On the International Technology Transfer through Licensing

Hideo Noda (Yamagata University)

1 Introduction

Since the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) came into force in 1995, issues concerning intellectual property rights in international technology transfer have been addressed more actively. The objective of this paper is to show how intellectual property rights protection in a developing country influences innovative performance, international technology transfer and wage gap in a global economy, within the framework of an endogenous growth model of open economy.

Our model implies that reinforcement of intellectual property rights protection in a developing country has positive effects on the rate of innovation in that developed country and the amount of technology transferred from that developed country to a developing country through licensing. As well, the model suggests that, in general, although the impact of reinforcement of intellectual property rights protection in a developing country on the wage difference between a developing and a developed country is uncertain.

2 The Model

2.1 Consumers

Identical consumers live in one of two countries or regions, North and South, \( i \in \{N, S\} \). For simplicity, we assume that the households in the North receive wage by inelastically supplying labor to the production sector or research and development (R&D) sector. On the other hand, the households in the South receive wage by supplying labor to the production sector inelastically. Households in both countries are also able to earn asset income. In the following, we express total amount of labor of the North and the South as \( L_N \) and \( L_S \), respectively.

The objective function of the households in each country is given by

\[
U_i = \int_0^\infty e^{-\rho t} u_i(t) dt,
\]

where symbol \( t \) denotes a time variable, \( \rho \) represents the rate of time preference, and \( u_i(t) \)
represents the instantaneous utility of household at time $t$ in each country. We now assume that each industry $j$ corresponding to the production line of different goods is distributed continuously within the interval $[0,1]$; the goods produced in each industry all have an imperfect substitution relationship with one another. Under such an assumption, $u_i(t)$ is formulated specifically as

$$u_i(t) = \int_0^1 \log \left[ \sum_m \lambda^m x_m(t, j) \right] dj, \ (\lambda > 1)$$

where $x_m(t, j)$ represents the consumption of good of quality $m$ produced by industry $j$ in each country. In addition, $\lambda^m$ is a qualitative indicator of goods having quality of level $m$. Therefore, this paper develops an argument based on such an innovation model in which the quality of goods improves over time, although the type of good is fixed.

In this paper, we regard the Southern labor as numeraire, and normalize the wage rate in the South to one. On the other hand, we express the Northern wage rate at time $t$ as $w(t)$. Then, it is assumed that a relation $1 < w(t) < \lambda$ holds.

We turn now to examine the optimization problem that households face. Let $p_m(t, j)$ and $E_i(t)$ be the price of good of quality $m$ produced by industry $j$ and total expenditure of household in each country. Solving this problem, we obtain

$$\frac{\dot{E}_i(t)}{E_i(t)} = r_i(t) - \rho.$$ 

### 2.2 Producers

We assume that such R&D activities for a next-generation product are not carried out by leader of the industry producing the most advanced good, but by followers, which are producing goods of lower quality than the most advanced good. We treat labor as the only factor of production and assume that one unit of labor is required for producing one unit of an arbitrary good. Consequently, the marginal cost of all goods produced by the Northern firms equals the wage rate $w(t)$; the marginal cost of all goods produced by the Southern firms equals one. As mentioned above, innovation derived from R&D activities occurring only in the North. Then, a Southern firm (licensee) is able to produce the most advanced product by obtaining technical information about its product from a Northern firm (licensor) through a license.

Let us first consider price competition among firms in a state of oligopoly in each industry. We now assume that a firm in the North is able to use the technology for the most advanced good, while a firm in the South is able to produce goods of quality that is one rank lower. As a result of Bertrand competition, the firm in the North producing the most advanced good will set limit price of such good
at $\lambda$, which drives the firm in the South to produce goods of a rank of lower quality out of the market. Hence, the resulting prices become equal in all industries and the aggregate demand for each good will be $[E_N(t)L_N + E_S(t)L_S] / \lambda \equiv E(t) / \lambda$. Hence, if the profit of the firm in the North producing the most advanced goods is expressed as $\pi_N(t)$, the following relation holds.

$$\pi_N(t) = E(t) \left[ 1 - \frac{w(t)}{\lambda} \right]$$

Next, we examine that a firm in the South is able to use the technology for the most advanced good through a license and another firm in the South is able to produce goods of quality that is one rank lower. As a result of Bertrand competition, the Southern firm producing the most advanced good will price the good at $\lambda$, which consequently drives the other firm in the South producing good of lower quality out of the market. In this case, too, because the resulting prices do not depend on the industry index $j$, the prices become equal in all industries. Therefore, the aggregate demand for these goods will be expressed as $E(t) / \lambda$. Hence, if the profit of the firm in the South producing the most advanced good is expressed as $\pi_L(t)$, then we get

$$\pi_L(t) = E(t) \left[ 1 - \frac{1}{\lambda} \right].$$

Let us discuss the relationship between R&D investment and new technology created by such investment. In our model, R&D activities in each industry are accompanied by uncertainty and that the occurrence of innovation is governed by a Poisson process. Specifically, we assume that a firm that invests resources $I(t)$ during a sufficiently short time interval of length $\Delta t$ will develop new technology at a probability $I(t)\Delta t$. Thus, $I(t)$ represents a Poisson arrival rate of an innovation, which indicates the momentary probability of successful innovation. Accordingly, $I(t)$ is interpreted as an indicator for measuring the rate of innovation. In addition, we assume that labor in a unit of $a_j I(t)$ per unit time must be invested for the rate of innovation at level $I(t)$ to occur.

A firm that has successfully developed technology for producing goods of the highest quality is able to gain exclusive profits by selling such goods, unless any of the firms following behind succeeds in developing goods for the next generation. Here we will express the sum total of the discounted present values of the profits as $V_j(t)$. On the other hand, it is found that the cost for R&D becomes $a_j I(t)\Delta t$. Therefore, the expected net profit of the firm that has succeeded in innovation can be written as

$$V_j(t)I(t)\Delta t - w(t)a_j I(t)\Delta t.$$
innovation occurs in terms of \( I(t) > 0 \). Then, we obtain

\[
V_I(t) = w(t) a_I. \tag{2}
\]

The Northern firm that has successfully developed the most advanced goods not only profits from the sale of the goods, but also becomes able to receive fees, i.e., royalties, by licensing technical knowledge as an intellectual property to the firm in the South. For simplicity, we assume that the amount of the royalty is the value obtained by multiplying the sum total of the discounted present values of the profits from the sale of the goods gained using the firm in the South receiving the technology transferred by a constant percentage \( \delta \in (0,1) \), that is, \( \delta V_I(t) \). We regard \( \delta \) as a parameter. We also assume that technology transfer through licensing is governed by a Poisson process and that technology transfer is successful at the probability of \( t \Delta \iota \). That is, \( t \) represents a Poisson arrival rate, which indicates the momentary probability of successful technology transfer through licensing. Therefore, a firm that succeeds in the development of new technology will gain an expected revenue of \( \delta V_L(t) t \Delta \iota \) by licensing the technical information as an intellectual property. Here, we assume that the firm in the North uses labor of \( a_L t \Delta \iota \) for instructing technical data provided to the Southern firm, training of manufacturing know-how, and other purposes. Accordingly, parameter \( a_L \) can be considered as an indicator that reflects the average absorptive capacity of the firms in the South. We should also take note that the firm in the North, which provides the license, incurs an opportunity cost of \( V_I(t) t \Delta \iota \). As a result, if the Northern firm that succeeds in developing the most advanced goods is to license, the firm receives the following expected net profit:

\[
\delta V_L(t) t \Delta \iota - w(t) a_L t \Delta \iota - V_I(t) t \Delta \iota.
\]

Therefore, in the equilibrium in which technology transfer through licensing occurs in terms of \( t > 0 \), we obtain

\[
\delta V_L(t) = w(t) a_L + V_I(t). \tag{3}
\]

2.3 Market Equilibrium

Here we will ascertain the conditions that hold in an equilibrium of asset and labor markets in each country. From the equilibrium condition of asset market in the North, we get

\[
\frac{\pi_N(t)}{V_I(t)} + \frac{\dot{V_I}(t)}{V_I(t)} + t \frac{\delta V_L(t)}{V_I(t)} - \left[ I(t) + I \right] = r_N(t).
\]

As is well known, because the South lacks a legal infrastructure for intellectual property rights
and their control, the licensee faces the risk of potential imitation within the South. We assume that imitation occurs according to the Poisson process with an arrival rate, $\kappa$, which denotes the momentary probability of imitation's occurrence. Consequently, in the equilibrium of the asset market in the South, the following condition holds:

$$ \frac{\pi_L(t)}{V_L(t)} + \frac{\dot{V}_L(t)}{V_L(t)} - [I(t) + \kappa] = r_s(t). \quad (4) $$

In our model, we consider the situation that asset markets are integrated internationally. Thus, a relation will hold.

If the number of variety of goods produced in the North and the South is expressed as $n_N(t)$ and $n_S(t)$ respectively, then labor $n_N(t)E(t)/\lambda$ for the production of goods, $I(t)a_i n_N(t) + I(t)a_s n_S(t)$ for R&D, and $a_l I n_N(t)$ for technology transfer will be demanded in the labor market in the North. Therefore, the following equation holds as the equilibrium condition of the labor market in the North:

$$ \frac{E(t)}{\lambda} n_N(t) + I(t)a_i n_N(t) + I(t)a_s n_S(t) + a_l I n_N(t) = L_N. $$

On the other hand, the equilibrium condition of the labor market in the South is given by

$$ \frac{E(t)}{\lambda} n_S(t) = L_S. \quad (5) $$

3 Steady-State Comparative Statics

We focus on a steady state, that is, a situation in which all variables grow at constant rates. Consequently, after some manipulation, we obtain the following equations.

$$ \frac{(1-n_s)}{n_s} L_S + Ia_i + a_l I n_s = L_N, \quad (6) $$

$$ (a_i + a_l)(\rho + I + \kappa) = \delta \left[ 1 - \frac{1}{\lambda} \right] a_i (\rho + I) - a_l I \frac{n_s}{1-n_s} + \frac{L_S}{n_s}. \quad (7) $$

Based on the preliminary discussion so far, we will now examine the comparative statics. Here, the parameter of imitation risk $\kappa$ is regarded as a proxy for the level of protection of intellectual property rights in the South, and a decrease in the imitation risk will be interpreted as reinforcement of
protection of intellectual property rights. Using eqs. (6) and (7), when the level of protection of intellectual property rights in the South is reinforced, we find that the rate of innovation will increase and so will international technology transfer.

We will now inquire into how the wage gap between the two countries changes when the level of protection of intellectual property rights in the South is reinforced. Let us recall now that the wage rate in the South has been normalized to one. Hence, the wage rate $w$ in the North can be construed as the relative wage between the North and the South. From eqs. (1), (2), (3), (4), (5) and (6), we obtain

$$w = \delta \frac{\lambda L_S}{n_S} \left( 1 - \frac{1}{\lambda} \right) \left( a_I + a_s \right) \left( \rho + \kappa + \frac{L_N + L_S - L_S}{a_I + a_L n_s} \right)^{-1}$$

$$\equiv w(n_S(\kappa), \kappa).$$

Therefore, we get

$$\frac{dw}{d\kappa} = \frac{\partial w}{\partial n_S} \frac{dw}{dn_S} + \frac{\partial w}{\partial \kappa}.$$

In this regard, however, the sign of $dw/d\kappa$ is inconclusive.

4 Concluding Remarks

This paper has developed an argument on the effects that reinforcement of protection of intellectual property rights in a developing country would have on innovation and international technology transfer and how the wage gap in labor income between a developing and developed countries would change, within the context of a quality-ladder model.

Main results can be summarized as follows. First, reinforcement of intellectual property rights protection in a developing country positively influences the rate of innovation in a developed country and the amount of technology transferred from a developed country to a developing country through licensing. Secondly, although the impact of reinforcement of intellectual property rights protection in a developing country on the wage difference between two countries is uncertain, such a difference is suggested to become smaller when R&D investment by a developed country is active and the absorptive capacity of the developing country is at a high level.