Economics Letters 118 (2013) 381–384

Contents lists available at SciVerse ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Optimal patent policy, research joint ventures, and growth

Yibai Yang *

Business School and School of Economics, University of Sydney, Sydney, NSW, 2006, Australia

ARTICLE INFO

Article history:
Received 30 July 2012
Received in revised form
1 November 2012
Accepted 2 December 2012
Available online 10 December 2012

JEL classification:
O31
O34
O38

Keywords:
Economic growth
Patent instruments
Research joint ventures

ABSTRACT

The patent-and-growth studies have found that there may be welfare loss without optimizing both patent breadth and the division of profit in competitive research joint ventures (NJs). This paper examines the effects of patent policy on an R&D-based growth model where innovations are produced by cooperative research joint ventures (CJs). We show that CJs always generate a higher equilibrium growth rate than NJs, and the social optimum can be achieved with CJs in equilibrium when only patent breadth is chosen optimally.

1. Introduction

Patent protection is one of the policy systems frequently used by policymakers to stimulate R&D and growth as well as to adjust allocations in a decentralized economy.[1] Additionally, the literature on patent policy and economic growth has investigated research joint ventures (RJVs) to improve a firm's R&D incentives and social welfare.[2] Particularly, Chu and Furukawa (2011) show that in an R&D-based growth model, optimizing a mix of patent instruments including patent breadth and the profit-division rule in *competitive* RJVs is necessary for the economy to achieve the *first-best* outcome in equilibrium. When the profit-division rule is not set optimally (unequal to 1/2), the economy would reach the *second-best* outcome by optimizing only patent breadth.

There is also a stream of literature discussing the asymmetries between partner firms in forming RJVs, such as Veugelers and Kesteloot (1996), Veugelers (1998), and the following papers. They demonstrate that unequal bargaining shares between firms that are asymmetric in size and absorptive capacities are crucial for forming successful joint ventures when the synergy effect is high; equal bargaining could even make joint ventures impossible if partners are too asymmetric. In this case, the optimal division rule of profit in competitive RJVs may not be attained, so the economy could have a lower growth rate than the social optimum, followed by a welfare loss.

To fully consider the optimal patent design, we follow the literature on RJVs along the lines of d'Aspremont and Jacquemin (1988) and Kamien et al. (1992) to incorporate *cooperative* RJVs into the seminal quality-ladder growth model (i.e., Grossman and Helpman (1991)).[3] We show that the equilibrium growth rate is higher with cooperative RJVs than with competitive RJVs. Further, without controlling the profit-division rule, cooperative RJVs will be the preferred regime that helps the economy achieve the first-best outcome by optimizing only patent breadth in equilibrium.

2. The setup

2.1. Preferences and production

Suppose that there is an economy admitting a representative household with preferences

* Tel.: +61 2 9518 6203.
E-mail address: yibai.yang@hotmail.com.

[1] See O'Donoghue and Zweimüller (2004) for the effect of patent policies on an endogenous growth model.

[2] See, for example, Che and Yang (2012) for a cooperative R&D option under patent protection that can always increase firms' incentives to invest in R&D.

[3] Kamien et al. (1992) define cooperative RJVs as an arrangement (RJV cartelization) where firms coordinate their R&D investment to maximize the joint profit, and competitive RJVs as an arrangement (RJV competition) where each firm simultaneously chooses its R&D investment to maximize the individual profit given other firms' R&D expenditures. Partner firms in both cases share the innovation.

0165-1765/$ – see front matter
doi:10.1016/j.econlet.2012.12.001

$$U = \int_0^{\infty} \exp(-\rho t) \ln C_t dt, \tag{1}$$

where C_t is the household's consumption of final goods, and $\rho > 0$ represents the discount rate at time t. There is no population growth and the household supplies a unit of labor with the wage rate W_t that is normalized to unity. Thus, the law of motion for the household's total assets is

$$\dot{\mathcal{A}}_t = R_t \mathcal{A}_t + W_t - P_t C_t, \tag{2}$$

where $\mathcal{A}_t$ denotes the household's assets, R_t is the nominal interest rate, and P_t represents the price of final goods. The household's optimization problem implies the usual Euler equation

$$\frac{\dot{E}_t}{E_t} = R_t - \rho, \tag{3}$$

where $E_t = P_t C_t$ is the (nominal) consumption expenditure. Moreover, the household owns a balanced portfolio of all firms in the economy.

The final good Y_t is produced competitively using a unit continuum of (fully depreciated) machines indexed by variety (line) $i \in [0, 1]$ according to the production function

$$\ln Y_t = \int_0^1 \ln X_t(i) di, \tag{4}$$

where $X_t(i)$ is the quantity of machine line i. We denote $P_t(i)$ as the price of $X_t(i)$ and assume that there is free entry into the final-goods sector. This assumption with (4) gives the demand for machine line i in the final-goods sector such that

$$X_t(i) = \frac{P_t Y_t}{P_t(i)}, \tag{5}$$

where the price of final goods is given by $P_t = \exp\left(\int_0^1 \ln P_t(i) di\right)$ due to cost minimization.

In each variety, machines are produced by a monopolistic leader holding the patent on the latest innovation and are replaced by the products of an entrant who has a new innovation due to *the Arrow replacement effect*. The leader has the following production function for the machines

$$X_t(i) = z^{q_t(i)} L_t(i), \tag{6}$$

where the parameter $z > 1$ measures the size of quality improvement, $q_t(i)$ denotes the number of innovations in machine line i between time 0 and time t, and $L_t(i)$ is the employment level of production labor in this variety. Then (6) implies that the marginal cost of producing machines for the leader in variety i is given by

$$MC_t(i) = \frac{W_t(i)}{z^{q_t(i)}}. \tag{7}$$

Assume that patent protection includes both *lagging* and *leading* patent breadth.[4] Bertrand competition in each machine line implies that the leader charges a *limit price* as a markup over the marginal cost for the machines at time t

$$P_t(i) = \mu_t MC_t(i), \tag{8}$$

where $b_t \in (0, \infty]$ is the degree of patent breadth and $\mu_t = z^{b_t} > 1$ represents patent breadth throughout for simplicity. The case $b_t = 1$ corresponds to complete lagging breadth in Grossman and Helpman (1991). Finally, the leader's profit in machine line i is

$$\Pi_t(i) = \left(1 - \frac{1}{\mu_t}\right) P_t(i) X_t(i) = (\mu_t - 1) W_t L_t(i), \tag{9}$$

where substituting (6)–(8) into $\Pi_t(i)$ yields the second equality.

[4] See O'Donoghue and Zweimüller (2004) for a discussion on the patentability requirement and leading patent breadth.

2.2. Innovations and RJVs

The value of owning a machine of variety i is denoted as $V_t(i)$. Following the standard literature, a symmetric equilibrium yields $\Pi_t(i) = \Pi_t$ and $V_t(i) = V_t$ for $i \in [0, 1]$. Denote λ_t as the *aggregate-level* Poisson arrival rate of innovation. Thus, the Hamilton–Jacobi–Bellman (HJB) equation for V_t is given by

$$R_t V_t = \Pi_t + \dot{V}_t - \lambda_t V_t, \tag{10}$$

which is the no-arbitrage condition for the asset value. In equilibrium, the return on this asset $R_t V_t$ equals the sum of the flow payoffs Π_t, the capital gain $\dot{V}_t$, and the capital loss $\lambda_t V_t$ if the technological leadership is replaced.

New machine vintages are invented by two types of complementary R&D activities: basic R&D and applied R&D, which are performed by basic research firms and applied research firms, respectively. There is a unit continuum of each type of firms indexed by $j \in [0, 1]$. A successful innovation comes from an RJV consisting of the two types of R&D firms with the same index j. The *firm-level* arrival rate of innovation $\lambda_t(j)$ follows a Cobb–Douglas functional form

$$\lambda_t(j) = \varphi(H_{1,t}(j))^{\alpha} (H_{2,t}(j))^{1-\alpha}, \tag{11}$$

where $H_{1,t}(j)$ ($H_{2,t}(j)$) is the research labor employed by the j-th basic (applied) R&D firm, and $\alpha \in (0, 1)$ is the relative factor share of the R&D activities.

RJVs can be undertaken in a *cooperative* form such that two types of R&D firms coordinate their research decisions and conduct joint profit maximization. After a successful innovation, the firms sell the patent to a machine producer and share the joint profit by a division rule $s_t \in (0, 1)$ according to a bargaining outcome.[5] Hence, the expected joint profit of the j-th firms is

$$\hat{\pi}_t(j) = V_t \lambda_t(j) - W_t[H_{1,t}(j) + H_{2,t}(j)]. \tag{12}$$

The expected profit of the j-th basic (applied) R&D firm is $\pi_{1,t}(j) = s_t \hat{\pi}_t(j)$ ($\pi_{2,t}(j) = (1 - s_t)\hat{\pi}_t(j)$).

In equilibrium, the aggregate-level arrival rate of innovation equals the firm-level one (for each machine line), namely, $\lambda_t = \lambda_t(j)$.[6] In addition, as is usual in the R&D-based growth models, we assume that there is free entry into research (RJVs) driving the R&D firms' profit to zero. Thus, with (11), the zero-expected-profit conditions for research are given by

$$\alpha V_t \lambda_t = W_t H_{1,t}, \tag{13}$$

$$(1 - \alpha) V_t \lambda_t = W_t H_{2,t}, \tag{14}$$

where the effect of the profit-division rule s_t is not included. These equations immediately yield the equilibrium ratio of research labor such that

$$\frac{H_{1,t}}{H_{2,t}} = \frac{\alpha}{1 - \alpha}. \tag{15}$$

[5] Chu and Furukawa (2011) refer to competitive RJVs in the Grossman–Helpman growth model as a regime where each research firm simultaneously chooses its R&D labor level to maximize the individual profit given the partner's R&D decision, and the partner firms share the patent value of a successful innovation by a profit-division rule s_t.

[6] This symmetry also holds for the research labor and the R&D firms' expected profit, i.e., $H_{k,t} = H_{k,t}(j)$ and $\pi_{k,t} = \pi_{k,t}(j)$, where $k = 1, 2$.