Legal Enforcement against Illegal Imitation in Developing Countries

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Abstract

This paper investigates the effect of seizing illegal imitations within developing countries on imitation, innovation, and economic growth. The model shows four main results. First, a higher seizure rate does not always decrease imitative activity in the South because it may encourage the infringer to commit repeated offenses. Second, the model shows a U-shaped relationship between innovation and the strengthening seizure rate. Third, numerical analysis indicates that a sufficiently high seizure rate that is larger than a critical value is required to enhance economic growth. Finally, unlike seizure, the extended model shows that a prohibition on importing Southern illegal imitations in the North necessarily lowers imitative activities.

JEL-Classification: O31, O34, L16.
Keywords: Innovation, North-South, Seizing Illegal Imitation, Import Prohibition.

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1 Introduction

In recent years, intellectual property rights (IPRs) protection has been strengthened in developing countries (e.g., Park, 2008). However, there are still many illegal goods in developing countries that imitate products in developed countries and infringe their IPRs, including patents, trademarks, and copyrights. Counterfeiting and infringement have been regarded as serious problems by foreign companies exporting or entering a market in a developing country because these illegal activities reduce the sales of the original products. According to a questionnaire survey by the USITC (2011)[1], in 2009, U.S firms conducting business in China estimated economic losses of around \$48.2 billion, with 75.9% of the losses (\$36.6 billion) due to lost sales. The Japan Patent Office also reported that Japanese firms' lost sales due to imitation were approximately \$187 million per firm in 2012. Such economic damage leads to discouraging foreign companies from exportation, foreign direct investment, and innovation.

In China, the Administration of Industry and Commerce (AIC) and Technical Supervision Bureau (TSB) have the power to investigate infringement and punish the infringer by imposing a fine and confiscating goods. When foreign companies detect illegal products that infringe upon their goods, they can request that the AIC and TSB investigate the infringers. Because detection and seizure happen quickly and are not expensive operations, many firms rely on the AIC and TSB instead of bringing criminal charges. In addition, the AIC and TSB can confiscate illegal goods independently, without an order from a foreign firm. Their seizure activities have recently become more frequent, as seen in the upward trend in Fig 1. However, despite the IPR enforcement by Chinese government institutions, the illegal activities do not seem to have stopped. The USITC (2011) reported that the number of U.S. IPR-related seizures from China by the U.S. Customs and Border Protection have grown year after year. In addition, the Japan Ministry of Economy, Trade, and Industry (METI) reported that Japanese firms state that imitation has increased year after year.[2] The METI (2012) notes that "*repeat offenses*" often occur soon after the first offense because the fine is relatively low compared to potential earnings and the guilty parties employ all available methods to attempt to escape criminal punishment. This fact means that seizure would just result in inducing imitators to infringe another product repeatedly

While both IPR enforcement and IPR protection are important issues, many theoretical studies have exclusively focused on IPR protection policies by using an exogenous

[1]The U.S. International Trade Commission.

[2]Annual Report of Counseling Service against Imitation and Pirate 2012, *in Japanese*.

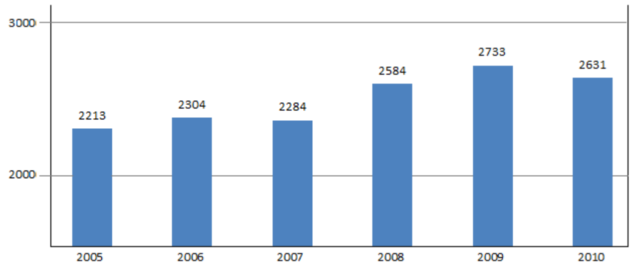

Figure 1: The Number of Seizures by AIC and TSB. *Source: The Japan Ministry of Economy, Trade, and Industry, 2012.*

probability of imitation (e.g., Grossman and Helpman, 1991) or the unit cost of imitation (e.g., Glass and Saggi, 2002) as a proxy for the strength of IPR protection. For simplicity, these models assume that the incumbent loses monopoly power forever after the imitation occurs. This assumption can be interpreted in two ways: (i) all imitations do not infringe on the IPRs, or (ii) there is no legal enforcement against the illegal imitation. Clearly, these interpretations are not realistic and contradict the previously listed empirical evidence. In reality, innovators are faced with the risk of illegal imitation even if IPR protection has been strengthened in developing countries. This implies that the strengthening IPR protection is not enough to secure the profit of innovators under the imperfect IPR enforcement. Therefore, to investigate the IPR policies more meaningfully, we require another framework that considers illegal imitation and IPR enforcement.

This paper analyzes the effects of strengthening IPR enforcement on illegal imitation, innovation, and economic growth after an infringement occurs. This paper consists of two parts. First, in a basic model, we extend the work of Grossman and Helpman (1991, ch12), which is a quality-ladder-type North-South model. The present model incorporates the seizure of illegal imitation into the basic North-South model. Due to the seizure, the infringer cannot keep producing the imitative good, and the original innovator can restore the monopoly after the seizure. The main findings of this basic model are as follows: (i) a higher seizure rate does not always decrease the imitative activity in the South because it may encourage the infringer to repeat offenses. (ii) there is a U-shaped relationship between innovation and the strengthening seizure rate; and (iii) a sufficiently high seizure rate is required to enhance the economic growth. Second, we discuss the economic impact of an import prohibition on Southern illegal imitations in an extended model. This model shows that, unlike seizures, an importing prohibition necessarily lowers imitative activities in South.

To my knowledge, only a few studies have investigated the effects of seizure of imitation in a North-South general equilibrium model.[3] In related literature, Hori and Morita (2011) studied a similar problem by using an exogenous seizure rate by the Southern government. An imitation good is immediately excluded from the market with a constant probability in each period. In contrast to the existing model, both the Northern followers (potential firms in North) and Northern leaders (Northern innovators whose products have been imitated by Southern firms) engage in R&D. Although a higher seizure rate always lowers the imitation rate, the effects of a higher seizure rate on the innovation rate are complicated. When the seizure rate is weak, a higher seizure rate always decreases total volume of R&D investment because both Northern followers and Northern leaders simultaneously lose their incentive to innovate. On the other hand, when the seizure rate is sufficiently strong, a higher seizure rate increases the level of Northern followers' R&D but stifles the Northern leaders' R&D investment. In this case, because the effect on total R&D investment is not known analytically, Hori and Morita (2011) conducted a numerical analysis. Sinha (2006) also analyzed the effect of patent enforcement in the South on Northern innovation in a two-period partial equilibrium model. He assumed that the Southern legal system can detect imitations and debar Southern imitators from using old Northern technologies, with an exogenous probability. He demonstrated that a higher detection rate leads to Northern firms losing their incentive to innovate new technologies because the strong patent enforcement against the infringement of old technologies promises high profits to Northern firms, even if the innovation fails. Consequently, stronger patent enforcement discourages Northern innovation.[4]

The present paper has several advantages compared with existing literature. First, the present model is a Dynamic General Equilibrium (DGE) model, while the Sinha (2006) analysis used a two-period partial equilibrium model. Hori and Morita (2011) used a quasilinear utility function, and there is no income effect. For this reason, their model is a type of partial equilibrium. Second, the present paper analytically provides non-

[3]Difficulty with the calculation may have prevented existing studies from modeling seizures. In many North-South models, a Northern innovator generally loses the profit after a Southern firm imitates the Northern good, for simplicity. Such a setup enables us to easily calculate the expected discounted total profit of the Northern firms. However, imitation seizure restores the Northern innovators' profits, which makes the calculation of the expected discounted total profit more difficult.

[4]Sinha (2006) only captures the negative effect of patent enforcement on innovation due to a limitation of the two-period framework. Indeed, his model does not consider patent enforcement against new technologies, which is invented in the second period. If his model, like the present model, assumed that a stronger IPR enforcement increases profits of innovators who invented new technologies, his monotonic effect on innovation would change.

monotonic effects of strengthened IPR enforcement on imitation and innovation. Numerous existing theories have already demonstrated non-monotonic effects of strengthening IPR protection on innovation and economic growth (e.g., Furukawa 2007; Horii and Iwaisako 2007). Using a North-South model, Akiyama and Furukawa (2009) demonstrated an inverted U-shaped relationship between the Southern IPR protection and innovation in the North. Although the present paper is in line with the previous literature, we focus on IPR enforcement rather than the protection. Finally, the present model examines the effect of prohibiting imports of Southern illegal imitations on imitation and innovation. Many existing models assume that Southern imitations are consumed not only by domestic households but also by Northern households, for simplicity. However, in reality, the Northern government seizes the illegal product, as is done by U.S. Customs and Border Protection. To investigate IPR enforcement policies more realistically, the effects of import prohibition should be examined.

The rest of the paper is structured as follows. Section 2 describes the basic North-South model with seizure. Section 3 analyzes the effect of strengthening the seizure rate on imitation, innovation, and growth rate. In Section 4, we extend the model and consider the import prohibition on Southern illegal imitations. Finally, Section 5 concludes the paper.

2 Basic Model

2.1 Setup

The world economy consists of two countries, North (N) and South (S). There is no population growth and no tariffs. All households serve their labor supply inelastically and labor cannot move across the countries. There are two final goods: A is the agricultural good and X is the manufacturing good. Labor is a fundamental input in the production of both goods. The market for A is perfectly competitive, while that for X is monopolistically competitive.

2.2 Households

All households in N and S have identical preferences. The intertemporal utility function is such that,

$$U_t^j = \int_t^\infty e^{-\rho(\tau - t)} \ln C_{A,j}^{1-\phi}(\tau) C_{X,j}^{\phi}(\tau) d\tau, \tag{1}$$

$$\ln C_{X,j}(\tau) = \int_0^1 \ln \left(\sum_{m=0}^{\tilde{m}_i} \lambda^m(i) x_{mt}^j(i) \right) di, \tag{2}$$

where ρ denotes the discount rate, $j = N, S$ is a country index, and $0 < \phi < 1$ is a share parameter. In the manufacturing sector, the industries continuously exist and the total size is one. The total expenditure in each period is represented as $E_j = P_A C_{A,j} + P_X C_{X,j}$, where P_A is the price of an agricultural good and P_X is the aggregate price index of the manufacturing goods. The intertemporal utility maximization problem yields each consumption level under a given expenditure: $C_{X,j} = \phi E_j / P_X$ and $C_{A,j} = (1-\phi) E_j / P_A$. As represented in the equations, all households spend ϕ percent of their expenditure on manufacturing goods and $1 - \phi$ on agricultural goods.

Moreover, by solving the instantaneous utility maximization problem, we can obtain the demand function of each good in manufacturing sector.

$$x_{\tilde{m}_i}^j = \frac{\phi E_j}{p_{\tilde{m}_i}} \tag{3}$$

Clearly, all households purchase only the highest-quality ($\tilde{m}_i$) good in each industry, i. Therefore, we hereafter omit the subscript ($\tilde{m}_i$) from the demand and price for simplicity.

Let n_N denote the fraction of the industries that Northern firms produce, and n_S be the fraction of the industries that Southern firms produce. Since the total number of the industries is 1, this leads to $n_N + n_S = 1$. Throughout this section, we assume that all households in the world consume Southern imitative goods. Then, the composition of the expenditure for manufacturing goods becomes as follows:

$$\phi E_j = n_N p_N x_N^j + n_S p_S x_S^j \tag{4}$$

Note that, from (3) and (4), $p_N x_N^j = p_S x_S^j$ holds. Therefore, n_N also represents the fraction of the expenditure on Northern goods.

2.3 Agricultural Goods

All agricultural goods are produced only in South, so Northern households must import them for the consumption. An agricultural good can be produced by employing one unit

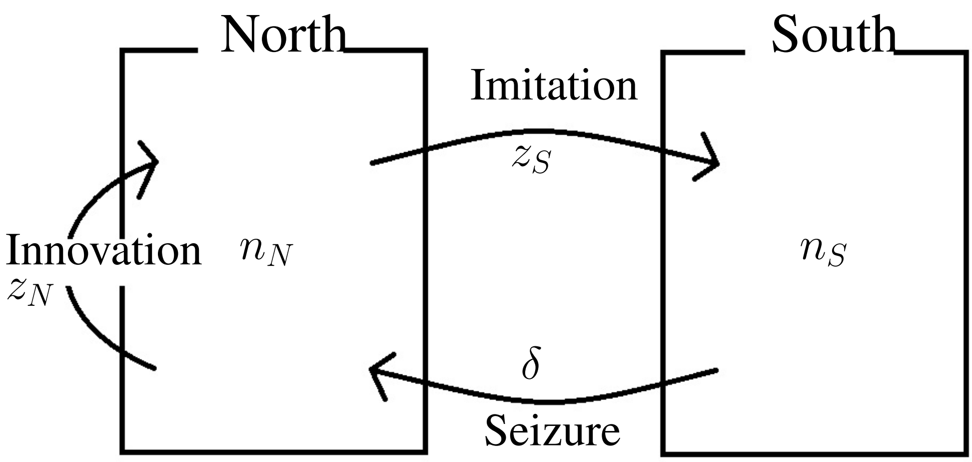

Figure 2: The production cycle composition.

of labor. Since the market is perfectly competitive, the price of good A is equal to the Southern wage rate, w_S. By defining w_S as the numeraire, we obtain $P_A = w_S = 1$.

2.4 Manufacturing Goods

Manufacturing goods are produced in both of North and South. Northern firms produce their original goods and earn a profit until an imitation or innovation in the industry occurs. Southern firms produce the imitative goods that infringe on IPR of the Northern firms, and earn a profit until the Southern government detects and seizes them. We assume that the production of one unit of the good requires one unit of labor in both countries.

Southern potential firms engage in imitative activity by employing labor. As will be shown later, the wage rate in North, w_N, is higher than $w_S = 1$ in equilibrium. Since the imitator can charge a price that is lower than the marginal cost of the Northern firm and they engage in Bertrand competition, a successful imitator can exclude the Northern firm that developed the original good by using the limit-pricing strategy. All imitations only target Northern goods that have not yet been imitated. Southern firms do not imitate Southern illegal products because the profit will be zero under Bertrand competition with other Southern firms.

Northern potential firms devote labor to conducting R&D. All innovation targets only Northern goods in equilibrium. Innovators' profit when they innovate a Northern good will be higher than when they innovate a Southern imitative good because the marginal cost of the old incumbent (w_N) is higher than the marginal cost of Southern imitators

($w_S = 1$). Therefore, a seizure is the only way in which Northern firms may recover their monopoly in the model.

The Southern government seeks domestic illegal products in each period without any cost. Once Southern imitators are detected by the government, imitators immediately exit from the market. Then, the Northern firms that created the original goods regain their monopoly power and once again serve their products. The confiscation activity is exogenous and the probability of seizure follows a Poisson rate of $\delta \in (0, \infty)$. For simplicity, we assume that imitators are not punished by the government and do not compensate the Northern firms.

The innovation rate and imitation rate are denoted by z_N and z_S, respectively. Then, the product cycle in the model can be illustrated as in Fig 2. The law of motion for n_N and n_S can be expressed as follows:

$$\dot{n}_N = n_S \delta - n_N z_S \text{ and } \dot{n}_S = n_N z_S - n_S \delta. \tag{5}$$

2.5 Price and Profit

The nearest rival of a Northern firm is the old Northern leader, and the price of a Northern good is $p_N = \lambda w_N$, by limit-pricing. Therefore, the profit of a Northern firm is $\pi_N = \phi E(1 - \lambda^{-1})$. Here, $E \equiv E_N + E_S$ represents the total world expenditure.

We assume that there are competitive fringes in South that can imitate Southern goods without a research cost and Southern firms face entry pressure. Competitive fringes can produce a good by employing $\beta > 1$ unit of labor, and $w_N > \beta$ holds in equilibrium. Since they are the nearest rival of a Southern firm, the price of Southern goods becomes $p_S = \beta w_S$ as a result of price competition. The profit of a Southern firm is $\pi_S = \phi E(1 - \beta^{-1})$.

2.6 Asset Market

Let V_N denote the firm value of a Northern firm that is not imitated, V_{NI} the firm value of a Northern firm that is imitated, and V_S the firm value of a Southern firm. The stockholders of these firms can earn a return equal to the sum of the dividend and the capital gain in each period, while there is a risk of losing the value with a certain probability. In the equilibrium of the asset market, the period return of each equity must be same as the return of other risk-free investments. The no-arbitrage conditions become as follows:

$$rV_N = \pi_N + \dot{V}_N - z_S(V_N - V_{NI}) - z_N V_N \tag{6}$$

$$rV_{NI} = \dot{V}_{NI} - \delta(V_{NI} - V_N) \tag{7}$$

$$rV_S = \pi_S + \dot{V}_S - \delta V_S \tag{8}$$

2.7 Free Entry

We assume that $(a/n_N)z_N dt$ units of labor are required to attain $z_N dt$, which is the probability of a successful innovation in an industry in a short term of dt. Similarly, a successful imitation in an industry, with probability $z_S dt$, needs $(b/n_N)z_S dt$ units of labor. Here, a and b are parameters that respectively represent the difficulty of innovation and imitation, and n_N in the denominator means that innovation and imitation become more effective as the number of the targets increases.[5]

Free entry into innovation implies that the firm value of the Northern firm, before imitation, is equal to the cost of innovation:

$$V_N = \frac{aw_N}{n_N}. \tag{9}$$

Similarly, the free-entry condition of imitation can be written as follows:

$$V_S = \frac{b}{n_N}. \tag{10}$$

2.8 Labor Market

In the North, labor is allocated between innovation and the production of manufacturing goods. The labor demand must be equal to domestic labor supply in equilibrium. Therefore, the labor market clearing condition in the North is:

$$n_N\left(\frac{\phi E}{\lambda w_N}\right) + az_N = L_N. \tag{11}$$

[5] This spillover can be justified by the following interpretation. Suppose that each good potentially has a different difficulty for innovation and copying. The discovery of a target that is suitable for innovation or imitation may take some time and incur a cost. However, the discovery becomes easier when the number of the targets is large. Mathematically, the equation of z_S in the steady state becomes too complicated hyperbolic function of δ without this assumption. Therefore, to obtain results clearly, we here assume that the cost depends on the number of the targets.

In the South, labor is allocated to imitative activity, the production of imitative goods, and the production of agricultural goods, as follows:

$$n_S \left(\frac{\phi E}{\beta} \right) + (1-\phi)E + bz_S = L_S \tag{12}$$

2.9 Trade Balance

Finally, we assume that the trade of both countries balances in each period.

$$(1-\phi)E_N + \phi n_S E_N = \phi n_N E_S \tag{13}$$

3 Equilibrium Effects of IPR Enforcement

3.1 Steady State

In the steady state, n_N, n_S, V_N, V_{NI}, V_S, E_N, and E_S are constant over time. Then, we can obtain the following relationships, which describe the steady state in the model:

$$n_N = \frac{\delta}{\delta + z_S},\ n_S = \frac{z_S}{\delta + z_S}, \tag{14}$$

$$V_N = \frac{\phi E(1-\lambda^{-1})}{r + z_N + rz_S/(r+\delta)},\ V_S = \frac{\phi E(1-\beta^{-1})}{r+\delta}, \tag{15}$$

$$\text{and } \ r = \rho. \tag{16}$$

By substituting (14)-(16) and free entry conditions into the labor market clearing conditions, we can obtain the imitation rate and innovation rate in the steady state, as follows:

$$z_S^* = \left[\frac{\Omega - (1-\phi)\delta}{\Theta + \delta} \right] \delta, \tag{17}$$

$$z_N^* = L_N(1-\lambda^{-1})/a - \rho\lambda^{-1} \left(1 + \frac{z_S^*}{\rho + \delta} \right). \tag{18}$$

where $\Theta \equiv \phi\rho\left(\beta^{-1} + \phi^{-1} - 1\right)$ and $\Omega \equiv \phi L_S(1-\beta^{-1})/b - (1-\phi)\rho$. The imitation rate does not depend on the innovation rate in the steady state. However, the seizure rate affects the imitation rate, and we define the imitation rate as $z_S^* = Z_S(\delta)$. To ensure the positiveness of z_S^* and z_N^*, we impose next assumption for parameters.

Assumption 1. *The parameters satisfy the following conditions: (i)* $\Omega > (1-\phi)\delta$*, (ii)* $0 < \Theta < 1$*, and (iii)* $L_N > a\rho\left[1 + Z_S(\delta)/(\rho+\delta)\right]/(\lambda - 1)$.

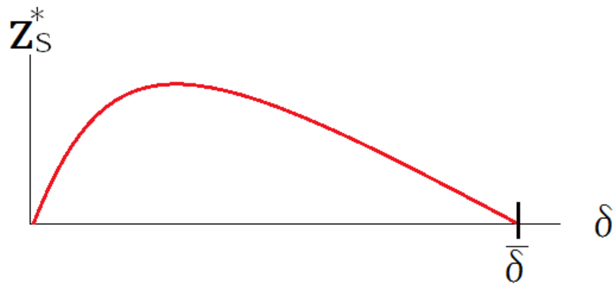

Figure 3: An example of the curve of z_S.

The condition (i) holds when the population size in the South is sufficiently large.[6] The condition (ii) is satisfied when ρ is sufficiently small. The condition (iii) requires a sufficiently large population in the North.

3.2 Southern Imitation

First, we investigate the effect of seizure on Southern imitation in the steady state.[7] From (17), we obtain the following result:

Proposition 1. *There is an inverted U-shape relationship between the imitation rate (z_S^*) and the seizure rate (δ) in (0, $\bar{\delta}$) where $\bar{\delta} \equiv \Omega/(1-\phi) > 0$.*

Proof. From (17), $Z_S(0) = 0$ and $Z_S(\bar{\delta}) = 0$ hold. From Assumption 1, $Z_S(\delta) > 0$ hold for all $\delta \in (0, \bar{\delta})$. These indicate that $Z_S(\delta)$ has at least one vertex on (0,$\bar{\delta}$). By solving $Z_S'(\delta) = \delta^2 + 2\Theta\delta - \Omega\Theta/(1-\phi) = 0$, we obtain the solution as follows: $\delta = -\Theta \pm \sqrt{\Theta^2 + \Theta\Omega/(1-\phi)}$. One solution is strictly higher than 0. This implies that $Z_S(\delta)$ has a unique vertex on (0, $\bar{\delta}$) and the curve is an inverted U-shape, as shown in Fig 3. $\square$

The interpretation of the non-monotonic effect of δ is as follows. When the seizure rate is low, many Southern firms are already imitating Northern goods. Since the number of the targets is small, the new infringement of Northern goods is relatively rare. However, if Southern government increases the seizure rate, imitators lose their job and then try to imitate a different Northern good. This reflects the structure of "repeated offenses."

[6]This condition can be rewritten as follows:$L_S > b(\phi^{-1} - 1)(\rho + \delta)/(1 - \beta^{-1})$.

[7]The equilibrium path in the model is too complex to examine analytically. Therefore, we assume that there exists a trajectory to the steady state. We then analyze the effect of seizure on imitation, innovation, and economic growth.

When δ is sufficiently large, seized imitators start to produce agricultural goods rather than imitate Northern goods because the expected profit becomes very low if they imitate a different good. Therefore, to prevent repeated offenses, the seizure activity of the Southern government has to be sufficiently frequent.

In addition, the imitation rate (z_S^*) is a decreasing function of b and an increasing function of β.[8] In many models, b and β are used as proxies for the strength of IPR protection. For example, β is usually used as the level of the patent breadth (e.g., Iwaisako, Tanaka, and Futagami, 2011). Interestingly, the imitation rate (z_S) and seizure rate (δ) exhibit a non-monotonic relationship, while typical IPR measures have a simple monotonic effect on imitation rate.[9]

By using Proposition 1, we obtain the following result:

Lemma 1. *A higher seizure rate necessarily increases (decreases) the number of Northern (Southern) firms (n_N).*

Proof. From (14) and (17), n_N can be calculated as follows:[10]

$$n_N = \left[1 + \frac{\Omega - (1-\phi)\delta}{\Theta + \delta}\right]^{-1} \tag{19}$$

We can find that the second term in the bracket is a decreasing function of δ. Therefore, n_N is an increasing function of δ. Then, $n_S = 1 - n_N$ naturally becomes a decreasing function of δ. □

The increase of δ has two effects on n_N. First, the more intense seizure activity directly increases the number of Northern goods because many Northern firms recover their monopoly. Second, a higher δ changes the level of imitative activity and indirectly affects n_N. The indirect effect is not always negative since a higher value of δ may induce repeated offenses. However, the direct effect always dominates the indirect effect in this model. Therefore, a higher δ necessarily increases n_N.

Note that both the imitation rate and the number of imitations in each period, $n_N z_S^*$, are important. By substituting (17) and (19) into $n_N z_S^*$, we can calculate the number of

[8] Ω is an increasing function of β and a decreasing function of b. In addition, Θ is a decreasing function of β.

[9] A small value of b means weak IPR protection of Northern goods in the South, and a large value of β means strong IPR protection of Southern goods in the South. From the proposition, we can see that imitation rate is accelerated under a discriminate IPR policy ($b \downarrow$ and $\beta \uparrow$).

[10] Surprisingly, in spite of the equation $n_N = \delta/(\delta + z_S)$, n_N is strictly greater than 0 when $\delta = 0$ in the steady state. The reason is that n_N becomes the indeterminate form of $0/0$ because the imitation rate also goes down to 0, according to $\delta \to 0$.

imitations in each period as follows:

$$n_N z_S^* = \left[\frac{\Omega - (1-\phi)\delta}{\Lambda + \phi\delta}\right]\delta, \tag{20}$$

where $\Lambda \equiv \Omega + \Theta$. This is also a non-monotonic function of δ, as the imitation rate is z_S^*. By same procedure in Proposition 1, we obtain following result.

Proposition 2. *In the steady state, there is an inverted U-shape relationship between the number of imitations ($n_N z_S^*$) and the seizure rate (δ).*

Proof. See Appendix. □

From the viewpoint of the number of imitations, a higher seizure rate may also make many Southern firms begin to imitate Northern goods again. The basic intuition is same as Proposition 1.

3.3 Northern Innovation and Growth Effect

Second, we examine the effect of seizure on Northern innovation in the steady state. From (17) and (18), we obtain following result:

Proposition 3. *The innovation rate (z_N^*) is non-monotonic function of the seizure rate (δ). The maximum values occur at $\delta = 0$ and $\delta = \bar{\delta}$, and the minimum value is attained in the range $\delta \in (0, \bar{\delta})$.*

Proof. By defining $\zeta(\delta) \equiv z_S^*/(\rho + \delta)$, the innovation rate is rewritten as follows:

$$z_N^* = L_N(1 - \lambda^{-1})/a - \rho\lambda^{-1}\left(1 + \zeta(\delta)\right) \tag{21}$$

As shown in Appendix, $\zeta(\delta)$ is non-monotonic function of δ, $\zeta(0) = \zeta(\bar{\delta}) = 0$ holds, and $\zeta(\delta) > 0$ holds for all $\delta \in (0, \bar{\delta})$. In addition, there is a unique vertex on $\delta \in (0, \bar{\delta})$. □

The innovation rate is high when the imitation rate is low, because a low risk of imitation stimulates the incentive for innovators. Therefore, the innovation rate basically exhibits the opposite behavior to that of the imitation rate, as shown in Fig 3 and Fig 4.

A higher seizure rate has several different effects on the innovation incentive. For example, a large δ directly stimulates the incentive because the expected interval of the non-profit term becomes short (direct effect). However, simultaneously, the imitation rate may be accelerated, which stifles innovation (indirect effect). When the seizure rate is small, the probability that new imitations occur is low, which raises the innovation rate.

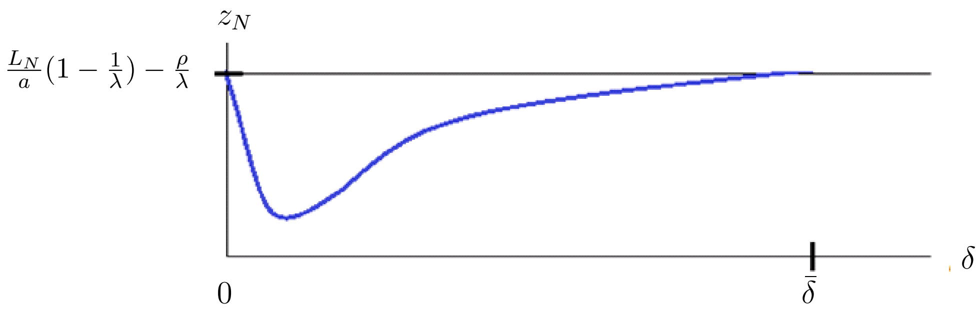

Figure 4: An example of the curve of z_N.

However, in this case, a higher seizure rate increases the imitation rate, and the negative indirect effect dominates the positive direct effect. Conversely, when δ is sufficiently high, the indirect effect becomes positive and the higher seizure rate stimulates innovation.

The number of innovations per period is also important because the growth rate in the model is determined by the expected time of improvement of quality at an instantaneous moment in time. The growth rate, g, can be calculated as follows:

$$\begin{aligned} g &= n_N z_N^* \ln \lambda \\ &= \left[1+\frac{\Omega-(1-\phi)\delta}{\Theta+\delta}\right]^{-1}\left[L_N(1-\lambda^{-1})/a-\rho\lambda^{-1}\left[1+\zeta(\delta)\right]\right]\ln\lambda. \end{aligned} \tag{22}$$

Although the central motivation is to analyze the growth effect of the seizure rate (δ), the functional form of (22) is too difficult to examine analytically. Therefore, the next subsection studies the growth effect using a numerical method.

Finally, we reveal the sufficient condition that $w_N > \beta$ always holds for all $\delta \in (0, \bar{\delta})$.

Proposition 4. *Suppose that all parameters satisfy the following condition:*

$$a\rho\left(\frac{\Omega}{\Theta}-1\right) < L_N < \rho\left(\frac{b}{\beta-1}-a\rho\right). \tag{23}$$

Then, $w_N > \beta$ always holds for all $\delta \in (0, \bar{\delta})$.

Proof. See Appendix. □

3.4 Numerical Analysis

Using a numerical method, we investigate the effects of seizure on imitation, innovation, and economic growth. The parameters are $L_N = 1$, $L_S = 12$, $\lambda = 1.3$, $\beta = 1.05$,

$\rho = 0.03$, $a = 3$, $b = 2$, and $\phi = 0.8$. The size of the quality improvement, λ, is also the size of markup. Sener (2006) pointed out that the markup is estimated to be between 1.05 and 1.4, in several empirical studies. We here adopt $\lambda = 1.3$ from within that range. Mansfield et al. (1981) found that the ratio of the imitation cost to the innovation cost is about $2/3$. Nonetheless, the ratio in the model is flexible, and changes according to the Northern wage. Here, we set $b = 2$ and $a = 3$. The reason is that the cost of an illegal imitation is smaller than the cost of an imitation that does not infringe on the IPR of original products, and therefore $2/3$ can be considered an upper bound of the cost ratio. In the model, w_N is always higher than $w_S = 1$. This implies that the maximum cost ratio in the model is also $2/3$ when $b = 2$ and $a = 3$. The labor supply of both countries, $L_N = 1$ and $L_S = 12$, reflects the population-ratio between Japan and China. These parameters satisfy all assumptions of the model.[11]

The result is shown in Fig 5. The simulation shows that the growth rate exhibits a non-monotonic relationship with the strengthening enforcement policy ($\delta \uparrow$). The interpretation is basically the same as for the innovation rate. However, while the innovation rate attains a maximum value when $\delta = 0$, the growth rate is very low when $\delta = 0$. The reason is that the total number of innovations per period is very small, because the number of innovation targets is low when $\delta = 0$. By increasing the seizure rate from $\delta = 0$, although the number of innovation targets increases, the innovation rate decreases because of the stimulated imitative activity, and the overall effect on innovation becomes negative. However, the slope of the growth rate turns upward when δ is sufficiently large because the policy effect on the innovation rate becomes positive. Unlike the innovation rate, no seizure policy ($\delta = 0$) is worse in terms of the economic growth.

Numerical Result 1. *Although a higher seizure rate does not always increase the growth rate, the strengthening IPR enforcement ($\delta \uparrow$) can enhance the growth if the current seizure rate is larger than a critical value.*

Finally, we observe an advantage of the model. In the model, w_N represents the relative wage between North and South. Gustafsson and Segerstrom (2011) point out that many quality-ladder-type North-South models have difficulty explaining actual large wage differences between North and South, as shown in empirical studies. However, the numerical result shown here includes the area in which the relative wage is larger than the size of quality gap, $\lambda = 1.3$.

[11] The assumption in Proposition 4 is satisfied: $0.6042 < L_N = 1 < 1.1973$.

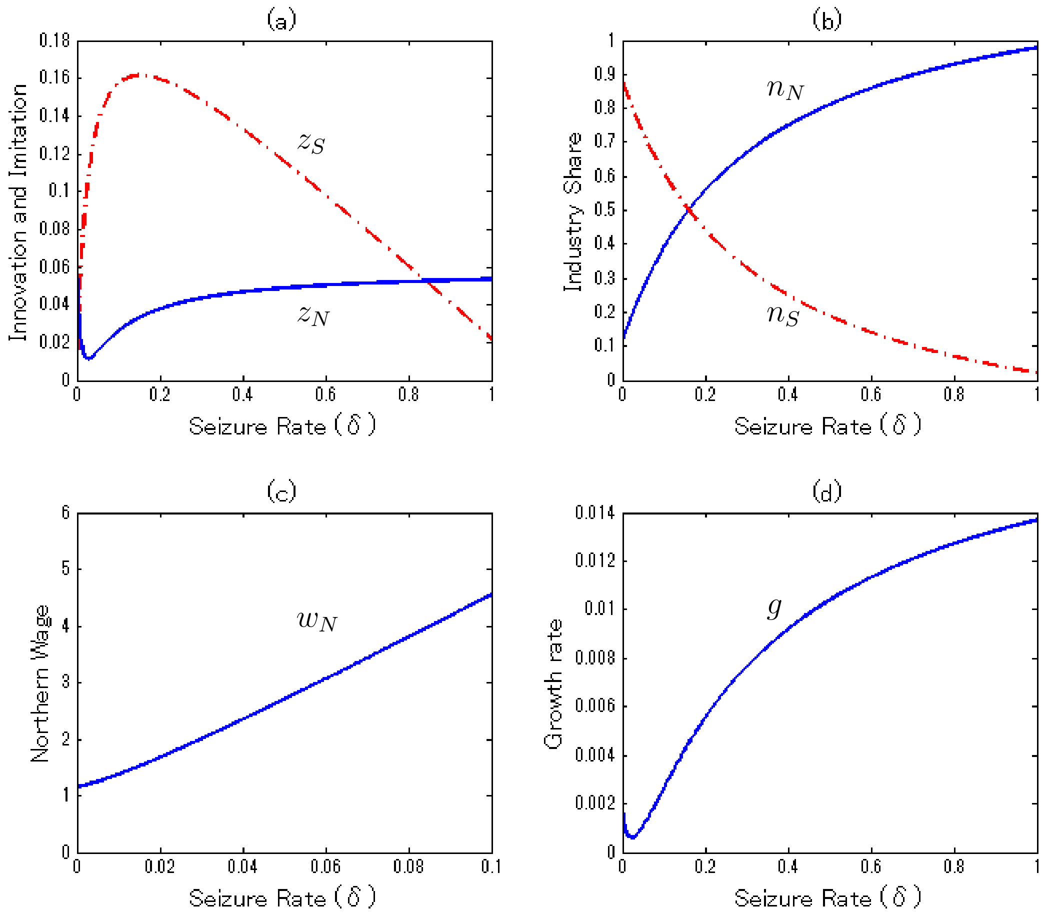

Figure 5: Numerical results.

4 Extended Model: Import Restriction

Many countries prohibit the import of imitative goods that infringe on the property rights of domestic firms, and have recently begun to police this prohibition more vigorously. For example, the Anti-Counterfeiting Trade Agreement (ACTA), which aims to prohibit trade of counterfeit goods and pirated copyright products, was signed in 2011. In fact, it seems that most illegal products are consumed locally. This section considers the effect of the import restriction on imitations by extending the previous model.

First, we briefly note the main modifications to the model. By the import restriction, Northern households cannot consume Southern imitative goods. Therefore, their expenditure on manufacturing goods becomes $\phi E_N = p_N x_N^N$. Southern infringers cannot sell their imitations to Northern households, so their profit naturally decreases. However, Northern firms that are imitated by Southern infringers can still sell their goods to Northern households at the price of $p_N = \lambda w_N$ and earn profit π_{NI}. Their period profit becomes as follows:

$$\pi_{NI} = \phi E_N(1 - \lambda^{-1}) \text{ and } \pi_S = \phi E_S(1 - \beta^{-1}) \tag{24}$$

The firm value of imitated Northern firms in the steady state also changes, as follows:

$$V_{NI} = \frac{\pi_{NI} + \delta V_N}{r + \delta} \tag{25}$$

By substituting V_{NI} into V_N, we can solve for V_N in the steady state:

$$V_N = \frac{\phi \left[E + z_S E_N/(r + \delta)\right] (1 - \lambda^{-1})}{r + z_N + r z_S/(r + \delta)} \tag{26}$$

The labor market clearing conditions are also rewritten, as follows:

$$\frac{\phi E_N}{\lambda w_N} + n_N \left(\frac{\phi E_S}{\lambda w_N}\right) + a z_N = L_N \tag{27}$$

$$n_S \left(\frac{\phi E_S}{\beta}\right) + (1 - \phi)E + b z_S = L_S \tag{28}$$

Then the trade balance condition becomes:

$$(1 - \phi)E_N = \phi n_N E_S. \tag{29}$$

By using the same procedure as in the basic model, we can obtain the imitation rate in the steady state.

$$z_S^* = \left[\frac{\phi L_S(1 - \beta^{-1})/b - (\rho + \delta)}{\Theta + \delta}\right] \delta \tag{30}$$

This equation is similar to that of the basic model, and we can see that z_S^* again describes an inverted U-shape curve with δ, by using same procedure in Proposition 1. Clearly, z_S^* in this model is strictly lower than that in basic model (17) because the numerator in the bracket in (30) can be rewritten as follows: $[\Omega - (1-\phi)\delta] - \phi(\rho + \delta)$. Thus, the imitation rate in the case of an import prohibition is lower than in the model that allows imports of imitative goods. We obtain the following result:

Proposition 5. *In the steady state, the imitation rate in the case of an import restriction is necessarily lower than that of the basic model. In addition, there is an inverted U-shape relationship between the imitation rate and the seizure rate.*

Intuitively, because of the import restriction, imitative activity becomes less attractive since it decreases the imitator's profit. Therefore, the labor demand for imitative activity decreases. Although many workers in Southern firms are now released from production, since imitators can now only sell goods to Southern households, this free labor resource is used in the production of agricultural goods rather than new imitative activities.

This proposition immediately gives following result:

Corollary 1. *The import restriction necessarily decreases $n_N z_S^*$, that is, the number of new imitations of Northern goods per period.*

Proof.

$$n_N z_S^* = \frac{\delta z_S^*}{\delta + z_S^*}. \tag{31}$$

This is an increasing function of z_S^*. □

5 Concluding Remarks

The paper showed that a higher seizure rate may actually stimulate imitative activity in South. When the Southern government increased the seizure rate, infringers stop producing imitative goods, but then later imitate other goods. The model suggests an ironic structure of repeat offenses induced by mild seizure activities. Intensive seizure activities that extirpate illegal imitations are required to decrease infringements and restore the incentive for innovation. Paradoxically, the imitation rate is also lowest when the seizure rate is almost zero in the model. This is because many Southern imitators already earn a profit by infringing the IPR of Northern goods, so they do not have an incentive to imitate additional products. Although the Northern innovation rate also reaches a maximum in this case, the growth rate is lower than in the case of intensive seizure activities, as shown in the numerical example. Therefore, a policy that stops seizure activities is not necessarily better, even in this case. We numerically investigated the growth effect of the eliminative activity of the Southern government and showed that there exists a non-monotonic relationship. The model in this paper suggests that the strength of the current policy should be considered by policymakers when deciding on a growth-enhancing regulatory policy. Furthermore, as an extension, we introduced an import prohibition policy as another regulation. This extension to the model showed that import prohibition always has a negative effect on illegal imitations and can stimulate innovation. Import prohibitions by other countries may be a more direct method of preventing IPR infringements than domestic seizure activities. This result indicates that the choice of an effective regulatory policy is also important to the government.

Appendix

Proof of Proposition 2

By following the proof of Proposition 1, we here prove the shape of $n_N z_S^* \equiv \Gamma(\delta)$ in $\delta \in [0, \bar{\delta}]$ is concave down. From (20), we have $\Gamma(0) = 0$ and $\Gamma(\bar{\delta}) = 0$. In addition, $\Gamma(\delta) > 0$ holds for all $\delta \in (0, \bar{\delta})$ by the assumption in Proposition 1. Therefore, $\Gamma(\delta)$ has at least one vertex in $\delta \in (0, \bar{\delta})$. If positive δ that satisfies $\Gamma'(\delta) = 0$ is unique, the vertex in $\delta \in (0, \bar{\delta})$ is also unique. From the differentiation by δ, we obtain

$$\Gamma'(\delta) = 0 \Leftrightarrow \delta^2 + 2\Lambda\phi^{-1}\delta - \Delta = 0. \tag{32}$$

where $\Delta \equiv \Lambda\Omega/(\phi - \phi^2)$. The solution of this quadratic equation is given by

$$\delta^* = -\Lambda\phi^{-1} \pm \sqrt{\Lambda^2\phi^{-2} + \Delta}. \tag{33}$$

Because Δ is positive, $\sqrt{\Lambda^2\phi^{-2} + \Delta}$ is larger than $\Lambda\phi^{-1}$. This implies that one solution of (32) is positive while another is negative. Consequently, a vertex of $\Gamma(\delta)$ exist in the positive domain and it must be in $\delta \in (0, \bar{\delta})$.

The Vertex of $\zeta(\delta)$

The section analyzes the functional form of $\zeta(\delta)$, which is defined as below.

$$\begin{aligned} \zeta(\delta) &\equiv Z_S(\delta)/(\rho + \delta) \\ &= \left[\frac{\bar{\Omega}}{\rho + \delta} - \bar{\phi}\right]\left[\frac{\delta}{\Theta + \delta}\right]. \end{aligned} \tag{34}$$

where $\bar{\Omega} = \Omega + (1-\phi)\rho$ and $\bar{\phi} = 1-\phi$. Because $Z_S(0) = 0$ and $Z_S(\bar{\delta}) = 0$ hold, $\zeta(\delta)$ satisfies $\zeta(0) = \zeta(\bar{\delta}) = 0$. In addition, $\zeta(\delta) > 0$ hold for all $\delta \in (0, \bar{\delta})$ because $Z_S(\delta) > 0$ hold for all $\delta \in (0, \bar{\delta})$. These mean that $\zeta(\delta)$ has at least one vertex in $\delta \in (0, \bar{\delta})$. The derivative of $\zeta(\delta)$ is given by

$$\begin{aligned} \zeta'(\delta) &= -\frac{\bar{\Omega}\delta}{(\Theta+\delta)(\rho+\delta)^2} + \left(\frac{\bar{\Omega}}{\rho+\delta} - \bar{\phi}\right)\left[\frac{\Theta}{(\Theta+\delta)^2}\right] \\ &= \frac{\Pi(\delta)}{(\rho+\delta)^2(\Theta+\delta)^2}. \end{aligned} \tag{35}$$

where $\Pi(\delta) \equiv -(\bar{\phi}\Theta + \bar{\Omega})\delta^2 - 2\bar{\phi}\Theta\rho\delta + (\bar{\Omega} - \bar{\phi}\rho)\Theta\rho$. By the definition, $\bar{\Omega} - \bar{\phi}\rho$ equals to Ω. Then, $\zeta'(\delta) = 0$ can be rewritten as follows:

$$\underbrace{(\bar{\phi}\Theta + \bar{\Omega})}_{+}\delta^2 + \underbrace{2\bar{\phi}\Theta\rho}_{+}\delta - \underbrace{\Omega\Theta\rho}_{+} = 0. \tag{36}$$

The solution of this quadratic equation is,

$$\delta^* = \frac{-\bar{\phi}\Theta\rho \pm \sqrt{(\bar{\phi}\Theta\rho)^2 + (\bar{\phi}\Theta + \bar{\Omega})\Omega\Theta\rho}}{\bar{\phi}\Theta + \bar{\Omega}}. \tag{37}$$

At least one of the solutions is negative. From the existence of δ that attains a maximum of $\zeta(\delta)$ in $\delta \in (0, \bar{\delta})$, the other must be in $\delta \in (0, \bar{\delta})$. Therefore, $\zeta(\delta)$ has a unique solution δ^*, which satisfies $\zeta'(\delta^*) = 0$, in $\delta \in (0, \bar{\delta})$.

The Slope of $\zeta'(\delta)$

We can see that the denominator of (35) is an increasing function of δ at least in $\delta \in (0, \bar{\delta})$. If the $\Pi(\delta)$, which is the numerator of (35), is a decreasing function of δ in $\in (0, \bar{\delta})$, $\zeta'(\delta)$ is a decreasing function on $(0, \bar{\delta})$.

$\Pi(\delta)$ is a quadratic function of δ and the curve is concave down. Therefore, if δ that attains the vertex of $\Pi(\delta)$ is lower than zero, $\Pi(\delta)$ is a decreasing function of $\delta \in (0, \bar{\delta})$. By rewriting $\Pi(\delta)$, we obtain next equation:

$$\Pi(\delta) \equiv -(\bar{\phi}\Theta + \bar{\Omega})\left[\left(\delta + \frac{\bar{\phi}\Theta\rho}{\bar{\phi}\Theta + \bar{\Omega}}\right)^2 - \left(\frac{\bar{\phi}\Theta\rho}{\bar{\phi}\Theta + \bar{\Omega}}\right)^2\right] + (\bar{\Omega} - \bar{\phi}\rho)\Theta\rho. \tag{38}$$

Above equation indicates that $\Pi(\delta)$ attains the maximum at $\tilde{\delta}$ such that

$$\tilde{\delta} = -\frac{\bar{\phi}\Theta\rho}{\bar{\phi}\Theta + \bar{\Omega}} < 0. \tag{39}$$

Therefore, $\zeta'(\delta)$ is a decreasing function at least in $\delta \in (0, \bar{\delta})$. This implies that $\zeta'(0)$ is larger than $\zeta'(\delta)$ for all $\delta \in (0, \bar{\delta})$. By $\Pi(0) = \Omega\Theta\rho$, we obtain the value:

$$\zeta'(0) = \frac{\Omega}{\rho\Theta}. \tag{40}$$

Proof of Proposition 4

We assume that $\rho\left[b/(\beta-1) - a\rho\right] > L_N > a\rho(\Omega/\Theta - 1)$. By using (9) and (14)-(18), w_N is calculated as follows:

$$\begin{aligned} w_N &= \left[\frac{\rho+\delta}{\rho(\zeta(\delta)+1)+L_N/a}\right]\left[\frac{b}{a(1-\beta^{-1})}\right] \\ &\equiv \Psi(\delta). \end{aligned} \tag{41}$$

w_N is strictly higher than β when $\delta = 0$ because $\Psi(0) = b\rho\left[(1-\beta^{-1})(a\rho + L_N)\right]^{-1} > \beta$ holds from the assumption. Therefore, to prove the proposition, it is enough to show that $\Psi(\delta)$ is increasing function in $(0, \bar{\delta})$. By differentiating $\Psi(\delta)$, we have

$$\Psi'(\delta) = \frac{\underbrace{\rho[\zeta(\delta)+1] + L_N/a}_{+} - \underbrace{\rho(\delta+\rho)}_{+}\zeta'(\delta)}{\underbrace{(\rho[\zeta(\delta)+1]+L_N/a)^2}_{+}}\underbrace{\left[\frac{b}{a(1-\beta^{-1})}\right]}_{+}. \tag{42}$$

Since the denominator is positive, we only have to check that the numerator is also positive. We already confirmed that $\zeta'(\delta)$ is a decreasing function of $\delta \in (0, \bar{\delta})$ and $\zeta'(0)$ is larger than $\zeta'(\delta)$, for all $\delta \in (0, \bar{\delta})$. Therefore, if $\Psi'(0) > 0$ holds, $\Psi(\delta)$ is an increasing function of $\delta \in (0, \bar{\delta})$. Using (40) and (42), $\Psi'(0) > 0$ can be calculated as follows:

$$\Psi'(0) = \left[\frac{\rho + L_N/a - \rho\Omega/\Theta}{(\rho + L_N/a)^2}\right]\left[\frac{b}{a(1-\beta^{-1})}\right]. \tag{43}$$

From the assumption of Proposition 4, the numerator in the first bracket is positive, and then $\Psi'(0) > 0$ holds.

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