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Effects of intellectual property rights protection and integration on economic growth and welfare

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Effects of Intellectual Property Rights Protection and Integration on Economic Growth and Welfare

Chung-hui Lai and Vey Wang

Abstract

The protection of intellectual property rights (IPR) and the distribution of rent are central issues in R&D-based growth models with the return to innovation serving as the engine of growth. In this paper the authors consider the strength of the intellectual property rights and franchise bargaining system to analyze how the rent/franchise fee and institutional quality affect the economic growth and social welfare. It is found that the intermediate good firm with full IPR protection charges a price equal to the marginal cost. In addition, if imitated technologies exhibit a labor spillover effect, decreasing the IPR protection will increase the rent/franchise fee. The authors also show that the growth-maximizing effects of IPR protection, the bargaining power of intermediate goods firms, and the imitation of technology are no longer equivalent to those effects on welfare-maximization since the welfare result depends on the relative degrees of the growth enhancing effect and crowding-out effect on production.

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Keywords IPR; R&D; bargaining; endogenous growth; social welfare

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1 Introduction

Research has examined the costs and benefits of IPR protection and its effects on innovation and growth. Specifically, in the literature on economic growth the protection afforded by the patent law is set either on a permanent basis or applies until a brand new product is invented. However, while patents are permanently protected, deadweight losses exist due to monopoly pricing. The seminal paper of Judd (1985) establishes an exogenous growth model in a dynamic general equilibrium framework and shows how permanent patents maximize social welfare. Helpman (1993) and Kwan and Lai (2003) emphasize the government's choice of the degree of IPR protection. Iwaisako and Futagami (2003) prove that the patent length that maximizes the social welfare is finite. Futagami and Iwaisako (2007) consider the dynamic properties of a growth model with finite patent length, and further show that an infinite patent length cannot maximize social welfare. Furukawa (2007) shows that IPR protection cannot induce growth enhancing if there exists a stronger effect of IPR on the productivity of the final good sector. Horii and Iwaisako (2007) use empirical data from 1966 to 2000 to indicate that it is difficult to find a positive relationship between IPR protection and the growth rate. However, Gould and Gruden (1996) find support for a positive but 'weak' relationship between IPR protection and growth. Eicher and García-Penalosa (2008) endogenize the strength of the IPR and show how private incentives of IPR affect economic development and growth. Most of the studies in the literature show that enhancing the protection of IPR increases the expected duration of a monopoly and the associated incentive to innovate. Therefore a large incentive to innovate helps the growth rate. Therefore, it is important to investigate the effects of intellectual property rights (IPR) protection on economic growth and welfare.

However, there are few studies that discuss IPR protection within the franchise fee bargaining mechanism. Not only does IPR protection, but also the acquisition of rents, play an important role in R&D-based growth models. The stronger IPR protection should indeed translate into a higher franchise fee. For instance, Ferrantino (1993) as well as Yang and Maskus (2001) find that the license fees perceived by American firms in different foreign countries are positively correlated with the level of patent protection offered in the partner country.¹ Moreover, Pfister et al. (2006) mention that Forby's Guide Survey indicates that the highest franchising rates can be found in Switzerland (78%), Germany (78%) and Great Britain (77%). Therefore, within the franchise system, as the IPR protection increases and competition decreases, the franchisee should be willing to pay higher sums for the varieties. A higher franchise fee paid to the franchisor implies that the intermediate goods firms obtain more profit through the return to innovation, and hence the higher the economic growth rate rises. In this paper we will incorporate the IPR protection in a franchise system economy (Wang et al., 2010) and try to analyze how the IPR protection influences the rent/franchise fee and further drives the growth and social welfare.

In contrast to Romer (1990), Wang et al. (2010) point out that the imperfect competition market structure of final goods is a key factor in the R&D-based endogenous growth model. They also support the benign effect of imperfect competition on economic growth and indicate that the firms producing final goods and intermediate goods engage in backward integration which is pointed out by Minkler and Park (1994) to be beneficial to economic growth. However, they do not

¹ See Wang et al. (2010).

consider the possibility of IPR protection or discuss the effect of vertical integration on social welfare. Based on the above points of view, we try to extend Wang et al. (2010)'s model by introducing the role of IPR protection and explain the effects of IPR and vertical integration on economic growth and welfare.

In this paper, we present a three-stage model. In the first stage, the final goods firms and the intermediate goods firms negotiate the franchise fee and the price of the intermediate goods on the franchising contract according to the Nash efficient bargaining framework. In other words, the intermediate goods firms no longer have full bargaining power to determine the prices of the intermediate goods as in the traditional R&D endogenous growth model. The final goods firms facing a monopolistic competitive market can only partially decide the prices of intermediate goods through bargaining. In the second stage, the final goods firms set the prices of the final goods to maximize their profits. In the third stage, the consumers determine the expenditure plan to maximize their utility. We will proceed by solving the model backwards.

2 The model

We expand the R&D growth models of Benassy (1998) and Wang et al. (2010) with successively imperfectly competitive economies and consider the possibility that IPRs are imperfectly protected.

2.1 IPR

According to Eicher and García-Penalosa (2008), the imperfect protection of intellectual property rights in relation to R&D is captured by the degree of IPR enforcement, denoted by $q \in [0, 1]$. q represents the probability that the inventor can enforce his/her patent in court and prevent imitation. If the innovator cannot enforce a patent in court, the intermediate goods will be imitated. This implies that the expected value of R&D equals qp_A where p_A refers to the value of a new blueprint. We treat the level of enforcement as exogenous institutional quality and discuss its effect on growth and welfare.

2.2 The intermediate goods sector

There are n intermediate goods firms that purchase the blueprint and operate in a monopolistically competitive industry. Each intermediate good can be produced under two possible scenarios. (i) If the technology is fully protected, only one single producer exists and we assume that the production of one unit of the intermediate good requires one unit of labor. Therefore, the production function can be presented as $x_i^M = l_i^x$. (ii) If enforcement of a patent right is lacking, the intermediate good will be copied by other firms and be produced by a competitive fringe. We suppose that there is no cost of imitation. However, since a copied technology comes with no need for blueprints or any support from the R&D sector, it is assumed that the average product of labor in the production of intermediate goods equals $1/b$ ($x_i^E = (1/b)l_i^x$). When $b < 1$, there exists a cost differential for imitated technologies and the smaller b is, the larger the cost differential will become. When we consider the possibility of labor spillover effect, labor may move from a patent-protected company to an imitated technology company. Therefore, the labor cost for the imitated technology company decreases if it hires its labor from the patent protected company. Hence once there exists a labor spillover effect, $b > 1$.

Accordingly, we can rewrite the production function for the representative

intermediate goods firm as $x_i = qx_i^M + (1-q)x_i^E = [(bq+1-q)/b]l_i^x$. Each intermediate goods firm produces and sells a variety x_i to all m final goods firms, taking the actions of all other producers in the intermediate goods sector as given². Its profit function is

$$\pi_i = m(p_i^x x_i - wl_i^x + f_i) \quad (1)$$

where p_i^x is the price of intermediate goods i , w is the common wage rate under the assumption of perfect mobility for labor, l_i^x is the labor hired by firm i , f_i is the franchise fee received from the final goods firms, and m is the number of different varieties in the final goods market.³

2.3 R&D sector

The number of intermediate goods can be increased by undertaking research through the labor input. Hence the production function in the R&D sector is given by

$$\frac{\dot{n}}{n} = L_A \quad (2)$$

where L_A is the amount of labor hired in the R&D sector, and \dot{n} is the number of newly-created blueprints.

2.4 The final goods market

We assume the final goods market is monopolistically competitive. Firm j produces y_j by using a continuum of intermediate goods. Following Dixit and Stiglitz (1977) the production function for final goods is designed by:

$$y_j \equiv n^\mu \left(n^{-1} \int_0^n x_{ij}^\alpha di \right)^\alpha, \quad \alpha > 1, \quad \mu \geq 1 \quad (3)$$

where x_{ij} represents the amount of intermediate goods i used by firm j . $i \in [0, n(t)]$ is the range of intermediate goods existing at time t . $\mu > 1$ implies returns to specialization. $-1/(1-\alpha)$ represents the elasticity of substitution between intermediate goods.

The producer j chooses output price p_j to maximize its profit

$$\Pi_j = p_j y_j - \int_0^n p_{ij}^x x_{ij} di - \int_0^n f_{ij} di \quad (4)$$

subject to the output demand function from households, and the production technology Eq. (3).

2.5 Households

The representative household maximizes its instantaneous log-form utility function in every period

$$U(C) = \ln C \quad (5)$$

where composite consumption good C with the type of monopolistic competition CES functional form following Dixit and Stiglitz (1977) is defined by

² To simplify the notation, the time arguments will all be dropped.

³ To simplify the analysis, we assume that the franchise fee received from final goods firms is identical to that in all other contracts.

$$C \equiv m^\eta \left(m^{-1} \int_{j=0}^m c_j^{(\sigma-1)/\sigma} dj \right)^{\sigma/(\sigma-1)}, \quad \sigma > 1, \quad \eta \geq 1 \quad (6)$$

Eq. (5) denotes a unitary elasticity utility function, C consists of a bundle of closely-related product varieties according to Eq. (6), η captures the consumer preference for diversity, and c_j is a consumption good of variety j . Commodities supplied by different producers are imperfect substitutes with a constant elasticity of substitution σ . $j \in [0, m]$ represents the varieties produced by different final goods firms.

The household faces the following second stage budget constraint

$$PC = \int_{j=0}^m p_j c_j dj \quad (7)$$

where PC is total spending on consumption goods; P is the aggregate consumption price index and will be derived latter.

3 The market solution

Backward solutions are applied to obtain the market solution. In the final stage, the household chooses its consumption levels of available product varieties, c_j , for utility maximization, given the definition of composite consumption in Eq. (6) and the budget constraint Eq. (7). The optimal consumption level of variety j is obtained:

$$c_j = m^{-(\sigma+\eta)+\eta\sigma} \left(\frac{p_j}{P} \right)^{-\sigma} C \quad (8)$$

where

$$P = m^{-\eta} \left(m^{-\sigma} \int_0^m p_j^{1-\sigma} dj \right)^{1/(1-\sigma)} \quad (9)$$

Eq. (8) gives the downward sloping demand curve for good j . Eq. (9) expresses the aggregate consumption price index.

In the second stage,⁴ the final goods firm sets the price of final goods to maximize its profit as in Eq. (4) with a production constraint, Eq. (3). To satisfy the optimal condition we can derive the final goods price which is determined by:

$$p_j = \frac{\sigma}{n^{\mu-1}(\sigma-1)} p_{ij}^x \quad (10)$$

The pricing rule shows that the final good price depends on market power $\sigma/(\sigma-1)$, the degree of returns to specialization (μ), and the prices of intermediate goods (p_{ij}^x). Obviously the final goods firm sets its price according to the markup pricing rule, which is similar to the result derived from the traditional model of successively monopolistic competition and expanding-variety-type R&D endogenous growth models, while the intermediate goods firm maintains the full strength of patent protection.

In the first stage, it is assumed that the final goods firms and intermediate goods firms negotiate on the franchise fee and the price of the intermediate goods according to the Nash efficient bargaining framework. Therefore the franchising contract (p_j^x, f_j) is bargained according to

$$\max_{p_j^x, f_j} N = (\Pi_j - \Pi_j^0)^\theta (\pi_i - \pi_i^0)^{1-\theta} \quad (11)$$

⁴ From the symmetry perspective, we have $x_{ij} = x_j$, $p_{ij}^x = p_j^x$, $\forall i$, in equilibrium.

θ describes the bargaining power of the final goods firm j and its value lies in the interval $[0, 1]$.⁵ When $\theta \rightarrow 0$ the model reduces to a forward integration case in which the intermediate goods firm i with full bargaining power decides the intermediate goods price. To keep the analysis simple, we assume that there exists an identical bargaining power for all final goods firms with decentralized status. The same is true for the intermediate goods firms.

Proposition 1 (i) *The price of intermediate goods will be set by marginal cost if the technology is perfectly protected.* (ii) *In the forward integration case, the intermediate goods firm with full bargaining power will extract all the rent.*

According to the Nash bargaining solutions derived by maximizing Eq. (11), the optimal franchise fee and intermediate price are shown as follows

$$p^x = \frac{b}{bq + (1-q)} w \quad (12)$$

$$f = \frac{(1-\theta)}{n} \left[\frac{1}{n^{\mu-1}(\sigma-1)} \frac{b}{bq + (1-q)} w \right] m^{-(\sigma+\eta)+\eta\sigma} \left(\frac{\sigma}{P} \frac{b}{n^{\mu-1}(\sigma-1)bq + (1-q)} w \right)^{-\sigma} Y \quad (13)$$

Eq. (12) states the pricing rule for intermediate goods. In a way that is different from Wang et al. (2010), we find that the price of intermediate goods will be set by the marginal cost as in the case of the socially optimal outcome if the technology is perfectly protected when $q \rightarrow 1$. If there is no patent awarded, this means that as $q \rightarrow 0$ the price of intermediate goods will be directly related to the cost differential ($b < 1$) or the labor spillover effect ($b > 1$). (i) If the imitation gives rise to a huge cost differential ($b \rightarrow 0$), the price of the intermediate goods will be far below the marginal cost; (ii) on the other hand, when the imitation exhibits a labor spillover effect, $b > 1$, the price of intermediate goods will be set by the markup. Compared to most of the literature for which the results of markup prices for the intermediate goods are derived based on the R&D growth model, we obtain a general solution for intermediate goods pricing that is set simultaneously by firms producing final goods and intermediate goods through bargaining.

In addition, Eq. (13) indicates that the optimal franchise fee depends on the bargaining power θ , the degree of technology protection q , and the cost differential b . The intermediate goods firm i with full bargaining power ($\theta \rightarrow 0$) will extract all the rent, namely, forward integration. On the contrary, the fee will vanish if the intermediate goods firm i has no bargaining power ($\theta \rightarrow 1$), namely, backward integration. The stronger IPR protection will increase the franchise fee if imitated technologies have a cost differential ($b < 1$). On the other hand, the weaker IPR protection will enhance the franchise fee if imitated technologies have a labor spillover effect ($b > 1$). This implies that the IPR protection is not necessarily completed for increasing the franchise fee to drive the economic growth.⁶

Accordingly, Eqs. (9) and (10) can be rewritten as

⁵ The outside option is assumed to be zero ($\Pi_j^0 = \pi_i^0 = 0$) because once they quit bargaining they are not able to produce anything (Binmore et al., 1986). In this case, the final goods firms have to purchase the goods from intermediate goods firms.

⁶ See Appendix A.

$$P = \frac{\sigma}{m^{\eta-1}n^{\mu-1}(\sigma-1)} \frac{b}{bq+(1-q)} w \quad (14)$$

$$p_j = \frac{\sigma}{n^{\mu-1}(\sigma-1)} \frac{b}{bq+(1-q)} w \quad (15)$$

And the profits can be derived as

$$\Pi = \theta \frac{1}{m^{\eta-1}n^{\mu-1}(\sigma-1)} \frac{b}{bq+(1-q)} wY \quad (16)$$

$$\pi = (1-\theta) \frac{1}{n} \frac{1}{m^{\eta-1}n^{\mu-1}(\sigma-1)} \frac{b}{bq+(1-q)} wY \quad (17)$$

If firm j is weaker than firm i in terms of the bargaining power of the franchising contract, more of the rent will be distributed to the intermediate goods firm. If imitation involves a cost saving ($b > 1$) the firms will make more profits although the enforcement of a patent right will be lacking.

The free entry condition in the R&D sector implies that the blueprint cost or value is as follows

$$p_A = \frac{w}{qn} \quad (18)$$

Eq. (18) indicates that the value of the blueprint is equal to its cost. p_A is the value of a new blueprint.

4 Growth

For a discussion on economic growth we further assume that the household maximizes its life-long discounted utility. The representative household is infinitely lived and endowed with a constant aggregate flow of labor L supplied inelastically. The household's discounted utility is given by

$$V = \int_0^{\infty} e^{-\rho t} U(C) dt \quad (19)$$

where ρ is the constant rate of time preference.

The budget constraint, describing the sum of spending on consumption goods and investment in new blueprints, is equal to the sum of labor income and the profits received from the intermediate goods firms and the final goods firms. It is therefore given by

$$PC + p_A \dot{n} = wL + n\pi + m\Pi \quad (20)$$

To maximize the household's discounted utility and subject to the budget constraint, we can obtain

$$\frac{\dot{C}}{C} = \frac{\pi}{p_A} + \frac{\dot{p}_A}{p_A} - \rho - \frac{\dot{P}}{P} \quad (21)$$

Eq. (21) indicates that the return on blueprints/investment, which includes the dividend (π) plus the capital gains (\dot{p}_A) expressed in terms of the blueprint minus the rates of time preference and inflation, equals the real consumption growth rate.

Now we have to find the equilibrium outcomes in the labor market and final goods market. First, the labor market equilibrium condition states that total labor demand is equal to total labor supply ($L_x + L_A = L$), and labor is perfectly mobile across the intermediate goods sector and the blueprint industry. Since the quantities of labor allocated to the intermediate goods sector and the R&D industry are $L_x = \{mn[bq+(1-q)]/b\}l^x$ and $L_A = \dot{n}/n$, respectively, the labor market equilibrium

condition will be rewritten as

$$\frac{\dot{n}}{n} = L - mn \frac{bq + (1-q)}{b} l^x \quad (22)$$

Secondly, the equilibrium condition for the final goods market is:

$$C = Y = m^{\eta-1} n^{\mu-1} L_x \quad (23)$$

Eqs. (14)-(18) and (21)-(23) fully define the dynamics of the economy. Therefore we can determine the growth rate of the economy. According to Eqs. (15)-(18), we obtain

$$\frac{\dot{p}_A}{p_A} = (\mu - 2) \frac{\dot{n}}{n} + \frac{\dot{P}}{P} \quad (24)$$

$$\frac{\pi}{p_A} = \frac{1-\theta}{\sigma-1} \frac{bq}{bq+(1-q)} L_x \quad (25)$$

From Eqs. (21)-(25), we derive the dynamic equation for L_x

$$\frac{\dot{L}_x}{L_x} = \left[\frac{1-\theta}{\sigma-1} \frac{bq}{bq+(1-q)} + 1 \right] L_x - L - \rho \quad (26)$$

Since the coefficient $[(1-\theta)bq/(\sigma-1)(bq+1-q)]+1$ is positive, Eq. (26) represents a differential equation with a divergent solution. This means that L_x jumps to a steady state immediately. Its steady state value is

$$\tilde{L}_x = \frac{1}{\frac{1-\theta}{\sigma-1} \frac{bq}{bq+(1-q)} + 1} (L + \rho) \quad (27)$$

and therefore a constant growth rate γ_c is as follows

$$\gamma_c = (\mu - 1) \left[L - \frac{1}{\frac{1-\theta}{\sigma-1} \frac{bq}{bq+(1-q)} + 1} (L + \rho) \right] > 0, \quad \gamma_c = \gamma_Y = (\mu - 1) \gamma_n \quad (28)$$

where $\partial \gamma_c / \partial q > 0$, $\partial \gamma_c / \partial (1-\theta) > 0$ and $\partial \gamma_c / \partial b > 0$.

Proposition 2 *The stronger that the IPR protection is, the greater the bargaining power that the intermediate goods firm has, and the greater the labor spillover effect of imitation, the more the economy grows.*

We can conclude that the stronger the level of IPR protection, the greater the bargaining power of the intermediate goods firm or the higher the labor spillover effect, the higher the economic growth.⁷ An increase in IPR protection will enhance the rate of economic growth through two effects. On the one hand, the stronger IPR protection increases the expected value of an innovation. However, on the other hand, the stronger IPR protection and higher rate of economic growth reduces the demand for employment in manufacturing intermediate goods and hence the wage. Both effects increase the incentives for investment in research. The reason why an increase in the bargaining power $(1-\theta)$ of the intermediate goods sector will improve the economic growth ($\partial \gamma_c / \partial (1-\theta) > 0$) is that the intermediate goods firms will increasingly engage in innovation when they can extract more rent/franchise fees from

⁷ See Appendix B.

the final goods market. A reduction in the cost differential for imitated technology will enhance the economic growth ($\partial\gamma_c/\partial b > 0$), especially as the higher labor spillover from imitation further enhances economic growth.

The elasticity of substitution σ also plays an important role in the growth. Its effect is negative ($\partial\gamma_c/\partial\sigma < 0$). It explains how the imperfect competition will foster economic growth. In other words, the market power of the final goods firm is beneficial to the growth rate of the economy.

5 Welfare analysis

We have discussed how institutional quality, bargaining power and the cost differential affect the level of output and the rate of economic growth. To understand their effects on social welfare, we first integrate the utility function (19) over time to express the welfare function as

$$V = \frac{1}{\rho} \ln C_0 + \gamma_c \frac{1}{\rho^2} \quad (29)$$

where C_0 is the initial balanced growth equilibrium level of consumption which is obtained from Eqs. (23) and (27).

Proposition 3 *The welfare effects of IPR protection, the bargaining power, and imitation of labor spillover depend on the relative degrees of the growth enhancing effect and crowding-out effect of production.*

Differentiating Eq. (29) with respect to q yields

$$\frac{\partial V}{\partial q} = \frac{1}{\rho} \underbrace{\frac{\partial \ln C_0}{\partial \ln \tilde{L}_x} \frac{\partial \tilde{L}_x}{\partial q}}_{(-)} + \frac{1}{\rho^2} \underbrace{\frac{\partial \gamma_c}{\partial q}}_{(+)} \quad (30)$$

The last term on the right-hand side of Eq. (30) captures the positive direct effect of IPR on welfare through growth which allows for higher consumption in the future. However, the first term shows the negative crowding-out effect of IPR on initial consumption.

Eq. (30) indicates that the effect of IPR protection on social welfare depends on the relative degree of IPR effects on economic growth and initial consumption. Only if the growth effect is larger than the consumption effect will the IPR protection enhance social welfare. The trade-off between these two effects was formalized by Grossman and Lai (2004) and Eicher and García-Penalosa (2008), and they showed that the socially optimal degree of enforcement is not necessarily full enforcement.

Differentiating Eq. (29) with respect to θ yields

$$\frac{\partial V}{\partial \theta} = \frac{1}{\rho} \underbrace{\frac{\partial \ln C_0}{\partial \ln \tilde{L}_x} \frac{\partial \tilde{L}_x}{\partial \theta}}_{(+)} + \frac{1}{\rho^2} \underbrace{\frac{\partial \gamma_c}{\partial \theta}}_{(-)} \quad (31)$$

Eq. (31) indicates that the effect of bargaining power on welfare is ambiguous. If the growth effect is stronger/weaker than the consumption effect, the final goods and intermediate goods firms that engage in forward/backward integration will enhance social welfare. This is because forward integration leads the intermediate goods firms to have a greater profit incentive to invest in research and speed up the growth rate of the economy. This innovation effect is larger than that which leads to the crowding out of the consumption effect. If the consumption effect is stronger than the growth effect,

the final goods and intermediate goods firms that engage in backward integration will enhance social welfare. In this case, backward integration which raises the production level will dominate the growth effect.

Differentiating Eq. (29) with respect to b yields

$$\frac{\partial V}{\partial b} = \frac{1}{\rho} \underbrace{\frac{\partial \ln C_0}{\partial \ln \tilde{L}_x} \frac{\partial \tilde{L}_x}{\partial b}}_{(-)} + \frac{1}{\rho^2} \underbrace{\frac{\partial \gamma_C}{\partial b}}_{(+)} \quad (32)$$

Eq. (32) indicates that if the growth effect of the cost differential is greater than the consumption effect, a decrease in the cost differential (i.e., the larger b) of the imitation will increase the social welfare. Moreover, the stronger labor spillover effect of imitation will speed up the social welfare. Otherwise, in the case where the growth effect is smaller than the consumption effect, the larger cost differential (i.e., a lower b) will increase the social welfare.⁸

6 Conclusion

This paper develops an R&D-driven endogenous growth model and analyzes the effects of IPR protection on growth and welfare in a bargaining franchise fee system. We find that the price of intermediate goods is charged according to the marginal cost if the technology is perfectly protected while there is no imitation, no cost differential and no labor spillover effect. In the forward integration case, the intermediate goods firm with full bargaining power will extract all the rent. As a result, the government may adopt a policy to increase the relative bargaining power of the intermediate goods firms. The more bargaining power the intermediate goods firms have, the more rent that will be extracted from the final goods firms. Therefore, the intermediate goods firms will be inclined to invest more in R&D even when they adopt marginal cost pricing.

The stronger that the IPR protection is, the greater the bargaining power that the intermediate goods firm has, and the higher the labor spillover effect of imitation, the more the economy will grow. The growth effect of IPR protection and the growth effect of forward integration exhibit a positive relationship with each other. A decreasing cost differential, or an increasing labor spillover of imitation, tends to push the growth rate of the economy upwards.

We have also examined the welfare effects of IPR protection, vertical integration, and the cost differential or labor spillover of imitation. The welfare effects of IPR protection, the bargaining power and the imitation of labor spillover depend on the relative degrees of the growth enhancing effect and crowding-out effect of production. If the growth effect dominates the consumption effect, the firms engage in forward integration and stronger IPR protection will enhance the social welfare. If the consumption effect is larger than the growth effect, the greater cost differential will result in the social welfare being further enhanced.

Appendix A

Differentiating Eq. (15) with respect to q yields

$$\frac{\partial f}{\partial q} = \frac{(1-\theta)}{n} \frac{1}{n^{\mu-1}(\sigma-1)} \frac{-b(b-1)}{[bq+(1-q)]^2} \omega m^{-\eta} Y > 0 \quad \text{if } b < 1 < \quad (A1)$$

⁸ See Appendix C.

Appendix B

Differentiating Eq. (28) with respect to q , θ , and b respectively yields

$$\frac{\partial \gamma_C}{\partial q} = (\mu - 1) \frac{1}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} \frac{1-\theta}{(\sigma-1)} \frac{b}{[bq + (1-q)]^2} (L + \rho) > 0 \quad (\text{B1})$$

$$\frac{\partial \gamma_C}{\partial \theta} = (\mu - 1) \frac{-1}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} \frac{1}{(\sigma-1)} \frac{bq}{bq + (1-q)} (L + \rho) < 0 \quad (\text{B2})$$

$$\frac{\partial \gamma_C}{\partial b} = (\mu - 1) \frac{1}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} \frac{1-\theta}{(\sigma-1)} \frac{q(1-q)}{[bq + (1-q)]^2} (L + \rho) > 0 \quad (\text{B3})$$

Appendix C

Differentiating Eq. (29) with respect to q , θ , and b respectively yields

$$\frac{\partial V}{\partial q} = \frac{1}{\rho} \frac{-\frac{1-\theta}{(\sigma-1)} \frac{b}{[bq + (1-q)]^2}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} + \frac{1}{\rho^2} \frac{(\mu-1) \frac{1-\theta}{(\sigma-1)} \frac{b}{[bq + (1-q)]^2}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} (L + \rho) \begin{matrix} > \\ < \end{matrix} 0 \quad (\text{C1})$$

$$\frac{\partial V}{\partial \theta} = \frac{1}{\rho} \frac{\frac{1}{(\sigma-1) bq + (1-q)} \frac{bq}{bq + (1-q)}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} + \frac{1}{\rho^2} \frac{-(\mu-1) \frac{1}{(\sigma-1) bq + (1-q)} \frac{bq}{bq + (1-q)}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} (L + \rho) \begin{matrix} > \\ < \end{matrix} 0 \quad (\text{C2})$$

$$\frac{\partial V}{\partial b} = \frac{1}{\rho} \frac{-\frac{1-\theta}{(\sigma-1)} \frac{q(1-q)}{[bq + (1-q)]^2}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} + \frac{1}{\rho^2} \frac{(\mu-1) \frac{1-\theta}{(\sigma-1)} \frac{q(1-q)}{[bq + (1-q)]^2}}{\left[\frac{(1-\theta) bq}{(\sigma-1) bq + (1-q)} + 1 \right]^2} (L + \rho) \begin{matrix} > \\ < \end{matrix} 0 \quad (\text{C3})$$

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