Innovation and Production Offshoring:  
Implications on Welfare

Nuttapon Photchanaprasert*  
Graduate School of Economics  
Hitotsubashi University  

November 11, 2010

VERY PRELIMINARY

Abstract

This paper theoretically analyzes the effect of the strengthening IPR protection and innovation subsidies on the rate of innovation offshoring, rate of imitation, rate of innovation, relative wages and real wages. I construct a North-South dynamic general equilibrium model of trade with endogenous imitation and innovation and production offshoring. To trade with lower Southern wages, the Northern firms confront the problem of information leakage to Southern firms and monitoring costs if they do offshore innovation and production. The model predicts that the strengthening of IPR protection in the South creates static and dynamic welfare losses. The static loss is from the decrease in real wages or its term of trade. And, the dynamic loss is from the decrease in the rate of innovation. On the other hand, the innovation subsidies creates static and dynamic welfare gains. The static loss is from the increase in relative real wages or its term of trade. And, the dynamic gain is from the increase in the rate of innovation.

Keywords: offshoring, innovation, information leakage, productivity gap, welfare, trade policies

JEL classification: F12, F13, F21, F23,D43,O31

*I am grateful to Prof. Jota Ishikawa, Prof. Taiji Furusawa and members of International Trade and Investment seminar at Hitotsubashi University
1 Introduction

Offshoring have been steadily increasing more areas of firm activities in the developed countries. Starting with offshoring of production activity decades ago, this economic phenomenon has changed from the production offshoring through back from office operations and services to higher value added, non-routinized areas, now including research and development and the overall sphere of innovation activity.

Business media now report the offshoring of innovation activity in sectors ranging from pharmaceutical and bio-technology to computer hardware and software. An increasing number refer to wholly owned innovation centers in countries such as Russia, China and India, or sometimes even arms length sub-contracting of innovation in these countries. Intel, for example, has labs carrying out advanced microprocessor design work in Novosibirsk and St.Petersburg in Russia, after having bought Elbrus, a leading Russian computer technology research center and boosting its Russian research staff to over 1500. Intel also has a hi-tech development center in Bangalore, India, working on digital signal processing, device drivers and process and chipset design, and a major facility in Beijing, the Intel China Research Center for the development of next-generation networking and wireless platform solutions. According to the Indian National Association of Software and Service Companies (Nasscom), the total market size of this so-called knowledge process outsourcing (KPO) business in India was around $1.2 billion in 2004, and is expected to increase substantially. Original equipment manufacturers to whom value added resellers would offshore component manufacturing, are giving way to original design manufacturers in the Asia-Pacific region. The latter design, engineer and manufacture products from the ground up with little input from their clients, whose major role often is to contribute the brand name.

The primary reason for innovation offshoring is the same as for offshoring in general-cost reductions. In additional to the cost saving, there are other reasons for this phenomenon including demand, supply of scientists, technologists and knowledge workers, interaction capabilities and new incentives. Demand (as defined by real gross national product in the world’s largest and most rapidly growing economies) is doubling every 14 to 16 years, creating a host of new specialist markets sufficiently large to attract innovation. The supply of scientists, technologists and knowledge workers has dramatically increased. as have knowledge bass and access to them. Software-based analytical, modeling, communications and market feedback technologies have lowered costs and risk substantially. allowing many smaller enterprizes to participate in emerging markets. Interaction capabilities have grown. Combined with the internet and other information technology capabilities, interactions among technologies-including the biotech, computer, chemistry, environmental and food fields- are growing exponentially. New incentives has emerged. Lower tax rates, privatization, the relaxation of many national and international trade barriers, and the lower capital investment needed in many fields have meant greater incentives for entrepreneurs worldwide to develop and exploit advances in knowledge. New management techniques, software, and communication systems have enabled much better coordination of highly dispersed innovation activities.

In terms of innovation offshoring literature and product cycle literature, this paper alone features innovation offshoring. This paper addresses how changes in IPR protection and innovation subsidies alter the rate of innovation, imitation and degree of innovation
offshoring. The literature on product cycle models has seen a revival in recent years. This literature is based on the seminal work done by Vernon (1966). He presents a model where new products are first introduced in high income countries, exports begin to other high income countries, eventually production shifts to low income countries, and finally the original product may be exported back to the high income country which first introduce it. Yet while Vernons (1966) original vision of the product cycle assigns a central role to foreign direct investment (FDI), most of the new models capturing his ideas use imitation as the channel of international technology transfer from an innovating region (the North) to an imitating region (the South).

Grossman and Helpman (1991b) follow the ‘product cycle’ idea that North is the only source of innovation (new varieties of products), and the only way South can acquire technology is through technology transfer(imitation) from North. Both innovation and imitation are costly activities and their levels are endogenously determined. They study the determinants of the long run rate of innovation and imitation. An increase in labor supply in the South or a decrease in the labor requirement for imitation generates an increase in the steady-states rate of imitation. In the North, this raises the risk premium for innovation and also boosts the profits of the surviving monopolies. The second effect dominates, raising the rate of innovation. Grossman and Helpman (1991a) developed a similar model where innovations are higher quality levels (the quality ladder model). An increase in the Southern labor force raises imitation and the number of Northern firms targeted for imitation. Innovation in the North may rise or fall. The Grossman-Helpman product cycle models has new products being invented by Northern firms and later directly imitated by Southern firms.

In the Vernon cycle, Northern firms move production to the South by forming subsidiaries there before imitation shifts ownership but not location of production. IPR reforms were not explicitly discuss in the above mentioned models. To analyze the debate between North and South about the enforcement of stronger IPRs in the South, Helpman (1993) employs a simplified version of the Grossman and Helpman (1991b) model with exogenous imitation. His main contribution is analyzing the transition dynamics between steady states following tightened IPRs in the South (modeled as a decrease in the exogenous imitation intensity): stronger IPRs initially raises the rate of innovation, but the rate of innovation subsequently declines. At the end of his paper he introduces FDI in a model with exogenous innovation and imitation. Lai (1998) modifies Helpmans model to consider the effects of imitation targeting multinational production on innovation. He considers two possible channels of production transfers between North and South: FDI and imitation. The effects of stronger IPR in South (modeled as a decrease in the exogenous imitation intensity) depend on the channel of production transfer. In the case of technology transfer through imitation (without FDI), stronger IPR lowers the rate of innovation. The effects are opposite if the transfer channel is FDI, or if both transfer channels coexist (and the rate of FDI is large). If the technology transfer is made through FDI, southern firms can imitate only after Northern firms transfer production to the South. Northern firms move production to the South in order to take advantage of lower labor costs. In this case the effect of stronger IPR does not affect the demand for Northern labor as production is entirely in the South. This will cause innovation to raise without an increase in innovation costs. Lai’s (1998) results change when innovation, imitation and offshoring are endogenously determined within the model and the
Southern labor supply is divided between skilled and unskilled labor. Glass and Saggi (2002) question the results of Lai (1998) where stronger Southern IPR protection encourage FDI and innovation. They employ a quality-ladder model and argue that stronger Southern IPR protection reduces the aggregate rate of innovation and the flow of FDI regardless of whether FDI or imitation targeting Northern production serves as the primary channel of international technology transfer. In their model, stronger IPR protection is an increase in the cost of imitation. Glass and Saggi (2002) conclude that the reason for the difference in their results relative to Lai (1998) appears to be the difference in how IPR protection was modeled: as an increase in the cost of imitation rather than as an exogenous decrease in the imitation intensity. But there is another important difference between the two models: the type of innovation (creating new varieties versus quality upgrading). Glass and Wu (2003) look at how differences in the type of innovation affect the consequences of stronger IPR. Their model is based on the quality-ladder model developed by Grossman and Helpman (1991a) and it assumes imitation to be exogenous. They found that stronger IPR in the South (decrease in the imitation intensity) decrease FDI and innovation, an opposite result to the one found by Lai (1996) where innovation targeted new varieties. They conclude that stronger IPR protection may shift the composition of innovation away from improvements in existing products toward development of new products. The newest extension to the Grossman and Helpman (1991b) model is done by Branstetter, Fisman, Foley and Saggi (2007). They analyze theoretically and empirically the effects of strengthening IPRs in developing countries in a product variety model with endogenous innovation, imitation, and FDI. The model predicts that IPR reform in the South leads to increased FDI in the North, increased global rate of innovation and a reduction in imitation rate. On the empirical part they analyze responses of U.S.-based multinationals and domestic industrial production to IPR reforms in the 1980s and 1990s. They find that there is an overall expansion of industrial activity after IPR reform, suggesting that the expansion of multinational activity more than offsets any decline in the imitative activity of indigenous firms.

The relationship between innovation subsidies and rate of innovation and imitation are studied in Grossman and Helpman (1991). They derive differing results depending on whether followers (firms who did not make a previous innovation) are efficient (have innovation costs low enough that engage in innovation) or not; see also Segerstrom et al. (1990). They find that subsidy to innovation increases the rate of innovation and decreases the rate of imitation for the case of efficient followers but increases the rate of imitation for the case of inefficient followers.

My model extends the work of Grossman and Helpman (1991b) by developing a dynamic general equilibrium model with endogenous imitation and innovation and production offshoring. I theoretically analyzes and innovation subsidies on the rate of innovation offshoring, rate of imitation, rate of innovation, relative wages and real wages.

The structure of this paper is as follows. A basic model will be presented in the following section. The effects of the strengthening IPR protection will be shown in section 3 and the effects of the innovation subsidies will be shown in section 4. And, concluding remarks are presented in Section 5.
2 Basic Model

There are two countries in the world-The North, N, and the South, S. Both countries freely trade their differentiated products which invented in North and imitated in the South. Labor is the only factor of production in each of the two countries. It is intersectorally mobile but internationally immobile. The representative household maximizes the intertemporal utility function given by

$$U_t = \int_t^\infty e^{-\rho(\tau-t)} \left[ \log D(\tau) \right] d\tau$$

subject to the intertemporal budget constraint given by

$$\int_t^\infty e^{-r(\tau-t)} E(\tau) d\tau \leq \int_t^\infty e^{-r(\tau-t)} I(\tau) d\tau + A(t)$$

where $E(\tau), I(\tau), U_t$ and $A(t)$ are the instantaneous expenditure, instantaneous income, instantaneous utility and current value of assets at time $\tau$ of the representative consumer in the $i$th country for $i = N, S$. $\rho$ and $r$ are the rate of time preference and the nominal interest rate in the $i$th country, respectively.

The relevant instantaneous subutility index is assumed to have the following form:

$$D = \left[ \int_0^n x(j)^\alpha dj \right]^{\frac{1}{\alpha}} , 0 < \alpha < 1$$

where $n$ and $x(j)$ stand for the number of products and the amount of the $j$th variety consumed by the representative consumer.

Solving the optimization problem we obtain the following instantaneous demand function for $j$th variety given by

$$x(j) = \frac{E p(j)^{-\varepsilon}}{\left[ \int_0^n p(j)^{1-\varepsilon} dj \right]^{\frac{1}{\varepsilon}}}$$

where $\varepsilon = \frac{1}{1-\alpha} > 1$ is elasticity of substitution.

We also obtain the following optimal time path of expenditure given by

$$\frac{\dot{E}}{E} = r - \rho$$

According to Grossman and Helpman(1991), I normalize $E = 1$ then in steady state we can get $r = \rho$

2.1 Product Market

There are 3 types of firms produce goods: Northern firms (N), Offshoring innovation and production firms O and imitative Southern firms S. Northern firms have an option to innovate and produce in the North or the South. A firm requires one unit labor to produce
a unit of output in the North and they requires $\xi > 1$ units of labor to produce a unit of output in the South. $\xi$ can be interpreted as the coordination costs or monitoring costs. To offshore the innovation to the South, a firm has to confront with the problem of an information or knowledge leakage to the Southern firm. Each firm completes each other according to Bertrand price competition fashion and all goods are freely traded internationally.

The profit of the representative Northern firm, offshoring innovation and production firms are, respectively, given by the following:

$$ \pi^N = p^N x^N - w^N x^N \quad (6) $$

$$ p^N = \frac{w^N}{\alpha} \quad (7) $$

Given the constant elasticity demand function, the monopoly price are marks-up over their marginal costs:

$$ p^N = \frac{w^N}{\alpha} \quad (8) $$

$$ p^O = \frac{\xi w^S}{\alpha} \quad (9) $$

Southern firms can produce only those goods that they have successfully imitated and they need one labor to produce a unit of goods. If successful in imitating an offshoring innovation and production firm, and assume $\xi \alpha > 1$, a Southern imitator limit prices the Northern firm whose produce it has copied by setting its price equal to the Northern firm’s marginal cost. Therefore the Southern firm’s price setting and profit function are respectively given by

$$ p^S = \xi w^S \quad (10) $$

$$ \pi^S = (\xi - 1) w^S x^S \quad (11) $$

Let $x^J$ denote the good that firm $J$ where $J = N, O$ or $S$ can sale. We know from the demand functions in eq. 4 that

$$ \frac{x(i)}{x(j)} = \left( \frac{p_i}{p_j} \right)^{-\varepsilon} \quad (12) $$

Substitute price equation for the three types of goods, we have

$$ \frac{x^O}{x^N} = \left( \frac{\xi w^S}{w^N} \right)^{-\varepsilon} \quad (13) $$

$$ \frac{x^S}{x^N} = \left( \frac{\alpha \xi w^S}{w^N} \right)^{-\varepsilon} \quad (14) $$

$$ \frac{x^S}{x^O} = \alpha^{-\varepsilon} \quad (15) $$
## 2.2 Innovation, imitation and innovation and production offshoring

At time $t$ there are $n$ goods existing in the world, among which $n^O$ goods are innovated and produced domestically, $n^O$ goods have been internationalized by offshoring their innovation and production processes to the South and $n^S$ are goods produced by Southern imitators. Therefore, $n^{SO} = n^O + n^S$ denote all goods that their innovation and production are performed in South and $n = n^N + n^O + n^S$ denote the total number of goods in this economy.

We define the rate of innovation offshoring as

$$
\Upsilon = \frac{\dot{n}^O}{n^N}
$$

(16)

In each point of time, the total number of goods innovated and produced in the South $\Upsilon$ denotes the number of goods increases by $\Upsilon n^N$. Note that this measures the inflow of innovation offshoring because imitation only targets $O$-type Northern firms and does not leads to North-South innovation and production shifting. Next, we define the rate of imitation as

$$
m = \frac{\dot{n}^S}{n^O}
$$

(17)

$m$ denotes the rate of increase of the number of imitated goods relative to the total number of goods produced by offshoring innovation and production firms. Because $O$-type Northern firm and Southern imitators produce in the South, imitation transfers ownership of a good from $O$-type firm to a Southern imitator.

On balance growth path or in a steady state equilibrium in which prices, nominal spending, and all goods grow at the same rate $g$,

$$
g = \frac{\dot{n}}{n} = \frac{\dot{n}^N}{n^N} = \frac{\dot{n}^O}{n^O} = \frac{\dot{n}^S}{n^S} = \frac{\dot{n}^{SO}}{n^{SO}} = \dot{E} = E
$$

(18)

and $g$, $\frac{n^N}{n}$, $\frac{n^O}{n}$ and $\frac{n^{SO}}{n}$ are constant over time. We can calculate the steady state allocation of goods across three types of firms as following.

\[
\begin{align*}
\frac{n^O}{n^N} & = \frac{\Upsilon}{g} \\
\frac{n^{SO}}{n^N} & = \frac{\Upsilon}{g} \left[ 1 + \frac{m}{\Upsilon} \right] \\
\frac{n}{n^N} & = 1 + \frac{\Upsilon}{g} \left[ 1 + \frac{m}{\Upsilon} \right] \\
\frac{n^S}{n^N} & = \frac{m}{g} \\
\frac{n^{SO}}{n^S} & = \frac{\Upsilon}{g} \left[ 1 + \frac{m}{\Upsilon} \right] \\
\frac{n^S}{n^N} & = \frac{m}{\Upsilon}
\end{align*}
\]
The expected present discounted lifetime value of profits of Northern firm type $N$ and $O$ and the Southern firm are respectively as following:

\[ v^N = \int_0^\infty e^{-(\rho + g)} \pi^N(t) \, dt = \frac{\pi^N}{\rho + g} \]  
(25)

\[ v^O = \int_0^\infty e^{-(\rho + m + g)} \pi^O(t) \, dt = \frac{\pi^O}{\rho + m + g} \]  
(26)

\[ v^S = \int_0^\infty e^{-(\rho + g)} \pi^S(t) \, dt = \frac{\pi^S}{\rho + g} \]  
(27)

We can see that the profit of the Northern O-type firm is discounted by the effective rate interest rate ($r + \rho$) but also by the rate of imitation ($m$). This is because imitation targets only Northern O-type firms. However, in reality Northern firms that domestically innovate and produce at North have also probability to be imitated but this risk of imitation is lower than the Northern O-type firm. For simplicity, I assume this risk become zero. Therefore the Northern firms have an option of innovation and production in the North or in the South. To innovate and produce in the South, firms pays a lower relative wages(Southern wages are lower Northern wage in equilibrium as I will show later) but they confront with the risk of imitation depending on rate of information leakage and stock of knowledge in the South.

Next we will consider the costs of innovation and imitation. Following Grossman and Helpman(1991), the cost of innovation by a Northern firm is assumed to be

\[ C^N_I = \frac{w^N a^N}{n} \]  
(28)

where $a^N$ is the cost parameter of innovation in the North. $\frac{1}{n}$ captures the spillover effect of knowledge generated on efficiency of current innovation. In other words, the efficiency of product development in North increases with $n$, with is proxy for the cumulative knowledge generated as by-products of all past innovations in North.

The cost of offshore innovation can be modeled as the same fashion as the costs of innovation in the North but a O-type firms pay $w^S$ in this case. Therefore, The costs of innovation in the South is

\[ C^O_I = \frac{w^S a^O}{n} \]  
(29)

where $a^S$ is the cost parameter of innovation in the South. Assume $a^N < a^O$. Intuitively, this is due to the costs of operating and conducting an innovation in unfamiliar foreign environments.

The imitation activity in the South is an investment activity similar to the innovation. Because in reality required managerial talent, scientists, and technicians, much like any other type of research. South can gain the ability to produce an existing variety by devoting $\frac{a^S}{\gamma n^{S0}}$ units of labor to the task of imitation Here $n^{S0}$ represents the number of technologies
that the South has already acquired and the number of products that the Northern firms offshore to the South. In other words, \( n_{SO} \) is the number of goods produced in the South. Both imitation and information offshoring generate information leakage to the South. \( \gamma \) captures the degree of information or knowledge leakage to the South. We can interpret that a lower in \( \gamma \) is a strengthening of IPR protection in the South or vice versa.

\[
C_M^S = \frac{w^S a^S}{\gamma(n^O + n^S)} = \frac{w^S a^S}{\gamma n_{SO}}
\]  

(30)

Assume \( a^S < a^N < a^O \). Intuitively, the labor required for imitation is less than newly invent a goods. The imitation costs of Southern imitators are

### 2.3 Relative wages

Since all Northern firms have the option of whether offshoring innovation and production to the South, the both types of firms will allocate until \( v^N = v^O \) which implies

\[
\frac{\pi^N}{\rho + g} = \frac{\pi^O}{\rho + m + g}
\]

(31)

\[
\left(\frac{\xi w^S}{w^N}\right)^{1-\varepsilon} = 1 + \frac{m}{\rho + g}
\]

(32)

Then, the relative wages are

\[
\frac{w^N}{w^S} = \omega = \xi (1 + \frac{m}{\rho + g})^{\frac{1}{\varepsilon-1}} > 1
\]

(33)

\[
= \xi \left(\frac{n_{SO}}{n^O}\right)^{\frac{1}{\varepsilon-1}} > 1
\]

(34)

The relative wage of Northern relative with the South increase with the production disadvantage caused by coordination and monitoring difficulties faced by O-type firm (\( \xi \)) and the rate of imitation (\( m \)) because they discourage Northern firm to offshore to the South. This reluctance to shift innovation and production processes to the South implicitly an increase Northern labor demand and finally relative wages.

### 2.4 Free entry into innovation and imitation

Free entry and profit maximization imply that the expected lifetime present value of each type of N-type and O-type firms must be equal to the costs of innovation. And the expected lifetime present value of the Southern firm must be equal to the costs of imitations.

\[
v^N = \frac{w^N a^N}{n} \Leftrightarrow \frac{\pi^N}{\rho + g} = \frac{w^N a^N}{n}
\]

(35)

\[
v^O = \frac{w^S a^O}{n} \Leftrightarrow \frac{\pi^O}{\rho + m + g} = \frac{w^S a^O}{n}
\]

(36)

\[
v^S = \frac{w^S a^S}{n_{SO}} \Leftrightarrow \frac{\pi^S}{\rho + g} = \frac{w^S a^S}{\gamma n_{SO}}
\]

(37)
Substituting profit function of each type of firms into eq. (35)- (37) gives the output of the N-type, O-type and S-type as following:

\[ x_N = \frac{\alpha}{1-\alpha} \frac{a^N(\rho+g)}{n} \]  
(38)

\[ x_O = \frac{a^O(\alpha(\rho+g+m))}{\xi(1-\alpha)n} \]  
(39)

\[ x_S = \frac{a^S\alpha(\rho+g)}{(\xi-1)n} \]  
(40)

From eq. (32) and (37) we have

\[ \frac{w_N}{w_S} = \frac{1}{\gamma} n \frac{a^S v^N}{a^N v^S} \]  
(41)

Free entry condition in innovation and imitation can be reexpressed as

\[ \gamma \alpha^{1-\varepsilon} n^{SO} a^N \xi - 1 \left( \frac{\rho + g + m}{\rho + g} \right) \frac{\xi}{\gamma} = 1 \]  
(42)

\[ \frac{(\alpha^{1-\varepsilon})^{\frac{\xi}{1-\varepsilon}}} {1 + \frac{\xi}{\gamma} \left( 1 + \frac{m}{g} \right) a^N \xi - 1 \left( \frac{\rho + g + m}{\rho + g} \right) \frac{\xi}{\gamma} = 1 \]  
(43)

Intuitively, this condition follows from the assumption of free entry into imitation and innovation and it ensures that neither activity leads to excess profits for firms that are successful in such activities.

### 2.5 Labor markets

In the North the Northern firms demand \( n^N x^N \) units of labor for manufacturing, while \( \frac{a^N \dot{n}^N}{n} \) to conduct research in the North. Northern labor market equilibrium requires that

\[ L^N = \frac{a^N \dot{n}^N}{n} + n^N x^N \]  
(44)

Where \( L^N \) is the supply of labor in North. Similarly \( n^S x^S \) units of labor used for manufacturing of Southern goods, while \( \frac{a^S \dot{n}^S}{\gamma n^{SO}} \) are engaged in imitation. Moreover, \( \xi n^{O \cdot x^O} \) units of labor used for manufacturing for offshoring Northern firms and \( \frac{a^O \dot{n}^O}{n} \) are engaged in innovation activity of offshoring northern firms in the South. Southern labor market equilibrium requires that

\[ L^S = \frac{a^O \dot{n}^O}{n} + \frac{a^S \dot{n}^S}{\gamma n^{SO}} + \xi n^{O \cdot x^O} + n^S x^S \]  
(45)
Figure 1: Equilibrium value of rate of innovation offshoring(\(\Upsilon\)), rate of imitation(\(m\)) and rate of innovation(\(g\)).

Substitute eq. (18)-(24) and demand function into above labor clearing condition we get,

\[
L^N = \frac{a^N g^2}{g + \Upsilon + m} + \frac{g}{g + \Upsilon} \frac{\alpha a^N (\rho + g)}{1 + \frac{m}{g}} \frac{1}{1 - \alpha} \quad (46)
\]

\[
L^S = \frac{a^O g \Upsilon}{g + \Upsilon + m} + \frac{\xi a^S (\rho + g) \alpha^E}{(\theta - 1) \gamma} \left( \frac{g}{g + m} \right) + \frac{a^S g m}{\gamma (g + m)} + \left( \frac{m}{g + m} \right) \frac{a^S (\rho + g)}{(\theta - 1) \gamma} \quad (47)
\]

So far we get the three equilibrium conditions to solve for steady state equilibrium of rate of innovation offshoring(\(\Upsilon\)), rate of imitation(\(m\)) and rate of innovation(\(g\)). We can draw the relationship between three equilibrium as following graph in figure 1.

The Southern labor market constraint is downward sloping in the \((g,m)\) space. In other words, since the South has only a fixed amount of labor resources, an increase in the Southern rate of imitation \(m\) implies that the rate of innovation \(g\) that can be supported by the global economy must be lower. And, the Northern labor market constraint is upward sloping in the \((g,m)\) space. Since a higher of imitation mean the high risk of being copied
and higher number of Southern firms relative to number of Northern firms (see eq. (24)). The lower number of Northern firms, the lower demand for manufacturing Northern goods in the North, the higher Northern resources are available for innovation. It generates the property that Northern labor market constraint is upward sloping.\footnote{The mathematical proof of slopes are in the appendix.}

The free entry condition constraint (in the lower panel) showing an equilibrium relationship between \( g \) and \( \Upsilon \) is downward sloping. Intuitively, from eq. 22, the higher of rate of innovation the higher number of Northern firms. It results 0-type Northern firms is lower and also rate of innovation offshoring is lower.

\section{Effects of Strengthening IPR Protection}

This objective of this section is to study how a strengthening IPR protection in the South, captured by a decrease in the rate of information leakage \( \gamma \), affects the relative wages(\( \omega \)), the rate of innovation(\( g \)), rate of imitation(\( m \)), and rate of innovation offshoring(\( \Upsilon \)). The effects of strengthening IPR protection can be shown by figure (2).

The strengthening IPR protection implies a low value of \( \gamma \). The lower \( \gamma \) raises the demand for labor of the South. Thus, the relative wages of the North (\( \omega \)) decreases. As a result of decrease of \( \omega \) and \( \gamma \), the costs of imitation is higher than the value of Southern firms \( v^S < \frac{w^S}{\gamma w^S} \), the number of Southern firms falls and then \( m \) decreases.

Next we consider the free entry between the Northern firm (N) and offshoring innovation and production firms(O). When \( \omega \) decreases, we found that

\[
\frac{w^N n^N}{n} < \frac{w^S n^O}{n} \Rightarrow v^N < v^O
\]

The value of O-type firms becomes higher than that of N-type firms. Northern firms change their innovation and production location by offshoring innovation and production to the South and becomes O-type firms. \( n^O \) increases while \( n^N \) decrease. Therefore, the rate of innovation on offshoring (\( \Upsilon \)) increases.

Using derivation in section 2, it is straightforward to show that the total labor requirement for producing goods of offshoring firms relative to those of Southern imitators has the following simple expression:

\[
\frac{\xi n^O x^O}{n^S x^S} = \frac{\xi \Upsilon \alpha^\varepsilon}{m} \tag{48}
\]

Thus, factors that lower the rate of imitation(\( m \)) or those that increase the rate of innovation offshoring (\( \Upsilon \)) will lead to increase in labor demand in the South for offshoring firm’s production relative to those of the Southern firms. The Southern labor resources are available for innovation of O-type firm decrease. The rate of innovation (\( g \)) by offshoring firms decreases.
Figure 2: Effects of Strengthening IPR Protection
Proposition 1  A strengthening of IPR protection decreases rate of innovation and the rate of imitation but increases the rate of innovation offshoring.

Intuitively, The strengthening IPR protection in the South raise costs of imitation and then decrease the rate of imitation. Not many of offshoring firms’ goods are not imitated anymore so the offshoring Northern firm slow down its innovation. It is resulted from the innovated goods can live longer without being imitated.

Next we will study the effects of a strengthening of IPR protection on real wages in the two regions. The real wage effects of a strengthening of IPR protection depends on nominal wages in the North and South and prices of goods produced by three types of firms: Northern firms($N$), innovation and production offshoring firms($O$) and Southern imitators($S$). Recall that

\[
\begin{align*}
    p^N &= \frac{w^N}{\alpha} \\
    p^O &= \frac{\xi w^S}{\alpha} \\
    p^S &= \xi w^S
\end{align*}
\]

We can calculate Northern real wages in terms of the three types of goods,

\[
\begin{align*}
    \frac{w^N}{p^N} &= \alpha \\
    \frac{w^N}{p^O} &= \frac{\alpha w^N}{\xi w^S} \\
    \frac{w^N}{p^S} &= \frac{w^N}{\xi w^S}
\end{align*}
\]

In other words, the Northern real wages in term of goods produced by Northern firms is unaffected by Southern IPR protection whereas in terms of the other two goods, it moves in the same direction as the Northern relative wages $\omega$. Consider now the effect on Southern real wages, We have

\[
\begin{align*}
    \frac{w^S}{p^N} &= \frac{\alpha w^S}{w^N} \\
    \frac{w^S}{p^O} &= \frac{\alpha}{\xi} \\
    \frac{w^S}{p^S} &= \frac{1}{\xi}
\end{align*}
\]

In other words, the only effect on Southern real wages of a change in IPR protection policy is in terms of Northern goods innovated and produced in the South. The Southern real wages in terms of offshoring innovation and production firms’ price increases. We can now state the following:
Proposition 2 A strengthening of IPR protection decreases Northern relative real wages but increases real wages in South.

So far we can see the overall effects of a strengthening of IPR protection. Stronger IPR enforcement in South generates a static and dynamic welfare losses. The static loss is the decrease in real wages (or in its term of trade since the relative price of Northern exports is determined by the relative wages). And the dynamic loss is the decrease in the rate of innovation.

Proposition 3 A strengthening of IPR protection creates static and dynamic welfare loss. The static loss is from the decrease in relative real wages or its term of trade. And, The dynamic loss is from the decrease in the rate of innovation.

4 Effects of Innovation Subsidies

We know that the strengthening IPR in the South generates losses in both static and dynamic to the North. What the Northern government should do to improve a domestic welfare? Governments may attempt to directly affect innovation through the use of innovation subsidies. This purpose of this section is to study the effects of the innovation subsidies on the relative wages($\omega$), the rate of innovation($g$), rate of imitation($m$), and rate of innovation offshoring($\Upsilon$).

Suppose now that the Northern government implements subsidies to innovation. I assume that the payment are financed by lump-sum taxes that keep the government’s budget intertemporally balance. While South continues to pursue a policy of laissez faire. Let $s^i$ denote the share of research expenses borne by the government in country $i$; $i = N, S$ so that $0 < s^N < 1$ and $s^S = 0$. With the subsidy in place, free entry into innovation of Northern firms implies that

$$v^N = \frac{(1 - s^N)w^N a^N}{n} \Leftrightarrow \frac{\pi^N}{\rho + g} = \frac{(1 - s^N)w^N a^N}{n}$$  \hspace{1cm} (55)

Then eq. (43) must be modified to

$$\frac{(\alpha^{1-\gamma}) \frac{\Upsilon}{g} \left(1 + \frac{m}{g}\right) (1 - s^N)a^N \xi - 1\alpha - 1}{a^S (\rho + g + m) (\rho + g + m) \left(\frac{\rho + g + m}{\rho + g}\right)^{\frac{\xi - 1}{\alpha - 1}}} = 1$$ \hspace{1cm} (56)

This is the only change introduced by the innovation subsidies into the system of equilibrium relationships. The innovation subsidies in the North does not disturb the labor market clearing conditions. The effects of the innovation subsidies can be shown by figure 3

Accordingly, the introduction of subsidies to innovation shifts the $Ls$ curve upward and $Ln$ and $\Upsilon$ downward in figure 3. The rate of innovation increases and the rate of Southern imitation and the rate of innovation offshoring decreases. Intuitively, from eq. 55 we can see that the innovation subsidies reduce costs of innovation by fraction $1 - s^i$. The value of Northern firms become less than the costs of innovation, thus, the number of Northern
Figure 3: Effects of Innovation Subsidies
firm($n^N$) or an the rate of innovation ($g$) must increase to balance the free entry condition of Northern firms. The increase in rate of innovation is higher the demand for Northern labor. This pressures the Northern wages relative to Southern wages raise. The costs of imitation reduces according to this increase in relative wages, so the rate of imitation increases.

Recall from eq. 31

\[
\frac{\pi^N}{\rho + g} = \frac{\pi^O}{\rho + m + g}
\]

The increase in rate of imitation and rate of innovation causes the value of innovation and production offshore firms ($v^O$) is lower than that of Northern firm ($v^N$), then the rate of innovation offshoring decreases. We can summarize the effects of innovation subsidies as following proposition.

**Proposition 4** An innovation subsidy in the North increases rate of innovation, the rate of imitation and Northern relative wages.

Next, we will study effects of innovation offshoring on the real relative wages in terms of the three types of goods in the two regions. From eq. 49-51. The Northern real wages in term of goods produced by Northern firms is unaffected by innovation subsidies whereas in terms of the other two goods, it moves in the same direction as the Northern relative wages $\omega$. That is the Northern relative wages in terms of offshoring innovation and production firms' price and Southern price increase.

The effect on Southern real wages of a change in innovation subsidies is in terms of Northern goods innovated and produced in the South like case of IPR protection. The Southern real wages in terms of offshoring innovation and production firms' price decreases. We can now state the following:

**Proposition 5** The innovation subsidies increases Northern relative real wages but decreases real wages in South.

The overall effects of innovation subsidies is that they generate a static and dynamic welfare gains. The static gain is the increase in real wages (or in its term of trade since the relative price of Northern exports is determined by the relative wages). And the dynamic loss is the increase in the rate of innovation.

**Proposition 6** The innovation subsidies creates static and dynamic welfare gains. The static loss is from the increase in relative real wages or its term of trade. And, The dynamic gain is from the increase in the rate of innovation.

5 Concluding Remarks

Innovation offshoring plays a prominently role in the current world economy. Media now report the innovation offshoring in sectors ranging from pharmaceutical and bio-technology to computer hardware and software. An increasing number refer to wholly owned innovation centers in countries such as Russia, China, and India, or sometimes even arms length subcontracting of innovation in these countries. Five powerful forces are currently driving...
the innovation revolution- lower wage rates, higher demand, increase in the supply of scientists, technologists and knowledge workers, growth in interaction capabilities and new incentives in developing countries. Therefore, the understanding of this emerging new forms of international trade and cross-border businesses are important to highlight.

This paper studies the effect of strengthening IPR protection in the South and innovation subsidies on the rate of innovation, rate of imitation, rate of innovation offshoring, relative wages and also real wages. To answer the research questions, I introduced innovation and production offshoring into Grossman and Helpman(1991) model with endogenous innovation and imitation. Previous authors who employed the Grossman and Helpman model in order to analyze the effects of stronger IPRs and innovation subsidies were more interested in determining the rate of imitation and in the steady state equilibrium without investigating about innovation and production offshoring. In my model the Northern firms confront the problem of information leakage to Southern firms and monitoring costs to trade with lower Southern wages if they do offshore innovation and production. According to my theoretical results, the strengthening of IPR protection in the South creates static and dynamic welfare losses. The static loss is from the decrease in real wages or its term of trade. And, the dynamic loss is from the decrease in the rate of innovation. On the other hand, the innovation subsidies creates static and dynamic welfare gains. The static loss is from the increase in relative real wages or its term of trade. And, the dynamic gain is from the increase in the rate of innovation.

6 Appendix

6.1 Proof upward slope of \( L^N \)

Recall from eq. 43

\[
\frac{(a^{1-\varepsilon})}{g} \left( \frac{1 + \frac{m}{g}}{a^{\gamma (1 - \alpha)}} \right) a^{N} \xi - 1 \left( \frac{\rho + g + m}{\rho + g} \right)^{\frac{1}{1+\varepsilon}} = 1
\]

We can calculate \( \Upsilon \) as the function of \( g \) and \( m \) as following.

\[
\Upsilon = \frac{a^{N} g^2(1 - \alpha)\alpha^\varepsilon}{(g + m) \left( a^{S(\alpha - 1)\alpha^\varepsilon} + a^{N}\alpha^{(\xi - 1)} \left( 1 + \frac{m}{g+\rho} \right)^{\frac{1}{1+\varepsilon}} \right)}
\]

For positive value of \( \Upsilon \), we assume \( a^{S(\alpha - 1)\alpha^\varepsilon} + a^{N}\alpha^{(\xi - 1)} \left( 1 + \frac{m}{g+\rho} \right)^{\frac{1}{1+\varepsilon}} > 0 \)

From eq. 46, we know that \( L^N = L^N(g, m, \Upsilon(g, m)) \). Thus the slope of \( L^N \) in the \((m, g)\) space is

\[
\frac{\partial m}{\partial g} = - \left( \frac{\partial L^N}{\partial m} \frac{\partial \Upsilon}{\partial m} + \frac{\partial L^N}{\partial g} \frac{\partial \Upsilon}{\partial g} \right) > 0
\]
\[
\frac{\partial L^N}{\partial g} = a^N g \left( -\frac{g}{(g + \bar{Y} + m)^2} + \frac{2}{g + \bar{Y} + m} - \frac{g\alpha}{(g + i + \bar{Y}m)(-1 + \alpha)} \right) + a^N g \left( \frac{g^2 - \bar{Y}m}{(g + \bar{Y} + \bar{Y}m)^2(-1 + \alpha)} \right) > 0
\]

\[
\frac{\partial L^N}{\partial m} = a^N g^2 \left( -\frac{1}{(g + \bar{Y} + m)^2} + \frac{\bar{Y}\alpha(g + \rho)}{(g + \bar{Y} + \bar{Y}m)^2(\alpha - 1)} \right) < 0
\]

\[
\frac{\partial L^N}{\partial \bar{Y}} = a^N g^2 \left( -\frac{1}{(g + \bar{Y} + m)^2} + \frac{g + m\alpha g + \rho}{(g + \bar{Y} + \bar{Y}m)^2(\alpha - 1)} \right) < 0
\]

\[
\frac{\partial \bar{Y}}{\partial m} = \frac{a^S g^2(-1 + \alpha)\alpha^\epsilon \left( a^S(-1 + \alpha)\alpha^\epsilon + \frac{a^N\alpha\gamma(-1 + \xi)((g + m)(1 + 2\epsilon)(1 + \epsilon)(1 + \gamma\frac{m}{g + \rho}))^\frac{1}{1+\epsilon}}{(1 + \epsilon)(g + m + \rho))} \right)}{(g + m)^2 \left( a^S(-1 + \alpha)\alpha^\epsilon + a^N\alpha\gamma(-1 + \xi) \left( 1 + \frac{m}{g + \rho} \right)^\frac{1}{1+\epsilon} \right)^2} > 0
\]

\[
\frac{\partial \bar{Y}}{\partial g} = \frac{a^S g(-1 + \alpha)\alpha^\epsilon \left( a^S(-1 + \alpha)\alpha^\epsilon + a^N\alpha\gamma(-1 + \xi) \left( 1 + \frac{m}{g + \rho} \right)^\frac{1}{1+\epsilon} \right)^2}{(g + m)^2 \left( a^S(-1 + \alpha)\alpha^\epsilon + a^N\alpha\gamma(-1 + \xi) \left( 1 + \frac{m}{g + \rho} \right)^\frac{1}{1+\epsilon} \right)^2} - a^S(g + 2m)(-1 + \alpha)\alpha^\epsilon + a^N\alpha\gamma(-1 + \xi) \left( \frac{g(m + \rho)(1 + \frac{m}{g + \rho})^{1+\epsilon}}{(1 + \epsilon)(g + m + \rho)} \right) - (g + 2m) \left( 1 + \frac{m}{g + \rho} \right)^\frac{1}{1+\epsilon} \right) < 0
\]

6.2 Proof upward slope of \(L^S\)

From eq. 47, we know that \(L^S = L^S(g, m, \bar{Y}(g, m))\). Thus the slope of \(L^S\) in the \((m, g)\) space is

\[
\frac{\partial m}{\partial g} = -\left( \frac{\partial L^S}{\partial g} + \frac{\partial L^S}{\partial \bar{Y}} \frac{\partial \bar{Y}}{\partial g} \right) < 0
\]

\[
\frac{\partial L^S}{\partial g} = \frac{a^O \bar{Y} + m}{(g + \bar{Y} + m)^2} + \frac{a^S m(m\xi - \rho) + a^S \alpha^\xi(g^2 + 2gm + m\rho)}{(g + \bar{Y} + m)^2\gamma(-1 + \xi)} > 0
\]

\[
\frac{\partial L^S}{\partial m} = -\frac{a^O \bar{Y} + m}{(g + \bar{Y} + m)^2} + \frac{a^S m(\xi - \rho - a^\xi(g + \rho))}{(g + m)^2\gamma(-1 + \xi)} < 0
\]

\[
\frac{\partial L^S}{\partial \bar{Y}} = \frac{a^O g(g + m)}{(g + i + m)^2} > 0
\]

7 References


