INTERNATIONAL HARMONIZATION OF INTELLECTUAL PROPERTY RIGHTS: CLOSING THE TECHNOLOGY GAP

by

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Abstract

This paper presents an endogenous growth model for two regions with asymmetric initial stocks of knowledge. The novel features of the paper lie in modelling the differentiation of regions into an innovator and an imitator as endogenous, and analyzing optimal intellectual property rights (IPRs) for the imitator's catching-up. Weak IPR protection and a high imitation rate allow the initially knowledge-scarce imitator region to accumulate sufficient knowledge and switch to innovation, at which time tight IPRs become socially optimal. Policy implications for the international harmonization of IPRs under are assessed in light of the theoretical results.

JEL Codes: F1, L1, O3
Key Words: innovation, imitation, intellectual property rights

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South lead to lower innovation in the North and higher imitation rates in the South in equilibrium.

Helpman's (1993) paper makes a path-breaking contribution by examining welfare effects of strengthening IPR protection in an endogenous growth framework. The developed North continuously innovates new product varieties using labor and knowledge capital while the developing South imitates at a given rate. With a lower wage rate, the South has a cost advantage in manufacturing. As the innovation experience and knowledge stock grow in the North, the productivity of innovative R&D increases as well. The innovation rate depends on regional size, technology and demand parameters, and South's IPRs, while the imitation rate is inversely related to the strength of IPR protection in the South.

With costless and exogenous imitation in Helpman's model, the South never gains by tightening IPRs as the South's terms of trade deteriorate due to the reallocation of manufacturing towards higher priced Northern goods. Endogenous changes in the Northern innovation rate and the resulting product variety changes are insufficient to offset South's welfare losses. Since the South does not accumulate knowledge capital in this model, it always remains an imitator. The North gains from tightening South's IPRs if the imitation rate is high, since an improvement in North's terms of trade outweighs the decline in product availability due to the endogenous adjustment of the innovation rate. When the imitation rate in the South is low, however, the terms of trade effect is small and the North looses from strengthening South's IPRs. With a substantial Northern direct investment in the South, the terms of trade effects are absent, but the regions still have conflicting interests with respect to tightening IPRs in the South.

Surprisingly few models in the literature consider the evolution of countries from imitation to innovation and the role of IPRs. One exception is Chou and Shy's (1991) overlapping generations model, in which countries have different starting points in the development of new products. The model demonstrates that government subsidies raise imitation and innovation rates and allow the developing country to catch up and even leapfrog the developed country. A similar finding results from Grossman and Helpman's (1991, Ch. 8) model of two countries with different prior research experience. In the endogenous growth model, the technologically-leading country specializes in the innovation and production of varieties of horizontally differentiated goods in a steady-state equilibrium. A traditional homogenous good is manufactured under constant returns to scale in the country with the lowest unit production costs. With R&D subsidies, the technologically lagging country can catch up and become a leader. Grossman and Helpman's (1991, Ch. 8) paper, however, concentrates on the technological race between innovators and does not analyze the catching-up of an imitator country.

The focus of the present paper is on the evolution of IPR protection as a developing region catches up or moves from imitative to innovative R&D. We develop a two-region endogenous growth model with innovation and imitation of horizontally differentiated product varieties treating imitation in the South as endogenous. A novel feature of this paper lies in modelling the differentiation of countries into innovators and imitators as endogenous. The differential between regional knowledge stocks determines the relative productivity of innovative and imitative R&D. Initially regional knowledge stocks are asymmetric and it is more productive for the South with a smaller stock to imitate rather than to innovate. As the South learns how to produce more product varieties, its knowledge stock increases. When the knowledge stock becomes sufficiently high -- so that the productivity of the innovative R&D exceeds that of imitative R&D -- the imitator initiates innovation. As does Helpman, we find that strengthening IPRs in an imitating region reduces imitation and innovation rates, and causes the reallocation of production to the innovating region with higher marginal costs than the imitating region.

In contrast to the existing literature with an *a priori* differentiation of regions into innovators and imitators (Chin and Grossman 1990, Grossman and Helpman 1991, Ch. 11; Taylor 1994, Helpman 1993), we find the South can catch up and become an innovator if it imitates at a sufficiently high rate relative to the North's innovation rate.[2] Given strong IPR protection in the North, the weaker is Southern IPR protection the faster is the rate of

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[2] This result is consistent with Chou and Shy's (1991) model of overlapping generations where the technology gap is also defined in terms of product varieties.

imitation and the accumulation of knowledge. When the South switches to innovation, it strengthens IPR protection to sustain the innovator status in the long-run.[3]

These findings are especially significant when considering the impact of various global IPR agreements on the accumulation of knowledge and the incentives to innovate in developing nations. Premature strengthening IPR protection imposes a penalty on imitating nations by slowing the rate of formation of production knowledge. This reduces the incentive to innovate and hence delays or even eliminates the possibility of catching up to the North in product innovation. Thus, IPR harmonization may have a permanent "lock-in" effect on economic development as nations that might otherwise evolve to be innovators with high IPR protection are prevented from gaining sufficient knowledge through imitation to provide the impetus for innovation.

The rest of the paper is organized as follows. A two-region endogenous growth model with innovation and imitation of product varieties is described in section 2. We explore conditions for South's switching from imitation to innovation in section 3. Section 4 considers steady-state equilibria and comparative statics with respect to changes in regional IPRs. Endogenous IPR protection in the South for a given IPR protection in the North is analyzed in section 5. Section 6 concludes the paper and suggests policy implications for IPR harmonization within the World Trade Organization (WTO).

2. The Model

We develop a two-region endogenous growth model with innovation and imitation of product varieties in the style of Helpman (1993), and Grossman and Helpman (1991, Ch. 11). In each of the two regions, North and South, profit-maximizing firms engage in monopolistic competition to satisfy the world consumer demand for product variety. Each firm hires labor

[3] A similar pattern of IPRs emerges from La Croix's (1992) model where IPRs are driven by changes in the political economy balance rather than the technological gap.

to manufacture a product brand according to a blueprint. The North innovates blueprints, while the South either innovates blueprints or imitates Northern blueprints. Both innovative and imitative research and development (R&D) require labor as an input and depend on the regional level of IPR protection. The relative experience of the South in R&D determines whether the South is an imitator or innovator. Initially the South has much less R&D experience than the North and hence the South imitates. Regional economies reach a general equilibrium where supply equals demand in the markets for blueprints, final goods and labor, and no-arbitrage conditions hold in the financial markets. We now turn to a detailed description of the model.

Consumers in the North and South have identical preferences in the style of Dixit and Stiglitz (1977). Individual welfare is represented by the discounted flow of utility

$$U^i(t) = \int_t^{\infty} e^{-\rho(\kappa - t)} \log u(\kappa) d\kappa$$

where $i = \{N, S\}$, ρ is the subjective rate of time preferences and $\log u(\kappa)$ is the utility flow at time κ. The flow of utility is given by a symmetric CES function of a variety of differentiated products $x(j)$

$$u = \left[\int_0^M x(j)^{\alpha} dj \right]^{1/\alpha}$$

where $i = \{N, S\}$, j is a product brand, M is the total variety of products available, ε is the price elasticity of demand, and $\alpha = 1 - 1/\varepsilon$ and $0 < \alpha < 1$. Free trade in goods implies that the same product variety is available in the North and South. The demand for product j is

$$x(j) = p(j)^{-\varepsilon} \left(\frac{E}{P^{1-\varepsilon}} \right)$$

where $i = \{N, S\}$, E is consumption spending, and P is a price index defined as

$$P = \left[\int_0^M p(j)^{1-\varepsilon} dj \right]^{1/(1-\varepsilon)} .$$

Under the above specification of consumer preferences, the logarithm of utility is equal to the difference between the logarithms of expenditure and price index

$$\log u = \log E - \log P. \tag{1}$$

Following Romer (1990), we distinguish between two products of R&D: general knowledge and blueprints. Knowledge represents a stock of technological, organizational and managerial ideas accumulated through R&D. With property rights over knowledge being unenforceable, knowledge is a public good. Moreover, since transaction costs are negligible by assumption, knowledge flows freely across international borders. In contrast, property rights over the design of a new product, blueprint, can be enforced. IPR protection in region i, where $i = \{N, S\}$, is denoted by a parameter τ^i, which is a fraction. Strengthening IPRs increases (reduces) productivity of innovative (imitative) R&D. We assume the world stock of innovative knowledge is proportional to total innovated blueprints.[4]

Northern firms produce original blueprints n^N, using inputs of labor and knowledge useful for innovation, i.e., world stock of knowledge that resulted from innovation,

$$\dot{n}^N = L^N (n^N + n^S) \tau^N \tag{2}$$

where $\dot{n}^N$ is the change in the total number of blueprints innovated by the North per time period and $(n^N + n^S)$ represents knowledge useful for innovation.

[4] See Grossman and Helpman (Ch. 8) for a similar form of the production function for innovated blueprints.

A unique feature of this model is that the decision to imitate as well as the imitation rate are endogenous. Southern firms produce imitated blueprints m^S using labor and knowledge relevant for imitation, i.e., the difference between knowledge accumulated through Northern innovation and knowledge associated with imitation in the South. The production function for imitated blueprints in the South is given by

$$\dot{m}^S = \frac{L^S(n^N - m^S)}{\tau^S} \tag{3}$$

where $\dot{m}^S$ is the change in the total number of blueprints imitated by the South per time period and $(n^N - m^S)$ represents knowledge relevant for imitation.[5] The more product varieties are available for imitation, the easier it is for the South to imitate. The South also has access to the innovation technology in the form analogous to (2); therefore, the South can catch up and become an innovator. Denote the domestic knowledge accumulated through region i's research and development, as K^i. Suppose K^i accumulates proportionally to the domestic R&D activity in region i, $K^i \equiv n^i + m^i$, and represents the feasible production set of product varieties in region i, where $i = \{N, S\}$. Southern firms innovate if the productivity of innovation is higher than that of imitation. This condition is expressed in terms of the relative regional stocks of domestic knowledge K^i as follows

$$K^S - \delta n^S > \delta K^N, \text{ where } \delta \equiv 1 - \left(\tau^S\right)^2,\ 0 < \delta < 1. \tag{4}$$

As a convention, we assume that when the productivities of innovative and imitative R&D are equal, firms choose to imitate.

The innovation rates g^i, where $i = \{N, S\}$, and imitation rate I^S are defined as follows

[5] Grossman and Helpman (Ch. 11) consider an analogous imitation technology in the appendix.

$$g^i = \frac{\dot{n}^i}{n^N + n^S}$$

$$l^S = \frac{\dot{m}^S}{n^N - m^S}.$$

Labor is the only input in the production of final goods. Corresponding to Helpman (1993) and Grossman and Helpman (1991, Ch. 11), we assume that the initial wage rate in the South is lower than in the North so that $w^S < \alpha w^N$. The total costs of producing good j are

$$TC^N(j) = aw^N x^N(j) + \upsilon^N$$
$$TC^S(j) = aw^S x^S(j) + \upsilon^S$$

where a is the marginal labor requirement, υ^i represents the fixed costs of R&D and $i = \{N, S\}$. Assume for convenience that $a = \alpha = 1 - 1/\varepsilon$.[6] Free entry into innovative and imitative R&D sectors implies that when R&D takes place the value of a representative firm is equal to the costs of innovation and imitation respectively,

$$\upsilon^N = \frac{w^N}{\tau^N\left(n^N + n^S\right)} \tag{5}$$

$$\upsilon^S = \begin{cases} \dfrac{w^S}{\tau^S\left(n^N + n^S\right)} & \text{if condition (4) holds} \\ \dfrac{\tau^S w^S}{n^N - m^S} & \text{otherwise.} \end{cases}$$

Assume that prior to and after imitation the market is monopolistically competitive and firms engage in Bertrand competition. An imitated blueprint becomes available to a single Southern firm. Since marginal costs in the South are lower than in the North and $w^S < \alpha w^N$, the imitator firm captures the entire market.

Financial markets are assumed to be perfect in both regions. Firms finance fixed costs associated with innovative or imitative R&D by issuing equity and use their profits to pay dividends to their shareholders. The value of a firm is associated with the value of the blueprint it owns and is equal to the present value of its expected profit stream. Firms face two types of risks. Idiosyncratic risks can be eliminated by holding diversified asset portfolios. The risk of being imitated is determined by the imitation rate, assuming that imitators select their target firms randomly. The corresponding no-arbitrage conditions when Northern firms innovate and Southern firms imitate are given by[7]

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[6] This simplifying assumption implies the profit-maximizing price equals the marginal cost, $p^i = w^i$, where $i = \{N, S\}$.

[7] See Helpman (1993) and Grossman and Helpman (1991, Ch. 11) for more details on the derivation of no-arbitrage conditions.

$$\frac{\pi_n^N}{\upsilon_n^N} + \frac{\dot{\upsilon}_n^N}{\upsilon_n^N} = r^N + l^S \tag{6}$$

$$\frac{\pi_m^S}{\upsilon_m^S} + \frac{\dot{\upsilon}_m^S}{\upsilon_m^S} = r^S$$

where r^N and r^S are the corresponding interest rates, and l^S represents the probability of imitation faced by Northern firms. When both regions innovate, no-arbitrage conditions are

$$\frac{\pi_n^i}{\upsilon_n^i} + \frac{\dot{\upsilon}_n^i}{\upsilon_n^i} = r^i$$

where $i = \{N, S\}$. Labor is immobile internationally, and regional labor resource constraints are respectively given by

$$L^N = (n^N - m^S)ax^N + \frac{g^N}{\tau^N}$$

$$L^S = \begin{cases} (n^S + m^S)ax^S + \dfrac{g^S}{\tau^S} & \text{if condition (4) holds} \\ (n^S + m^S)ax^S + l^S\tau^S & \text{otherwise}. \end{cases} \tag{7}$$

The total labor supply is equal to the employment in the innovative and imitative R&D and final manufacturing sectors respectively. The profit-maximizing price of good j is equal to $p^i(j)\left(1 - \frac{1}{\varepsilon}\right) = aw^i$, where $i = \{N, S\}$. With $a = \alpha$, $p^i(j) = w^i$. Profits of innovator and imitator firms in region i, where $i = \{N, S\}$, are equal to

$$\pi^i = (1 - \alpha)w^i x^i. \tag{8}$$

Define ζ the ratio of non-imitated product varieties to global product vatieties where

$\zeta = \dfrac{n^N - m^S}{n^N + n^S}$. When the North innovates and the South innovates (imitates), ζ respectively satisfies the following differential equations

$$\dot{\zeta} = \begin{cases} g^N - \left(g^N + g^S\right)\zeta & \text{if condition (4) holds} \\ g^N - \left(g^N + l^S\right)\zeta & \text{otherwise.} \end{cases} \tag{9}$$

Assuming that capital is immobile, trade is always in balance, and spending is equal to the value of production, i.e., $E^N = p^N x^N (n^N - m^N)$ and $E^S = p^S x^S (n^S + m^S)$. Spending grows at the following rate[8]

$$\begin{aligned} \frac{\dot{E}^N}{E^N} &= \frac{-\dot{g}^N}{L^N \tau^N - g^N} + \frac{\dot{w}^N}{w^N} \\ \frac{\dot{E}^S}{E^S} &= \begin{cases} \dfrac{-\dot{g}^S}{L^S \tau^S - g^S} + \dfrac{\dot{w}^S}{w^S} & \text{if condition (4) holds} \\ \dfrac{-\dot{l}^S \tau^S}{L^S - l^S \tau^S} + \dfrac{\dot{w}^S}{w^S} & \text{otherwise.} \end{cases} \end{aligned} \tag{10}$$

Intertemporal welfare maximization[9] requires the optimal consumption spending to grow at a rate equal to the difference between the interest rate and the subjective rate of time preferences.

$$\frac{\dot{E}^i}{E^i} = r^i - \rho \tag{11}$$

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[8] We obtain (10) by substituting the labor resource constraint (7) and differentiating the expression for E^i, where $i = \{N, S\}$.

[9] Intertemporally optimizing consumers maximize the present discounted value of the logarithm of time-separable utility flow subject to the intertemporal budget constraint that equates the present value of the infinite stream of expenditures and the present value of income plus the value of initial asset holdings.

where $i = \{N, S\}$. Aggregate world spending is normalized to equal one. Hence, in a steady-state equilibrium regional shares in the aggregate world spending are constant and interest rates equal the subjective rate of intertemporal preference.

Equations (10) and (11) together imply that interest rates are equal to

$$
\begin{aligned}
r^N &= \rho + \frac{\dot{w}^N}{w^N} + \frac{-\dot{g}^N}{L^N\tau^N - g^N} \\
r^S &= \begin{cases} \rho + \dfrac{\dot{w}^S}{w^S} + \dfrac{-\dot{g}^S}{L^S\tau^S - g^S} & \text{if condition (4) holds} \\[2ex] \rho + \dfrac{\dot{w}^S}{w^S} + \dfrac{-\dot{i}^S\tau^S}{L^S - i^S\tau^S} & \text{otherwise.} \end{cases}
\end{aligned}
\tag{12}
$$

Consumer maximization implies that an interest rate is positively related to the subjective rate of intertemporal preference and the rate of nominal spending growth. Consumers adjust their rate of spending according to changes in the rate of innovation or imitation respectively. An acceleration of the innovation or imitation rate, for example, induces the shift of labor from the production of final goods into the respective R&D sector, and the decline in the growth rate of the final output. As a result, the growth rate of consumer spending falls. In the financial market, slower growth of consumer spending lowers the interest rate, as the demand for consumer borrowing falls.

Equations (5) are differentiated and together with (8) and (12) substituted in (6). No-arbitrage conditions (6) and equation (9) constitute autonomous systems of differential equations in innovation and imitation rates and the share of imitated blueprints. An economy in which the North innovates and the South imitates is represented by the following system

$$\dot{g}^N = \left(L^N\tau^N - g^N\right)\left(\rho + g^N + \iota^S - \frac{1}{\varepsilon - 1}\left(L^N\tau^N - g^N\right)\frac{1}{\zeta}\right)$$
$$\dot{\iota}^S = \left(\frac{L^S}{\tau^S} - \iota^S\right)\left(\rho + \frac{g^N}{\zeta} - \iota^S - \frac{1}{\varepsilon - 1}\left(\frac{L^S}{\tau^S} - \iota^S\right)\frac{\zeta}{1-\zeta}\right) \tag{13}$$
$$\dot{\zeta} = g^N - \left(g^N + \iota^S\right)\zeta.$$

If both regions innovate, the respective system of no-arbitrage conditions and the dynamic equation for the share of product varieties produced in the North is given by

$$\dot{g}^N = \left(L^N\tau^N - g^N\right)\left(\rho + g^N - \frac{1}{\varepsilon - 1}\left(L^N\tau^N - g^N\right)\frac{1}{\zeta}\right)$$
$$\dot{g}^S = \left(L^S\tau^S - g^S\right)\left(\rho + g^S - \frac{1}{\varepsilon - 1}\left(L^S\tau^S - g^S\right)\frac{1}{1-\zeta}\right). \tag{14}$$
$$\dot{\zeta} = g^N - (g^N + g^S)\zeta.$$

3. The Critical Knowledge Stock

Whether the South is an innovator or imitator depends on the relative size of its knowledge stock. If the South's knowledge stock is low relative to that in the North, imitation is more productive than innovation, and condition (4) is not satisfied; hence, the South imitates. Condition (4) with an equality sign describes the critical stock of knowledge at which the South switches between imitative and innovative R&D. When such switching occurs, the corresponding original equilibrium is denoted as a *short-run* equilibrium. If the South's knowledge stock never reaches the critical level and the South does not change the type of R&D, such equilibrium is denoted as a *long-run* equilibrium. To focus on the South's catching-up, we restrict our attention to the North that innovates in the long run. We consider two alternative types of equilibria: both regions innovate; and the South imitates while the North innovates.

Suppose in the initial equilibrium the South's knowledge stock consists only of imitated blueprints (i.e., $n^S = 0$). Knowledge stock in the South is much less than in the innovating North so that condition (4) is not satisfied, and the South imitates. The regional knowledge stocks grow according to the following differential equations: $\dot{K}^N = g^N K^N$ and $\dot{K}^S = l^S(K^N - K^S)$. If in the initial equilibrium the South's knowledge stock accumulates to the critical level, the South switches to innovation; otherwise, the South remains an imitator in the long run.

Solutions to the simultaneous system of equations $\dot{K}^N = g^N K^N$ and $\dot{K}^S = l^S(K^N - K^S)$ are $K_t^N = K_0^N e^{g^N t}$ and $K_t^S = \dfrac{l^S K_0^N (e^{(g^N + l^S)t} - 1)}{(g^N + l^S)e^{l^S t}} + \dfrac{K_0^S}{e^{l^S t}}$. Using Taylor approximation and solving equation $K_{\tilde{t}}^S = \delta K^N$, gives a (short-run) equilibrium imitation rate sufficient for knowledge stock to reach its critical level at the time moment $\tilde{t}$: $\tilde{l}^S = \dfrac{\delta + \zeta + \delta g^N \tilde{t}}{\zeta \tilde{t}}$. In the limit as $\tilde{t}$ goes to infinity, $\tilde{l}^S$ goes to $\dfrac{\delta}{\zeta} g^N$. The South has to imitate at a rate greater than the fraction $\dfrac{\delta}{\zeta}$ of the innovation rate to catch up in a finite time. Hence, the necessary and sufficient condition for the South to catch up in a finite time is

$$\varphi \equiv \zeta l^S - \delta g^N > 0. \tag{15}$$

Proposition 1. *The South catches up and becomes an innovator if its (short-run) equilibrium imitation rate satisfies (15) and remains a (long-run) imitator otherwise.*

Similarly, a sufficient condition for the innovating South remain an innovator in the long run is

$$\psi \equiv g^S - \frac{\delta}{1-\delta} g^N > 0. \tag{16}$$

Proposition 2. *The South remains a (long-run) innovator if its equilibrium innovation rate satisfies (16) and switches back to imitation otherwise.*

If in a steady-state equilibrium the South innovates at a fraction $\frac{\delta}{1-\delta}$ of the North's innovation rate, condition (4) is satisfied and the South remains an innovator in the long run. Otherwise, the South's knowledge stock falls relative to that in the North, imitative R&D become more productive than innovative R&D, and the South switches back to imitation.[10]

[10] Note that by assumption the North always innovates, i.e., a condition analogous to (16) holds for the North.

4. Steady-State Equilibria and Comparative Statics

A long-run equilibrium in which the North and South innovate is described by the following system of equations

$$\begin{aligned}
&\frac{1}{\varepsilon-1}\left(L^N\tau^N-\bar{g}^N\right)\frac{1}{\zeta}=\rho+\bar{g}^N\\
&\frac{1}{\varepsilon-1}\left(L^S\tau^S-\bar{g}^S\right)\frac{1}{1-\zeta}=\rho+\bar{g}^S\\
&\bar{\zeta}=\frac{\bar{g}^N}{\bar{g}^N+\bar{g}^S}\\
&\psi\equiv\bar{g}^S-\frac{\delta}{1-\delta}\bar{g}^N>0.
\end{aligned}\tag{17}$$

The last equation in the above system (17) represents condition (16) which differentiates a long-run equilibrium from a short-run one. By Cramer's rule we find the comparative statics effects of changes in IPR protection on the equilibrium innovation rate. Strengthening IPR protection in one region increases innovation rates in both regions.

Proposition 3. *If the North and South innovate in a steady-state equilibrium, strengthening IPR protection in one region increases innovation rates in both regions.*

<insert Figure 1>

A long-run equilibrium in which both regions innovate is a saddle point.[11] Certain combinations of regional innovation rates are infeasible, as the entire labor force cannot be employed in the R&D sector. These infeasible combinations are shown as dashed areas in Figure 1. Lines *nn* and *ss* represent equations $\dot{g}^N=0$ and $\dot{g}^S=0$ respectively.[12] Strengthening

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[11] The system of equations (17) has three real eigenvalues: two positive and one negative.

[12] The value of ζ is fixed at its equilibrium value to draw a diagram in a two-dimensional space.

IPR protection in the South results in an outward shift of *ss* line and a movement of the long-run equilibrium from A to A′. Equilibrium innovation rates increase in both regions.

A long-run equilibrium in which the North innovates and the South imitates is given by the following system of equations

$$\begin{aligned}
&\frac{1}{\varepsilon-1}\left(L^N\tau^N-\bar{g}^N\right)\frac{1}{\bar{\zeta}}=\rho+\bar{g}^N+\bar{\imath}^S\\
&\frac{1}{\varepsilon-1}\left(\frac{L^S}{\tau^S}-\bar{\imath}^S\right)\frac{\bar{\zeta}}{1-\bar{\zeta}}=\rho+\frac{\bar{g}^N}{\bar{\zeta}}-\bar{\imath}^S\\
&\bar{\zeta}=\frac{\bar{g}^N}{\bar{g}^N+\bar{\imath}^S}\\
&\varphi\equiv\bar{\zeta}\bar{\imath}^S-\delta\bar{g}^N\le 0
\end{aligned}\qquad(18)$$

where the last equation differentiates a long-run equilibrium from a short-run one by ensuring that the catching-up condition (15) does not hold. By Cramer's rule we find comparative statics effects of changes in regional IPRs on equilibrium innovation and imitation rates.

Proposition 4. *If the North innovates and the South imitates in a steady-state equilibrium, strengthening IPR protection in the South (North) reduces (increases) imitation and innovation rates.*

<insert Figure 2>

The phase diagram with the innovator North and the imitator South is shown in Figure 2. A steady-state equilibrium is a saddle point.[13] Equations $\dot{g}^N=0$ and $\dot{\imath}^S=0$ are represented by lines *nn* and *ss* correspondingly.[14] Strengthening IPR protection in the South

[13] The system of equations (18) has three real eigenvalues: two positive and one negative.

[14] The value of ζ is fixed at its equilibrium level to draw a phase diagram in a two-dimensional space.

is shown as a movement from equilibrium A to A′ with lower imitation and innovation rates. As in Helpman's (1993) and Grossman and Helpman's (1991, Ch. 11) models, tighter IPRs in the South reduce both the profit rate and effective cost of capital in the North. With the innovation of product varieties and the logarithmic utility function, the effective cost of capital falls by less than the profit rate, causing the innovation rate to fall.[15]

5. Endogenous IPRs for Catching-up

In this section we consider endogenous IPRs that allow the South to catch up and become an innovator in the long run. Assume that IPR protection in the North is strong, i.e., close to one, and the South takes North's IPRs as given. Suppose initially the innovating North and imitating South are in a steady-state equilibrium. If the South imitates at a sufficiently high rate so that condition (15) holds, it can accumulate the critical knowledge in finite time and switch to innovation (Proposition 1.)

Solving equations (18) and substituting the equilibrium innovation and imitation rates in condition (15), we express the catching-up condition (15) in terms of South's IPRs and exogenous parameters as follows[16]

$$\varphi(\tau^S, L^N, L^S, \varepsilon, \rho) > 0.$$

When IPR protection in the South is symmetrically high relative to the North, φ goes to zero in the limit. Condition (15) does not hold with strong IPRs in the imitating South, and the South remains an imitator in the long run. If South's IPRs are close to zero, φ goes to

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[15] These results are not robust to the form of the utility function. Such comparative statics, however, are typical for models of R&D in product varieties. See Grossman and Helpman (1991, Ch. 11) and Helpman (1993) for the detailed discussion of comparative statics.

[16] See Appendix for the algebraic expression of φ.

infinity in the limit. Therefore, the imitating South chooses relatively weak IPR protection to catch up in finite time.

With weak IPR protection, however, the productivity of innovative R&D and hence the equilibrium innovation rate in the South are close to zero, and condition (16) does not hold. For both regions to remain long-run innovators, the South that has become an innovator increases its IPRs to match the high level of IPR protection in the North.

Proposition 5. *In a steady-state equilibrium, the imitating South chooses weak IPRs to catch up, whereas the innovating South chooses strong IPRs for given strong IPRs in the North.*

6. Conclusion

This paper focuses on the role of intellectual property rights (IPRs) in the catching-up in an endogenous growth model for two regions, North and South, with asymmetric initial stocks of knowledge. This model extends earlier works (Helpman 1993, Grossman and Helpman 1991, Chin and Grossman 1990, Diwan and Rodrik 1991, Taylor 1994) by allowing for the endogenous evolution of a developing region from imitative to innovative R&D through the accumulation of knowledge capital and considering IPRs that are optimal for catching-up in terms the rate of product variety innovation.

Several important results emerge. In the long-run, if the South is an imitator and the North an innovator strengthening South's IPRs reduces imitation and innovation rates and slows down the growth of product variety. In a long-run equilibrium with both regions innovating, strengthening IPRs in one region increases innovation rates in both regions.[17]

Given strong IPR protection in the North, we find that the imitating South has an incentive to maintain weak IPRs to catch up to the North in terms of ability to innovate, i.e.,

[17] Helpman (1993) and Grossman and Helpman (1991, Chs. 9 and 11) obtain similar results.

production variety knowledge. Upon accumulating a critical level of knowledge relative to the North, the South has an incentive to begin innovation and strengthen IPR protection.

Important policy implications of the Agreement on the Trade-Related Intellectual Property Rights (TRIPS) within the Uruguay Round of GATT emerge from this paper. The economic effects of harmonization of IPRs and hence enforcement of TRIPS depend on the technological capabilities of developing countries. If a country is on the brink of starting indigenous innovation (e.g., Newly Industrialized Countries), an exogenous policy change under TRIPS coincides with the endogenously optimal policy. Hence, such country has an inherent incentive to enforce TRIPS.

If an imitating country is a long way from closing the technological gap (for example, Sub-Saharan Africa), stronger IPRs do not significantly alter its chances of catching up. However, if a country is predominantly an imitator but may catch up in the foreseeable future (for example, Thailand, Malaysia, Philippines), it may forego catching up by premature tightening of its IPRs. While agreeing to the treaty in terms of legal code, such country may be expected to demur the enforcement of the TRIPS Agreement. Therefore, it is enforcement and dispute resolution that will predictably be on the next agenda in international trade debates.

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Appendix

Solving the system of equations (18) gives the equilibrium innovation and imitation rates, respectively

$$\bar{g}^N = \frac{\beta L^N \tau^N \rho\left(\tau^S\right)^2 + \beta^2 L^N \tau^N L^S \tau^S + 3\beta\rho L^S \tau^S + \beta^2\left(L^S\right)^2 - \sqrt{\Theta}\left(\rho\tau^S + \beta L^S\right)}{(1+\beta)\tau^S\left(\sqrt{\Theta} - \beta L^N \tau^N \tau^S - \beta L^S\right)} \tag{i}$$

$$\bar{l}^S = \frac{\rho + \dfrac{\beta L^S}{\tau^S} - \dfrac{2\rho^2\tau^S}{\beta L^N \tau^N \tau^S + 2\rho\tau^S + \beta L^S - \sqrt{\Theta}}}{1+\beta} \tag{ii}$$

where $\Theta = \beta\left(\beta\left(L^N \tau^N \tau^S\right)^2 + 2\beta L^N \tau^N L^S \tau^S + 4\rho L^S \tau^S + \beta\left(L^S\right)^2\right)$ and $\beta = \dfrac{1}{\varepsilon - 1}$.

Condition (15) can be expressed in terms of the equilibrium innovation and imitation rates and the share of product varieties produced in the North as follows

$$\varphi \equiv \bar{\zeta}\bar{l}^S - \delta\bar{g}^N > 0 \tag{iii}$$

where $\bar{\zeta} = \dfrac{\bar{g}^N}{\bar{g}^N + \bar{l}^S}$ and $\delta = 1 - \left(\tau^S\right)^2$. Substituting (i) and (ii) in (iii), taking the limit as τ^N goes to one and rearranging gives

$$\begin{aligned}&\left(1-\left(\tau^S\right)^2\right)\frac{\beta L^N \rho\left(\tau^S\right)^2 + \beta^2 L^N L^S \tau^S + 3\beta\rho L^S \tau^S + \beta^2\left(L^S\right)^2 - \sqrt{\Theta}\left(\rho\tau^S + \beta L^S\right)}{(1+\beta)\left(\tau^S\right)^3\left(\beta L^N \tau^S + \beta L^S - \sqrt{\Theta}\right)} + \\ &+ \frac{\rho + \dfrac{\beta L^S}{\tau^S} - \dfrac{2\rho^2\tau^S}{\beta L^N \tau^S + 2\rho\tau^S + \beta L^S - \sqrt{\Theta}}}{1+\beta} > 0.\end{aligned} \tag{iv}$$

As τ^S goes to one, expression on the right-hand side (RHS) of (iv) converges to zero. The limit of the RHS as τ^S approaches zero is positive infinity.

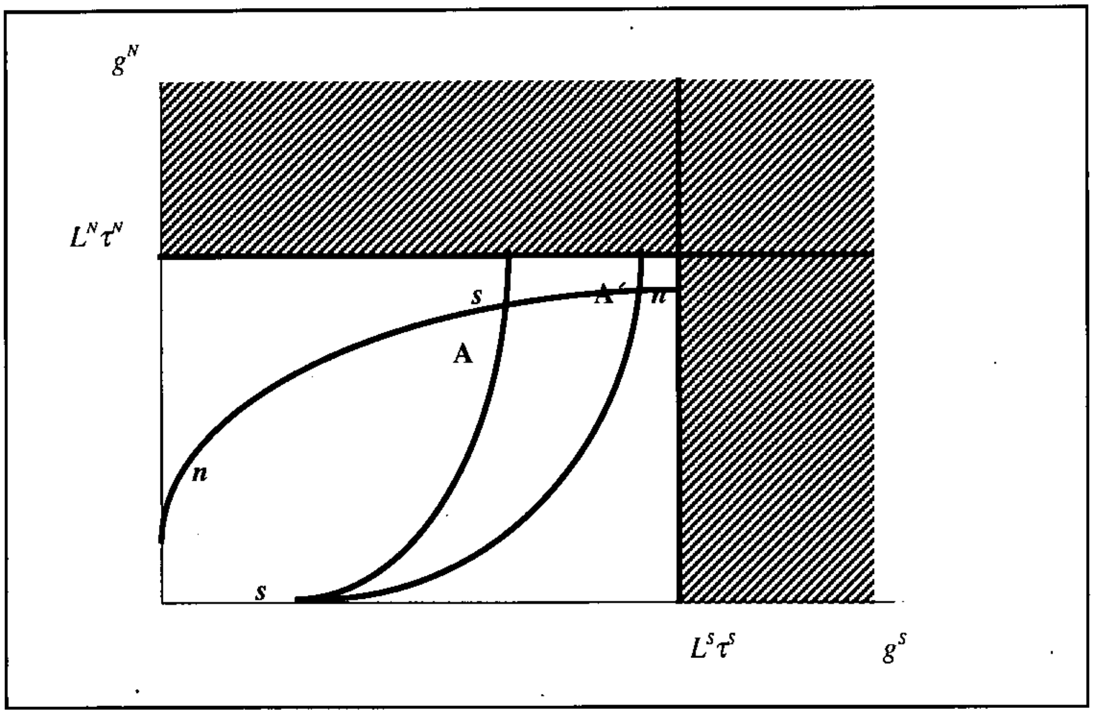

Figure 1. The North and South innovate.

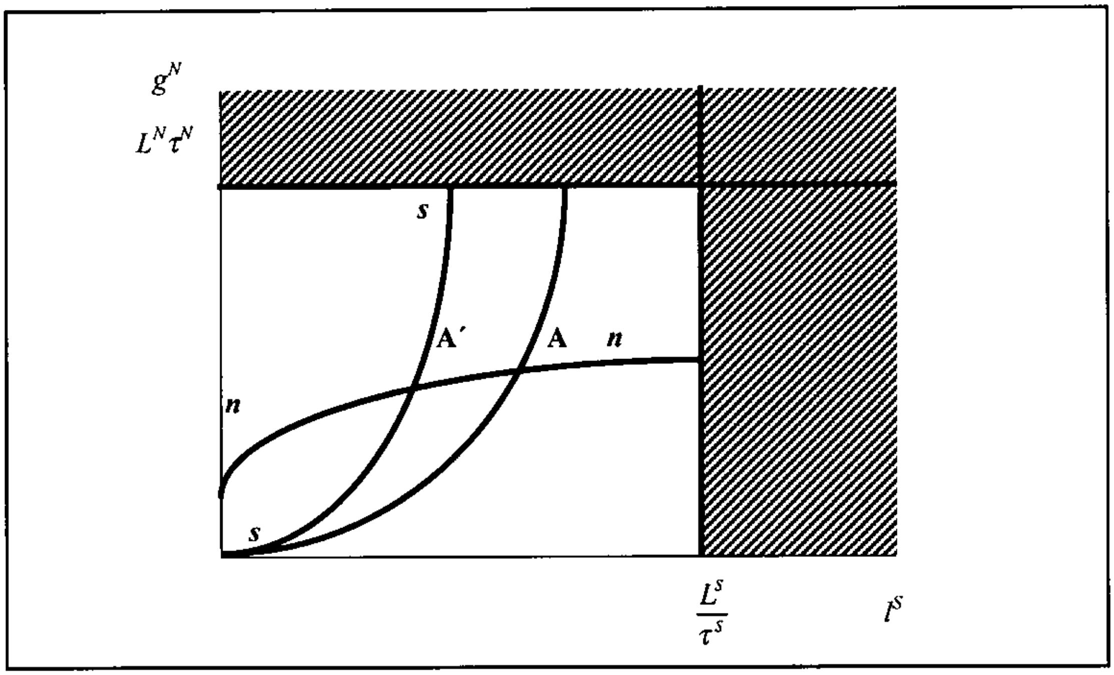

Figure 2. The North innovates and the South imitates.