Patents in a Model of Growth with Persistent Leadership

Christian Kiedaisch

ETH Zürich

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Introduction

- In many sectors: cumulative quality improving/ cost reducing innovation
- Unlike in most quality-ladder models, industry leaders often do a lot of R&D:

Bartelsman and Doms (2000) and Foster, Haltiwanger and Krizan (2001): net entry accounts for about one fourth of productivity growth in the US manufacturing sector; about half of it was due to within plant growth
Other studies: Malerba and Orsenigo (1999); Czarnitzky, Etro and Kraft (2009)...

- I analyze the effect of different patent policies within the context of a quality-ladder growth model in which there is persistent leadership

Related Literature

- O' Donoghue and Zweimüller (2004) and Hopenhayn, Llobet and Mitchell (2006): leapfrogging case
- Bessen and Maskin (2009) and Acemoglu and Akcigit (2009): duopoly case
- Denicolò and Zanchettin (2010); assume that leader is better in doing R&D

Main difference in my model:

1. all technologies are nonrival and access to them is only restricted by IP
2. possibility of preemption

The Model Setup

- There is a good the quality of which can be increases step-by-step through innovation
- Flow profits of a firm producing the newest version of the good depend on whether the firm has a patent (preventing imitation of this version of the good) and on how far it is ahead of its rivals
- Without patent protection: Bertrand competition $\pi_0 = 0$
- One-step lead: limit pricing π_1
- Two- or more-step lead: π_2, with $\pi_2 > \pi_1 > 0$

Profit flows are for simplicity assumed to be independent of quality level (but looked at more general case as well)

- R&D technology: the instantaneous arrival rate ϕ of an innovation can be obtained at the total (industry) costs

$$C(\phi) = \begin{cases} c\phi^{1+\varepsilon} & \textit{if} \quad \phi \leq \phi_m \\ \infty & \textit{if} \quad \phi > \phi_m \end{cases}$$

- Marginal R&D costs increase at the industry level (due to duplication or an upward sloping supply curve for R&D inputs)
- If more than one firm does R&D, its innovation probability is given by $\alpha\phi dt$ if its share in total R&D costs is given by α

In order to simplify calculations later on, an upper bound ϕ_m on the total arrival rate is assumed and the case where $\varepsilon \to 0$ is analyzed.

- Time is continuous and the rate of interest is exogenous and given by r
- In the basic setup, patents are infinitely lived but effective patent length depends on the probability of being replaced by a new innovator
- Free entry into the R&D sector: an entrant without patent must get zero expected profits
- In equilibrium, the value of an innovation for an entrant cannot exceed the average cost of undertaking R&D:

zero profit condition

$V_E \leq c\phi^{\varepsilon}$

Equilibrium

- An incumbent with a two-step lead in an industry has no stand-alone incentives to do R&D. However, the ZP - condition pins down an innovation rate which is independent of whether the incumbent herself innovates or not
- As the incumbent values not being replaced more than entrants value entry (as $\pi_2 > \pi_1$), she wants to preempt entry. If the incumbent moves first in the R&D game, she does all the R&D necessary to satisfy the zero profit condition so that there is no entry in equilibrium (look at MPE)
- Persistent leadership!
- Same reasoning as in Gilbert and Newbery (1982) and Denicolò (2001)

R&D Incentives

The value of an innovation for an entrant expecting to become the next incumbent is given by:

Value of an innovation

$V_E = \frac{\pi_1 - c\phi_1}{r+\phi_1} + \frac{\phi_1}{r+\phi_1}\frac{\pi_2 - c\phi_2}{r}$ where either $\phi_1 = \phi_2$ or $\phi_1 = \phi_m > \phi_2$

- If the incumbent has a two–step lead, the zero profit condition $V_E = c$ determines the equilibrium innovation rate as a positive function of profit flows and a negative function of c and of r.
- Policies that increase V_E lead to an increased rate of innovation!

Growth-Enhancing Policies

- VOLUNTARY DEALS: If incumbents cannot commit to compete, allowing them to consolidate market power with entrants (which increases π_1) and to coordinate joint R&D spendings (which can lead to cost reductions in the case where $\phi_1 = \phi_m$) increases entry pressure and growth (similar to Segal and Whinston (2007))
- R&D incentives are maximal if entrant gets π_2 directly if enters

Implementable through a "PATENT TRANSFER SCHEME": force incumbent to freely give all patents to entrant if innovation occurs $\rightarrow$ also works in the case of leapfrogging and in product variety settings

Forward Protection

- Compensating previous innovators by requiring entrants to pay a fee F to the previous incumbent upon replacement

zero profit condition: $V_E = c + F$
$\rightarrow$ reduces growth

- LEADING BREADTH (of one step): the innovation of an entrant infringes on the patent of the incumbent

Assumption: without forward protection, no voluntary deals
$\rightarrow$ decreases growth, unless it allows for considerable reductions in R&D costs

- Different in the case of leapfrogging! (O´Donoghue/ Zweimüller 2004)

Patentability Requirement

Variable Innovation Size μ

$C_i(\phi_i, u_i) = c\lambda(\mu_i)\phi_i(C_{tot})^{\varepsilon}$ with $\frac{\partial \lambda}{\partial \mu} > 0$ and $\pi_1 = \pi_1(\mu)$

- Restricting the choice of the inventive step reduces entry pressure and therefore the amount that incumbents need to spend on R&D in order to preempt entry
- Imposing a patentability requirement only on the incumbent might however be useful to avoid inefficiently small inventive steps (need to be able to distinguish between incumbents and entrants...)
- Different in the case of leapfrogging, where a patentability requirement can prevent low markups, an excessive rate of turnover and inefficiently small inventive steps.

Varying Enforcement Probabiltiy

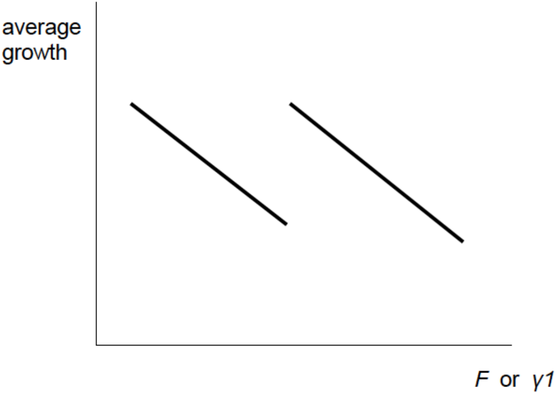
- Patents expire with probability γ_1 (γ_2) if one (two) steps ahead ("STATE DEPENDENT IPR" like in Acemoglu and Akcigit (2009))

$$V_E = \frac{\pi_1 - c\phi_1}{r + \gamma_1 + \phi_1} + \frac{\phi_1}{r + \gamma_1 + \phi_1} \frac{\pi_2 - c\phi_2}{r + \gamma_2}$$

- If γ_1 is similar to γ_2, we have $\phi_1 = \phi_2$ and increasing the probabilities of expiration reduces the value of an innovation for an entrant and growth.
- However, if γ_1 is large enough relative to γ_2 or if there are large enough fixed costs of entry (F) we get:

$\frac{\partial V_E}{\partial \phi_1} > 0$ so that $\phi_1 = \phi_m > \phi_2$

Then, the R&D incentives are higher in industries with a one-step lead compared to industries with a two-step lead or industries where firms are neck-and-neck



- In the case where $\phi_1 = \phi_m > \phi_2$, increasing γ_2 can increase the share of industries in which the leading firm is one step ahead. However, it also leads to a decrease in ϕ_2 and this effect is stronger than the composition effect, so that average growth decreases.

Possible Perils of Strong Patents

Under full patent protection, incumbents might be able to preempt entry without doing R&D themselves if:

1. Entrants have to pay a fixed (catch–up) cost in order to enter the R&D sector and incumbents can readjust their R&D effort after observing entry
2. Incumbents can hire the most able researchers but make them do other things then R&D instead
3. Incumbents can make ex ante agreements with potential entrants to reduce R&D effort

- In these cases, equilibrium growth is zero under full patent protection
- An intermediate probability of patent enforcement (finite patent length) maximizes average growth (similar to Horowitz and Lai (1996)). Reducing patent breadth/ markups does not have the same effects

Intermediate R&D Inputs

- In order to improve the quality of the good by one step, two R&D stages have to be completed. Again, preemption is possible at each stage.
- Growth is maximal if entrants are allowed to patent intermediate R&D inputs (but not allowed to license them to incumbents) but incumbents are not
- Incumbents still race to invent the intermediate R&D inputs in order to prevent that an entrant patents them. At the second R&D stage, the analysis is the same as above...

Conclusion

- While the current literature focuses on the case of leapfrogging, I analyze the other extreme of persistent leadership
- While R&D incentives are increased in both cases if entrants get considerable market power right upon entry, the effects of leading breadth and of a patentability requirement are different.
- Making patent policy conditional on whether an entrant or an incumbent innovates can stimulate innovation and growth.
- In some cases, an intermediate strength of patent protection maximizes average growth
- The main results are the same if a more general model with increasing profit flows is analyzed
- Restrictions: continuous quality-ladder without initial innovator (different in Chu, Cozzi and Galli (2010)); perfect preemption

Increasing Profit Flows

- Utility is given by: $U(\tau) = \int_{t=\tau}^{\infty} c(t) e^{-\rho(t-\tau)} dt$
- Final good y which can be consumed, used for research or to produce intermediate goods x of which there exist different generations (the newest one indexed by k)
- The final good is produced using labour (in fixed supply) and intermediate goods according to the following production function

$y(k) = X_k^{\alpha}$ with $X_K = \sum_{s=0}^{k} q^s x_s$ and $0 < \alpha < 1$

- Only the newest generation of intermediate goods is in use: $y(k) = q^{k\alpha} x_k^{\alpha}$

- Deriving the demand for the newest intermediate good and assuming that $\alpha q \leq 1 \leq \alpha q^2$, patent holders with a two-step lead charge the unconstrained monopoly price while those with a one-step lead engage in limit pricing
- Profits for generation k of the good are given by

$\pi_1(k) = \pi_1 g^k$ and $\pi_2(k) = \pi_2 g^k$. The Arrow replacement effect is present

- R&D sector: $\phi(k+1) = min\left\{\left(\frac{n}{cg^k}\right)^{\frac{1}{1+\varepsilon}}; \phi_m\right\}$
- Qualitatively, the main results are the same