarrow$  The innovator invests only if  $T \geq C/\alpha\pi^p$

So  $T$  must be at least  $C/\alpha\pi^p$

- Social return flow on innovation
  - When the IPR is in force  $Wp = \pi^p + CS_p$
  - After the IPR expires  $Wc = \pi^c + CS_c = CS_c$  (if  $\pi^c = 0$ )
  - In general,  $Wp < Wc$ , i.e.,  $Wc - Wp = DWL$ 
    - E.g., with  $MC = 0$  and  $P = a - Q$  we have  $DWL = a^2/2 - 3a^2/8 = a^2/8$

# Market for proprietary information goods



- Ex post social welfare as a function of the duration of an IPR:

$$S(T) = \int_0^{\tau} e^{-rt} W^p dt + \int_{\tau}^{\infty} e^{-rt} W^c dt = \frac{W^c}{r} - T(W^c - W^p)$$

i.e, the full social value minus DWL over the duration

- so the IPR is like a tax *on users*
- The effect of the IPR duration on ex post social welfare:  
 $dS/dT = -DWL < 0$ .

- We see a virtue of IP:
  - The discounted social value of innovation  $S(T) = a^2/2(1/r - T/4)$
  - The inventor with an idea expects to get  $\alpha T a^2/4$
  - If  $a \uparrow$ , then both  $S(T)$  *and*  $P(T) \uparrow$ 
    - the investments will be made in relation to social value
  - The more valuable is the invention to society, the more is the inventor willing to put resources in innovation

- Seek the optimal IP duration  $T^*$
- Assume that the government can commit to  $T^*$ 
  - ⇒ a two-stage principal-agent game where the policy-makers choose first  $T^*$  and then the firm chooses whether to invest
  - ⇒ better to proceed backwards (look for a subgame perfect equilibrium)

## The second stage

- The firm's problem has been solved:
  - Invest if  $T \geq C/\alpha\pi^p$ , do not invest otherwise
- In this kind of a principal-agent problem this rule is often called the agent's *incentive constraint (IC)*

## The first stage

- The policy-makers choose  $T$  to maximize  $\alpha\mathbf{S}(T)-\mathbf{C}$  subject to the firm's optimal decision/incentive constraint  $T \geq C/\alpha\pi^p$
- Solution: Since  $S' < 0$ , choose  $T$  as small as possible subject to the firm's incentive constraint

$$\Rightarrow T^* = C/\alpha\pi^p$$

- Optimal duration of an IPR optimally *balances* the ex ante and ex post problems in the creation of knowledge.
- It minimizes the ex post DWL but provides enough protection to justify the investment

## Notes:

- 1) Requires commitment to the optimal policy  $T^*$ 
  - Ex post the government has an incentive to cheat and put  $T=0$ : this is optimal ex post.
  - However, if this were possible, the inventor would realize it, and would not invest
    - e.g. Apple iTunes vs Finland, France (+other countries)

2) One size does not fit all.

- If  $T^*$  is the same for all inventions, there are
    - inventions where the incentive constraint is not satisfied ( $T^* < C/\alpha\pi^p$ )
    - or where the incentive constraint is slack ( $T^* - C/\alpha\pi^p > 0$ ) and hence DWL is higher than necessary.
- ⇒ Optimal rule suggests that  $T$  should be invention specific. With linear inverse demand  $P = a - Q$ , the optimal rule is given by  $T^* = 4C/\alpha a^2$
- ⇒ The larger is  $C$  or the smaller is  $\alpha$  or  $a$ , the longer should be optimal IP duration ( $T^*$ )

- 3) According to economic theory, costs should play a fundamental role determining how strong IP protection is awarded (patentability, damages for infringement etc)
- in practice they do not

# Recent debates on the duration of IPRs

- The US Sony Bono Copyright Extension Copyright Act of 1998
  - Huge lobby by Walt Disney and others
- ⇒ the US copyright law was extended to the level of EU (an extension of 20 years)
- The extension was retroactive i.e. applied to *existing* works, too
- The reason....

**MICKEY MOUSE 75 YEARS**

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**STEAMBOAT WILLIE**

**FREE MICKEY**



- Under the former law, Mickey would have been free stuff 2003 (Pluto 05, Goofy 07, Donald Duck 09) because he appeared first time in the 1928 cartoon "Steamboat Willie"
- Steamboat Willie was a cartoon version of the Buster Keaton's popular movie with the same name
  - Even the opening music was the same
- Disney typically uses a lot of stuff in public domain: e.g. Cinderella, Pinocchio, Peter Pan, Snow White and the Seven Dwarfs, Beauty and the Beast, Hunchback of Notre Dame...

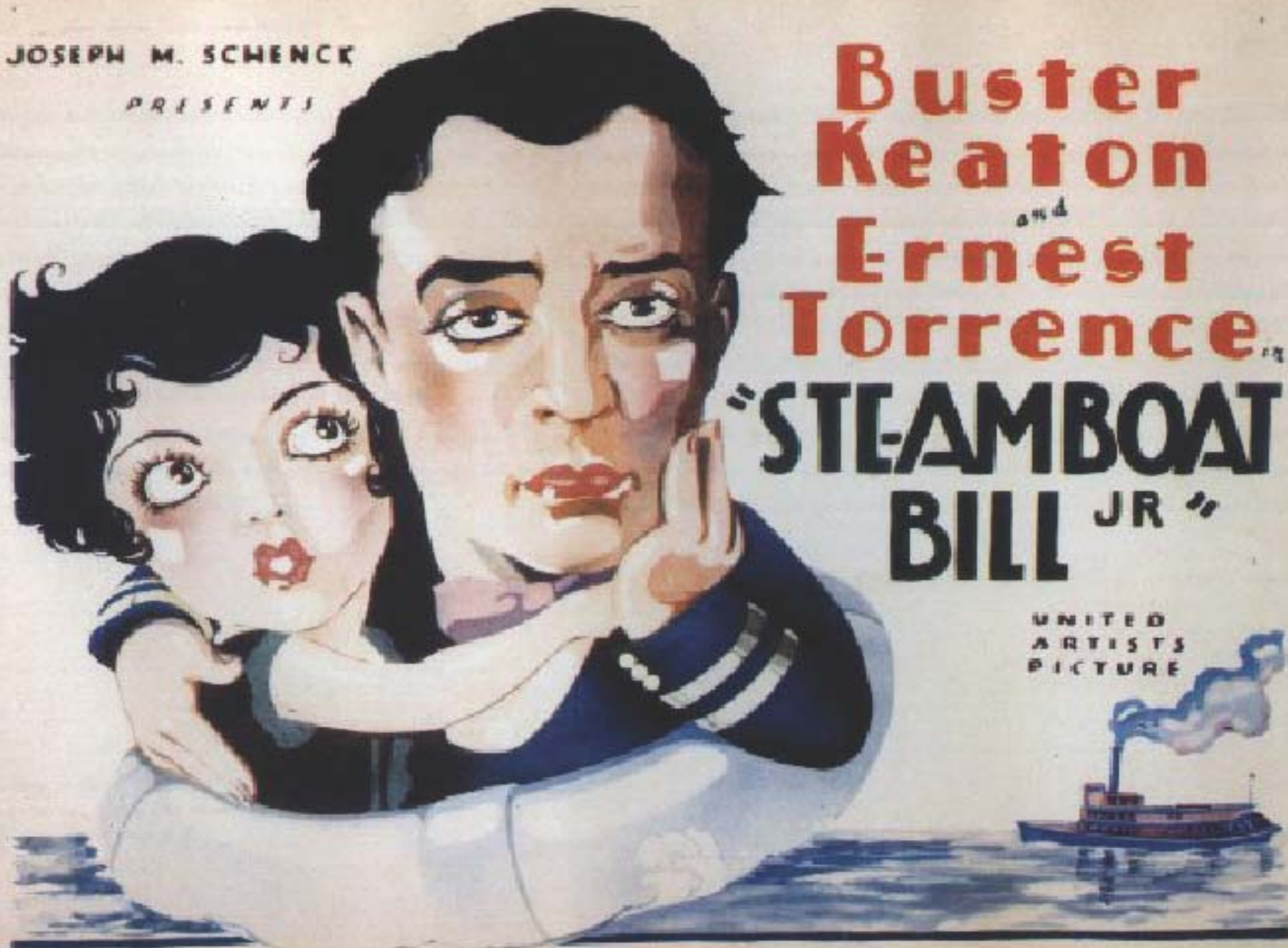
JOSEPH M. SCHENCK

PRESENTS

**Buster  
Keaton**  
and  
**Ernest  
Torrence**

**"STEAMBOAT  
BILL JR"**

UNITED  
ARTISTS  
PICTURE



## Another US extension:

- The US patent term extension of 1995  $\Rightarrow$  the US patent duration was extended to the level of EU (an extension from 17 to 20 years)

- The harmonization of patent term extensions
  - in pharmaceutical industry marketing and sales of new drugs are delayed due to regulatory reviews required for commercialization
- ⇒ patentees unable to exploit full term ⇒ US, Japan, Europe allow for patent extensions
- extensions (ex post) bad news for consumers and generic drug industry but stimulate the innovation of new drugs
- e.g., the US Patent Term Restoration Act of 1984 explicitly designed to balance the opposing interests

- Debate on the harmonization of copyright term (cf. Gowers' review)
- Should copyright for sound and performance recordings be extended from 50 to 95 years?
  - Does this increase incentives to create more performances?
  - Even if it does, is it justified?

# Breadth of Protection as a Policy Lever

- An elusive concept
- Not a legal concept but essential in practice and economics
- A loose definition: determines how different a competing product must be to avoid infringement/violation

## Patent breadth

- exclusive right to use invention commercially
- if a patent were restricted to the original invention exactly, protection would be trivial to circumvent (invent around)
- Doctrine of equivalents: “patent covers any product that does the same work substantially the same way to obtain the same result”
  - E.g., if you patent a bottle that is closed by a screw cork the invention covers a bottle closed by an oak cork
  - E.g., change of color not sufficient to escape infringement

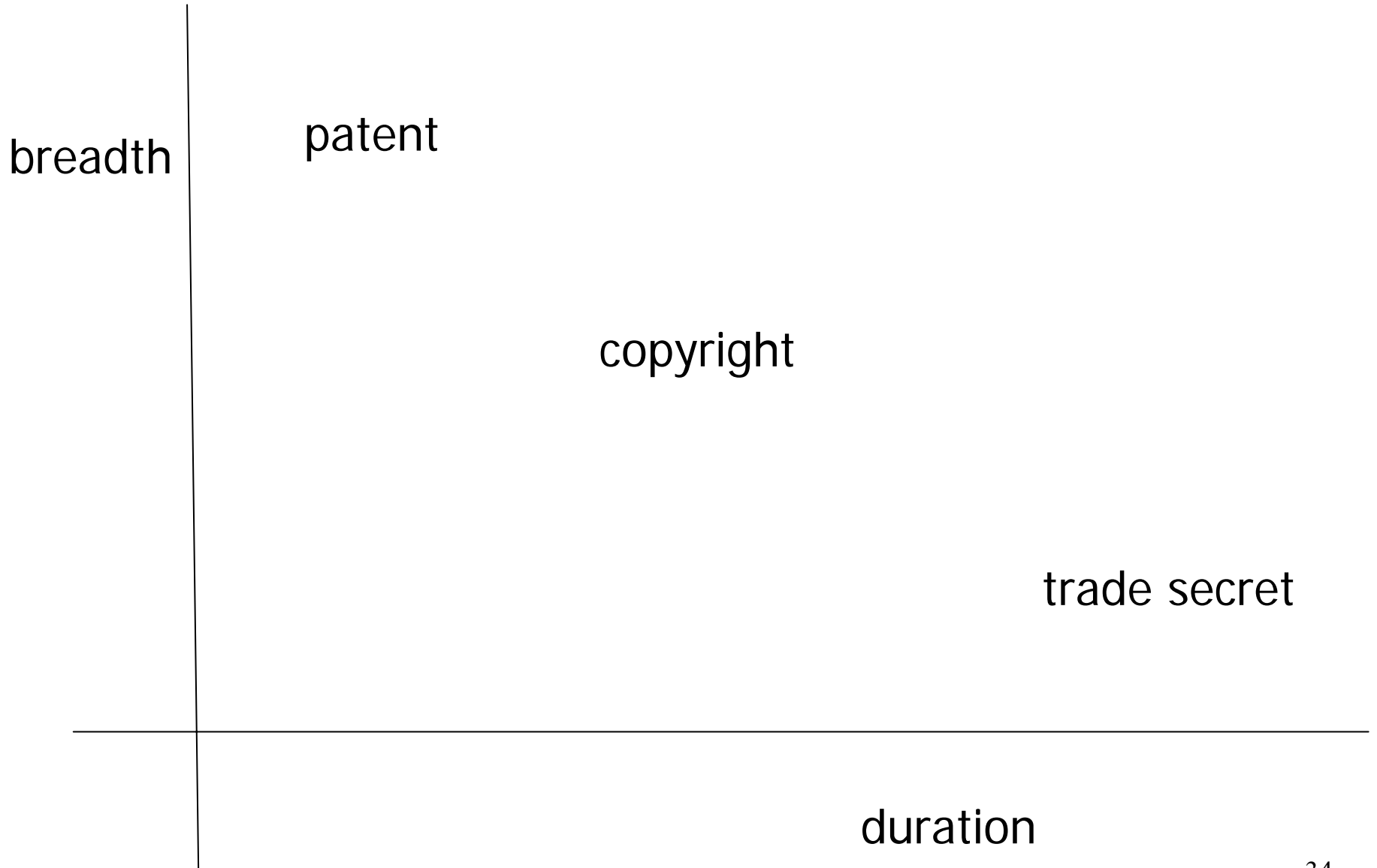
- Infringement must be established with respect to patent claims
    - Patent protects what is claimed for
    - Claims chosen by the applicant and checked by the PO (patent examiners)
    - All claims should be related to one invention
- ⇒ Writing claims carefully/strategically important

- Patent breadth is endogenous
  - the applicant and the PO determine the range of applications covered by claims
  - the applicant claims as much as she can
  - the PO checks out what claims allowable
  - ultimately breadth is determined in the court
    - what infringes and what does not infringe

Example 1: IBM's patent on 'smooth end of auction in the internet', US patent 6,665,649

- it 'claims' a computer program that determines the end time of an auction according to  $D = -d \ln(1 - r/m)$  where  $d$  is the posted expected duration of the auction, and  $r < m$  is a pseudo random number picked by the program from an exponential distribution
- what if a competitor enters and introduces a similar auction where  $r$  is picked from a uniform distribution?
  - a very narrow patent would allow the competitor enter
  - a very broad patent would prevent anyone using random-ending auctions (in the internet)

# IP durations and breadth



## Notes:

- Breadth affects economic duration
- Breadth is endogenous (claim writing, DRM, IP management, contracting etc)
- Ultimately determined in the court

- Even patents do not necessary leverage a strong market power (not to mention a monopoly) on output market
  - Breadth is nonetheless limited and patents can be invented-around
  - Patents and protected innovations are usually inputs,
  - Substitute inputs/patents are available

## Economic Effects of Breadth of an IP

- *economically* breadth measures how difficult it is to bring a non-infringing substitute in the market
  - Determines the pricing power of the IP holder over the duration of the IP
  - Product space (shift in demand) and technology space (the costs of inventing around)

Product space: How “similar” a competing product must be to infringe the IP, reminds “doctrine of equivalents” in the case of patents

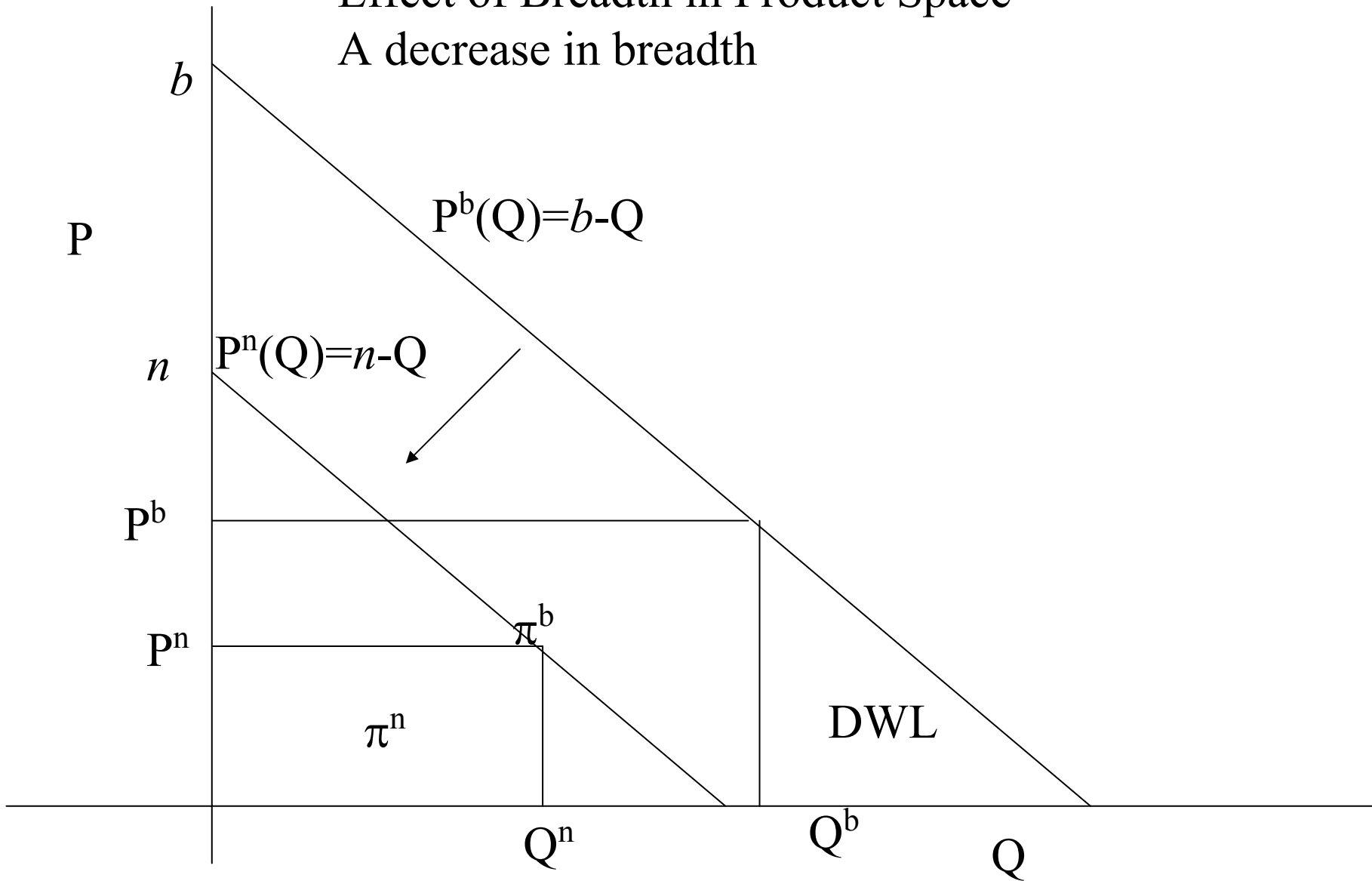
Example: Breadth affects the demand of the proprietary good.  
E.g., demand

- with a broad IP:  $P^b = b - Q$
- with a narrow IP:  $P^n = n - Q$

where  $b > n$

# Effect of Breadth in Product Space

A decrease in breadth



Technology space: How costly it is to find a non-infringing substitute for the proprietary technology. E.g.,

- to “invent around” a patent
  - e.g. medical process patent vs. full product patent
- to “independently-innovate” around a copyright

**Example:** Two firms, an innovator and an imitator

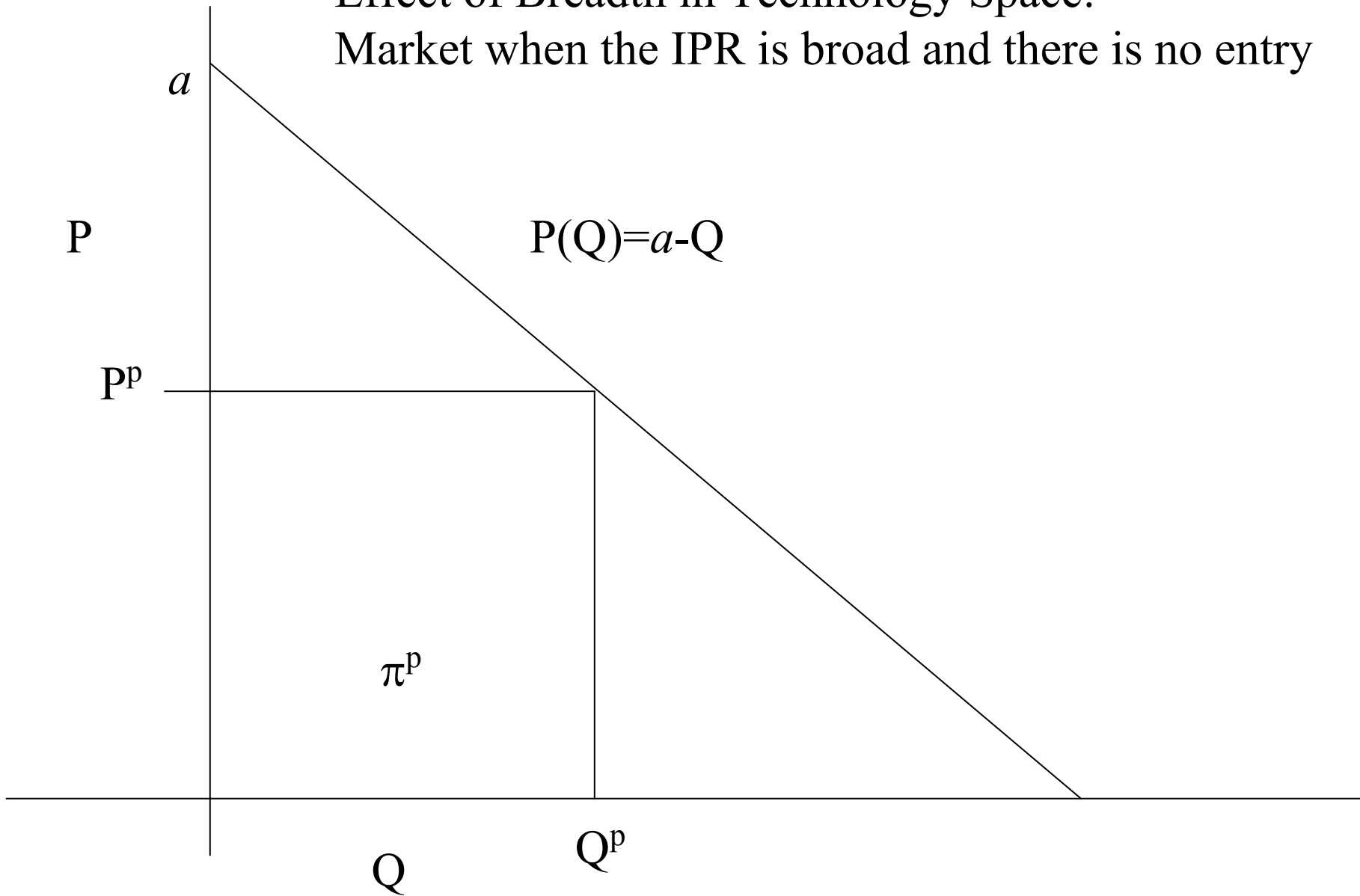
- the imitator can copy the innovator's product with cost  $K(b)$ , where  $b$  is the breadth of IP and  $K' > 0$ .
- For brevity, let  $K = b$ .
- if the innovator is alone at the market, she earns  $\pi^p$
- if the imitator enters, both firms earn  $\pi^d < \pi^p$
- if  $b < \pi^d$ , there is entry, if  $b > \pi^d$ , no entry

## Generalization: IPRs and market structure

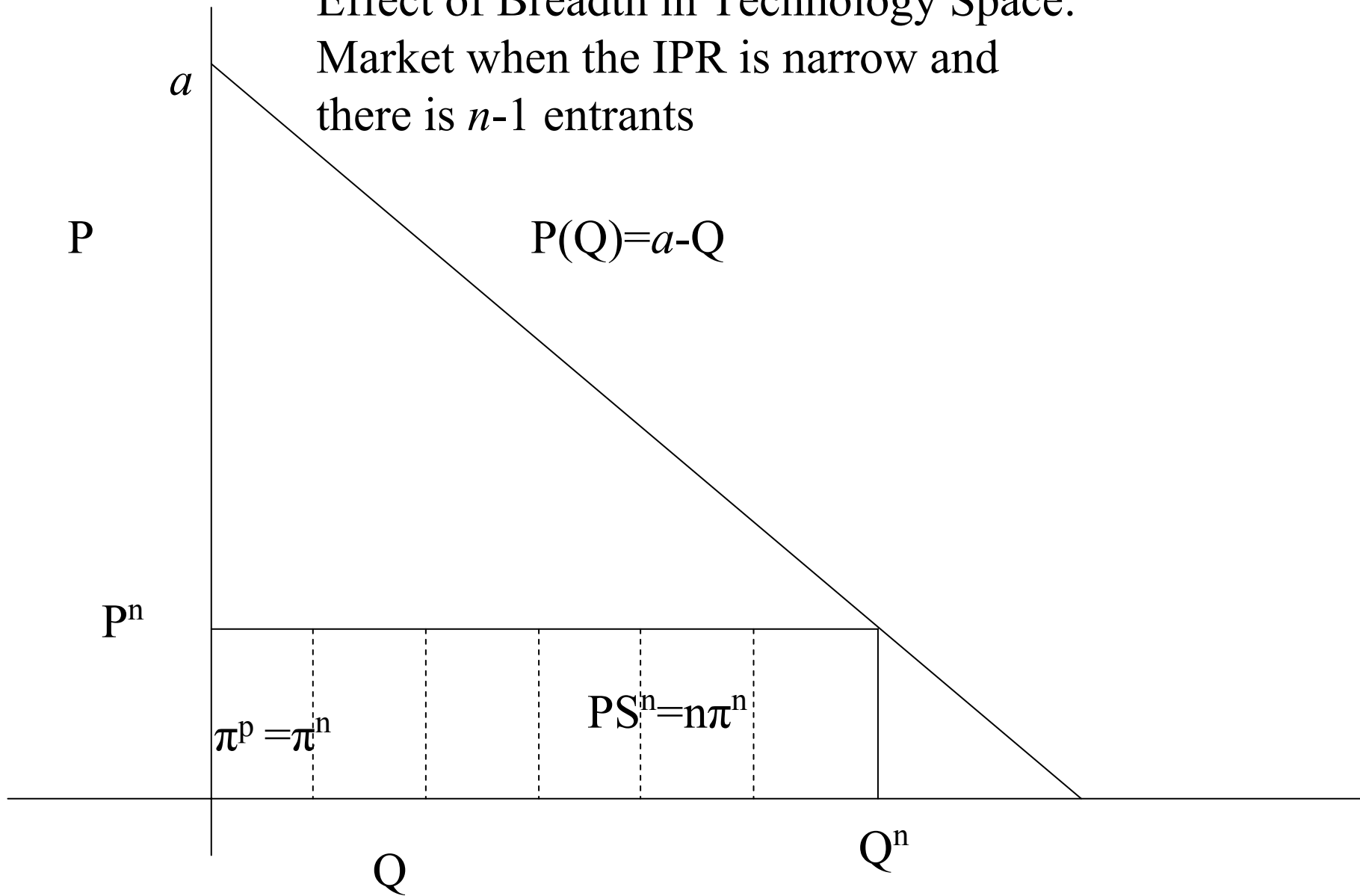
- The more there are rivals in the market, the lower is the profit of a single firm, i.e.,  $\pi(1) > \pi(2) > \dots > \pi(n-1) > \pi(n) > \pi(n+1)$ 
  - e.g., Cournot/quantity competition
- Free entry with entry cost  $b \Rightarrow$  market will consist of  $\mathbf{n}$  firms defined by  $\pi(n) > b > \pi(n+1)$ .

$\Rightarrow$  the profit of the IP holder is at most  $b$

Effect of Breadth in Technology Space:  
Market when the IPR is broad and there is no entry



Effect of Breadth in Technology Space:  
Market when the IPR is narrow and  
there is  $n-1$  entrants



# Generic Effects of Breadth

- let  $\mathbf{b}$  denote IP breadth,  $\mathbf{b} \in [0, 1]$
- $\pi(\mathbf{b})$  = the profit flow as a function of breadth (when the IP is in force)
- assume  $\pi' > 0$ ,  $\pi(1) = \pi^p$  and  $\pi(0) = \pi^c = \mathbf{0}$
- $W(\mathbf{b})$  = welfare flow as a function of breadth over the duration of the IP
- $W' < 0$ ,  $W(1) = W^p$ ,  $W(0) = W^c$

# Designing Optimal Breadth and Duration

- Ex post profits as a function of duration & breadth,  $\mathbf{P}(\mathbf{T}, \mathbf{b})$ :

$$\int_0^{\tau} e^{-rt} \pi(b) dt = \pi(b) \left( \frac{1 - e^{-r\tau}}{r} \right) = T \pi(b)$$

- Ex post social welfare  $\mathbf{S}(\mathbf{T}, \mathbf{b})$ :

$$\int_0^{\tau} e^{-rt} W(b) dt + \int_{\tau}^{\infty} e^{-rt} W(0) dt = \frac{W^c}{r} - T(W^c - W(b))$$

i.e, full social value minus DWL as before. Now DWL is a function of breadth DWL(b)

- For  $b < 1$ ,  $P(T, b) < P(T, 1) = P(T)$  and  $S(T, b) > S(T, 1) = S(T, 1)$

⇒ Generic effects of breadth:

- $\partial P(T,b)/\partial b = T\pi' > 0$  and  $\partial S(T,b)/\partial b = -TDWL' = TW' < 0$

⇒ the tradeoff between ex ante and ex post inefficiencies!

i.e., increasing breadth reduces ex post competition in the market, increasing both the incentive to innovate and DWL

- Seek optimal breadth-duration mix
  - Stage 1) The policy-maker chooses policy  $(T, b)$
  - Stage 2) The firm invest in R&D  $(\alpha)$
  - Proceed backwards, look for a SPE

Stage 2) The firm chooses  $\mathbf{C}$  so as to maximize  $\alpha\mathbf{P}(T, \mathbf{b}) - \mathbf{C}$

$\Rightarrow$  the firm invests only if  $\mathbf{P}(T, \mathbf{b}) \geq \mathbf{C}/\alpha$

Stage 1) The optimal policy  $(T^*, b^*)$  maximizes the ex ante social welfare:  $\alpha \mathbf{S}(\mathbf{T}, \mathbf{b}) - \mathbf{C}$  subject to the firm's incentive constraint

- By the same logic as before, the optimal policy satisfies

$$P(T^*, b^*) = C/\alpha \Leftrightarrow \pi(b^*)T^* = C/\alpha$$

- Differentiating the optimal rule with respect to  $T^*$  and  $b^*$  yields:

$$\frac{dT^*}{db^*} = -\frac{\pi'}{\pi} < 0$$

- Duration and breadth are *policy substitutes*

- Problem: two substitute variables – what is their optimal mix?
- Consider two policies
  - Policy 1: narrow but long IP ( $b_1, T_1$ ) (~copyright)
  - Policy 2: broad but short IP ( $b_2, T_2$ ) (~patent)

such that  $T_1 > T_2$ ,  $b_1 < b_2$  and  $\pi(b_1)T_1 = \pi(b_2)T_2 = C/\alpha$

- Which policy is better?

**Answer:** choose the one with higher ex post social welfare  $S(T, b)$

- The problem is to choose **T** and **b** so as to

minimize TDWL(b)

s.t.  $\pi(b)T = C/\alpha$

- The effect of T is linear both on the incentive to innovate and DWL

⇒ We can focus on the effects of b, and use T to compensate

⇒ the choice of optimal policy mix boils down to *a ratio test*:

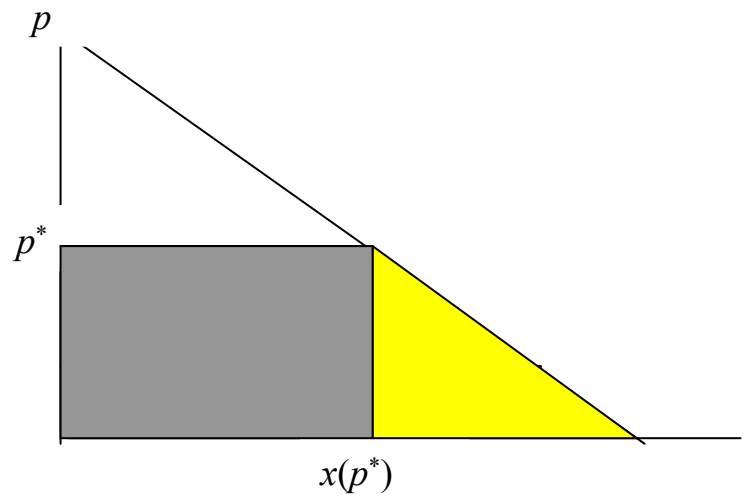
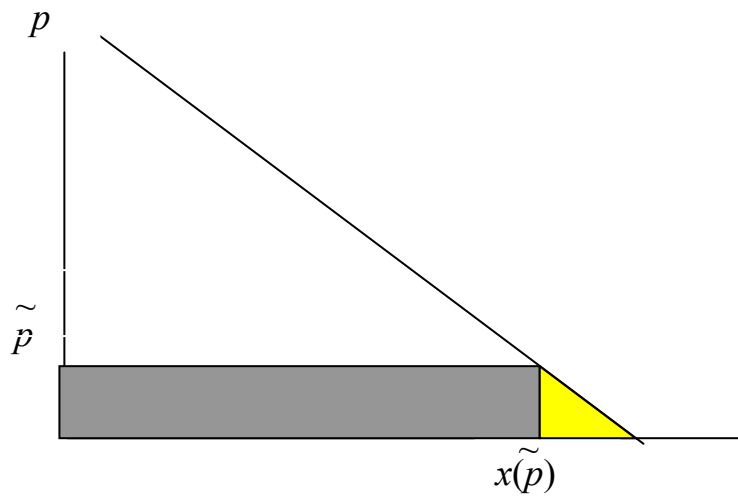
- Choose breadth to minimize  $DWL(b)/\pi(b)$

⇒ if  $DWL(b_1)/\pi(b_1) < DWL(b_2)/\pi(b_2)$ , copyright (narrow but long) is better

⇒ if  $DWL(b_1)/\pi(b_1) > DWL(b_2)/\pi(b_2)$ , patent (broad but short) is better

- The benefit of IP is that it provides the incentive to innovate
- The cost of IP is dead-weight loss
- Higher ratio means that the cost of creating the required incentive to innovate is higher

- with linear demand, which policy is better,  $\sim$  or  $*$ ?



## Notes:

- 1) Both DWL and incentive to innovate crucially hinge on  $b$  and the shape of the demand. e.g. with very convex demand broad but short is optimal
  - 2) we have a prediction in which industries one should apply patents and in which industries one should apply copyrights
- ⇒ We have a prediction concerning the welfare impacts of the expansion of patentable subject matter