Optimal Patent Strength under Financial Constraints

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Introduction

- What is the optimal strength of patent protection?
- Numerous studies analyzing the trade-off between ex ante innovation incentives and ex post inefficiencies stemming from patents
- This paper analyzes how financial constraints affect this trade-off
- Setup: two-stage patent race with inventor and developers.
- Study how the optimal strength of patent protection on a basic invention is affected by financial constraints on the side of developers or inventor
- **Related literature**
  - Aghion and Tirole (1994a and b) analyze the optimal allocation of property rights between a research unit and a customer when contracts are incomplete. However, simultaneous moves and don't focus on IP
  - Scotchmer and Green (1995) study effect of patents on sequantial innovation. Do not analyze role of financial constraints.

The model setup

- R&D technology: An inventor makes an invention with probability x if she incurs the R&D costs $C(x) = \frac{x^k}{k}$
- The invention can be used by different firms aiming to develop marketable goods out of it
- The probability of successfully developing a good is given by p^H if a developer exerts effort (which costs e) and by p^L if he does not exert effort
- If a good is successfully developed, a developer i derives profits π_i from selling it (independent markets).
- Exerting the high level of effort is assumed to be efficient: $p^H\pi - e > p^L\pi$

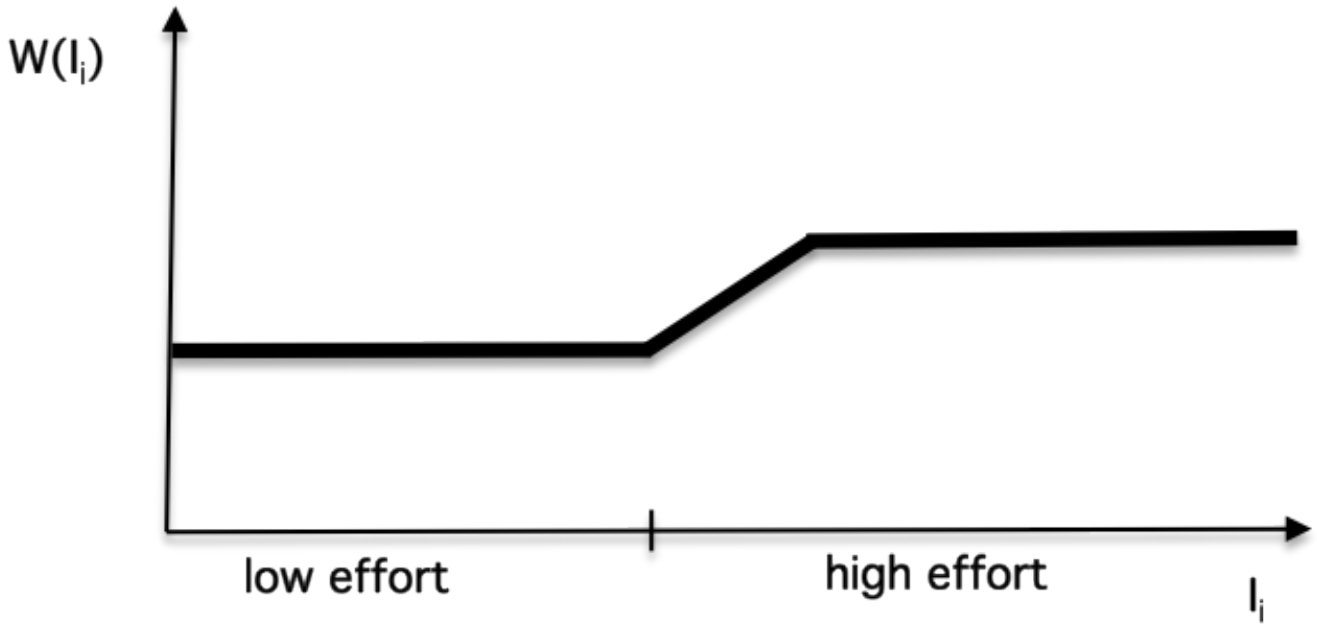
Model setup continued

- Developers are endowed with net assets $l_i \Rightarrow$ limited liability
- Effort unobservable for outsiders
- The inventor (if successful) gets a patent which is enforced with probability Δ. If not enforced, developers have free access to invention and successful developers still get π_i
- All agents are risk neutral and maximize expected payoffs
- Given an invention has occurred and the patent is enforced, the inventor licenses it to the developers (simplifying assumption: inventor has all the bargaining power)

The optimal licensing contract

- Fixed fee F_i plus royalty R_i in case of success
- Due to limited liability: $F_i \leq I_i$ and $F_i + R_i \leq I_i + \pi_i$ (non-monetary effort costs)
- Participation constraint: developer must get nonnegative expected payoff (e.g. $p^H(\pi_i - R) - F - e \geq 0$ if high effort)
- Incentive compatibility constraint if high effort induced: developer must have incentives to exert effort ($p^H(\pi_i - R) - F - e \geq \pi^L(\pi_i - R) - F$)
- Expected licensing revenues from developer i are denoted by $W_i(I_i)$

  $\Rightarrow$ **optimal licensing contract** as a function of I_i: relies more heavily on distortive royalty the lower I_i is



- For low levels of I_i the inventor prefers to implement the low level of effort in order not to give away to much rents

  $\Rightarrow$ Ex post distortion that arises in the case of patent enforcement. If not enforced, developer always exerts high effort

Equilibrium

- Expected profits of the inventor:

$$\Pi = x\Delta \sum_{i=1}^{n} W_i(I_i) - \frac{x^k}{k}$$

- Profit maximizing research intensity:

$$x^\star = (x\Delta \sum_{i=1}^{n} W_i(I_i))^{\frac{1}{k-1}}$$

$\Rightarrow$ increases in Δ and (weakly) increases in I_i

Optimal patent strength

- Expected "social" surplus:

$$S(\Delta) = x^* \left[\Delta \left(\sum_{i=1}^{h} V_i^L + \sum_{i=h+1}^{n} V_i^H \right) + (1-\Delta) \sum_{i=1}^{n} V_i^H \right] - \frac{x^{*k}}{k}$$

$$V_i^H = p^H \pi_i - e > V_i^L = p^L \pi_i$$

Main Result 1

The optimal patent strength $\Delta^\star$ (weakly) decreses in the number of credit constrained developers h

- Intuition: in the case of credit constraints, reducing Δ can increase the probability that a final good is developed

Financially constrained inventor

- Somewhat different setup:
- one credit constrained developer who exerts the low level of effort if the patent is enforced $\Rightarrow$ distortions from patent protection
- The inventor needs to spend Y in order to be able to do R&D and successfully obtains an invention with probability x^H if she exerts effort (which costs f) and with probability x^L if no effort is exerted

Outside investor

- If inventor is financially constrained she can obtain funds from a risk neutral investor who, however, cannot observe the effort undertaken by the inventor
- If the inventor has no net wealth, the investor can only charge a royalty T which the inventor has to pay if she is successfull and extracts licensing revenue from the developer
- Standard problem: increasing T beyond a certain level discourages effort of the inventor. The investor needs to leave some of the rents to the inventor in order to induce effort.

Optimal patent strength

- If inventor is not financially constrained, it is optimal to set patent strength at the lowest level which allows her to break even (still exert high effort if $Y > \frac{(x^L f)}{(x^H - x^L)}$)
- Under financial constraints, implementing the high level of effort requires a higher level of protection as the investor needs to break even while at the same time giving rents to the inventor.

Main Result 2

The optimal strength of patent protection is higher if the inventor is financially constrained

- If ex post inefficiencies from patent protection are large, it is optimal to reduce the strength of protection to a level for which only the low effort is induced (in the case of financial constraints)

  $\Rightarrow$ But also this lower level of protection is higher than the optimal one in the case without financial constraints.

Varying invention costs

- A uniform strength of patent protection Δ applies to several inventors that operate in different markets and have different R&D costs Y (that are known to investors).
  - Inventor types Y distributed with density $q(Y)$
- Trade-off: increasing Δ increases the number of active inventors (Effect A) but reduces the surplus generated by all inframarginal inventors (Effect B)
- Given that all inventors are financially constrained, less of them break even for any given Δ, weakening Effect B. Given that $q(Y)$ does not rise in Y, this implies that the optimal strength of IP protection $\Delta^\star$ increases.

Policy Implications

- Optimal to have lower patent protection on basic inventions in industries/regions in which financial constraints are a serious problem for developers
  - developing countries that license technologies from rich countries?
- Optimal to have stronger protection on basic inventions if inventors tend to be financially constrained
  - Using firm level panel data from Belgium, Czarnitzki, Hottenrott and Thorwarth (2010) find that research investments are more sensitive to operating liquidity than development investments

Extensions (financially constrained developers)

Asymmetric information abour I_i

- Optimal to offer a menu of contracts: distortion of effort choice with positive probability in order to encourage self selection into different contracts without giving away too much rents

- If nonpledgeable income is source of agency problem: inventor might charge such a high fixed fee that some developers are excluded from getting a license

  $\Rightarrow$ additional distortions $\Rightarrow$ lower IP is optimal

Possible further extensions

- More finetuning possible?
  - restrict fixed fees/ royalties
  - Make patent protection differ for R&D inputs and in final good markets
- More complicated settings where royalties are used to signal the quality of an innovation or to provide insurance for the licensee...