The Dual Role of Intellectual Property Rights under Imitation and Innovation Driven Development[☆]

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Abstract

The rise of East-Asian economies to significant innovator countries suggests that imitation can be a source of knowledge transfer and can help to spur original R&D in emerging countries. At the same time, the empirical evidence reveals a positive relationship between growth and Intellectual Property Rights for countries with sufficiently large R&D sectors. In this paper, a North-South increasing variety model with endogenous southern research efficiency is developed to explain these observations. The model predicts a threshold level of southern R&D costs above which two equilibria with positive southern R&D activity can exist. In the imitation equilibrium, the southern innovation output and welfare are low, the wage gap between North and South is high, and higher IPRs are associated with lower research activity and long-run welfare. In the innovation equilibrium, the southern research efficiency, welfare and the product variety are high, and stronger IPRs are accompanied by more innovation and higher welfare in both regions. For countries which face research costs below the threshold, the imitation equilibrium ceases, and only the innovation equilibrium exists.

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1. Introduction

For many former developing countries initial phases of high imitation and weak intellectual property rights (IPRs) provided the possibility to adopt foreign technologies and gain experience from reverse engineering. In Japan, weak intellectual property protection was chosen as a policy instrument to facilitate the adoption of foreign technologies in order to develop a domestic R&D sector: The exclusion of certain products such as food, beverage and pharmaceutical products from patenting as well as the application of utility models, compulsory licenses and the first-to-apply system created a climate of weak protection for foreign innovators, but helped domestic firms to acquire foreign knowledge through imitation (Kumar, 2003). Only in the mid 1970s, when the research sector was sufficiently developed, product patents for chemicals and pharmaceuticals were introduced (Kawaura and La Croix, 1995). Today, Japan is one of the world's top innovators; it accounted for about 16% of world gross expenditures on R&D (GERD) in 2008 (3.4% of Japan's GDP) and its number of researchers per million inhabitants was as high as 5,573 in 2007 (UNESCO, 2010; OECD, 2010).[2] Many developing and emerging countries have followed or are currently following a path similar to the one demonstrated by Japan.[3]

While imitation can be a "stepping stone to innovation" (Glass, 2010) at early stages of development, the empirical evidence suggests that Intellectual Property Rights (IPRs) are related to higher growth for countries in which the original research activity is sufficiently

[2]These figures compare to 2.7% GERD in GDP and 4,707 researchers per million inhabitants for the United States of America.

[3]Taiwan and South Korea followed a similar path of maintaining a weak IPR system which helped them to obtain relevant know-how through imitation (Kim, 2001; Kumar, 2003). South Korea targets a GERD share in of 5% for 2012 and achieved 3.4% in 2008; it inhabited 4,627 researchers per million inhabitants in 2007 (OECD, 2010; UNESCO, 2010). Taiwan's share of GERD in GDP was 2.6% of GDP in 2007 (OECD, 2009). Glass (2010) presents similar statistics obtained from the World Competitiveness Yearbook (2009) and argues that trends similar to Japan's path can be observed increasingly also for China, Indonesia, Malaysia and Thailand.

high, i.e. a significantly sized research sector exists (Park and Ginarte, 1997; Kim et al., 2011).[4] Maskus (2000) finds a U-shaped relationship between a country's level of IPR protection and development, and Chen and Puttitanun (2005) find that IPRs have a positive impact on innovation, but that a country's optimal level of IPRs depends on the level of development.

In this paper, I propose a model of international trade between developed and developing countries ("North" and "South") which is consistent with the above empirical findings. To this end, I incorporate a southern R&D sector and a learning channel into a standard North-South increasing variety model of non-scale growth. In particular, I let the development of the southern research sector be endogenously determined by the degree of innovative and imitative activity in the South.

The results suggest that for countries with research costs above a threshold level multiple equilibria associated with different emphases on imitative and innovate activities in the South can exist. In particular, I show that the same level of IPRs can be associated with an either high or low level of development depending on the country's R&D specialization: In the innovation equilibrium, the welfare in the South is high, southern firms efficiently invent a large number of varieties, northern firms face a low risk of imitation, and the number of available varieties in the world is high. In contrast, the imitation equilibrium is characterized by a southern focus on adopting northern varieties, the southern research sector is less efficient, the welfare in the South is low, and the number of available varieties on the world market is small.

[4] Park and Ginarte (1997) argue that the effects of IPRs on growth realize mainly through the incentives they create for R&D, such that IPRs are positively related to growth for developed countries, but do not have an effect on growth in developing countries in which the research sectors' sizes are insignificant. Kim et al. (2011) argue that patent rights enhance innovation and growth in countries which have the capacity to innovate, but a system which protects incremental innovations is more appropriate in countries in which this capacity is missing.

Higher levels of IPRs are associated with larger differences between the equilibria: In the innovation equilibrium, an increase in IPRs increases the incentives to conduct own R&D via two channels: First, it makes imitation more costly relative to innovation. Second, by raising the research activity, it creates learning spillovers from own R&D. These spillovers overcompensate the loss of spillovers from imitation. Consequently, IPRs accompany higher R&D and welfare in that scenario. In the imitation equilibrium, however, the loss in imitation spillovers is not compensated by the initial gain in R&D related knowledge, so that the cost of innovation increases, the final effect on research is negative, and welfare is affected negatively.

The next section relates this paper and its results to the literature. Section 3 presents the model which is solved in section 4. Section 5 then analyzes the effects of stronger IPRs on innovation, imitation and research efficiency, and section 6 numerically analyzes the impact of IPRs on welfare. Section 7 concludes.

2. Related literature

My paper is closely related to the literature which analyzes the trade-off between imitation and innovation in developing countries. Rather than analyzing the conflicting interests between North and South in the protection of intellectual property as done in the seminal models by Helpman (1993), Deardorff (1992), Segerstrom et al. (1990) and Grossman and Helpman (1991a,b), this literature is interested in policies which help developing countries to catch up to developed ones not only in welfare, but also in their R&D activity. Consequently, this literature relaxes the previous restriction of the South to imitation and the assumption that all innovation is conducted in the North.

Currie et al. (1999) analyze the effects of subsidies on southern economies at different stages of development. While IPRs are not treated explicitly in their analysis, they argue that subsidies to imitation have qualitatively the same effect as a loosening in IPRs. Following this argument, an increase in IPRs would increase the world rate of innovation and stimulate southern research activity if the South engages in both imitation and innovation. Lorenczik and Newiak (2011) augment this analysis by introducing the imitation of southern goods. They show that stronger IPRs are associated with more southern R&D and higher welfare if they surpass a threshold level. This threshold level is shown to be decreasing in the southern research efficiency: If southern research is inefficient, then an increase in IPRs fails to stimulate R&D and decreases welfare. However, the southern research efficiency which determines the IPR threshold level in Lorenczik and Newiak (2011) and implicitly whether the South is a pure imitator or both imitator and innovator in Currie et al. (1999), is exogenous in both models.

To account for the fact that imitation can increase the knowledge transfer from North to South and therefore encourage innovation, Glass (2010) presents a product cycle model in which a given fraction of industries in the South has to engage in imitation before they are able to conduct original R&D. While not treating the effects of increases in IPRs explicitly, she shows that a general subsidy to the South (to both innovation and imitation sector) increases the rate of innovation.

My model combines the approaches by Currie et al. (1999) and Lorenczik and Newiak (2011) with the one by Glass (2010) by endogenizing the southern R&D efficiency. Like Glass (2010), I account for the idea that imitation can increase the southern innovative capability, but I additionally introduce own R&D efforts as a source of efficiency gains. I thereby endogenously capture the idea that the R&D enhancing effect of imitation becomes less important if the own R&D sector becomes large. Consequently, I am able to analyze the effects of IPRs on both, imitation and innovation focused countries, while the model by Glass is more suitable for the former case.

The results of my model relate to the ones obtained in the literature on endogenous IPRs.

Eicher and García-Peñalosa (2008) show in a closed economy set-up that if R&D firms face the costs of enforcing their intellectual property, multiple equilibria with different levels of R&D and institutions (IPRs) can exist. As IPRs emerge from innovators' incentives to protect their returns to innovation, higher research is related to higher levels of IPRs. While imitation decreases the expected returns to innovation in their model, in my paper, imitation can additionally raise the incentive to conduct R&D through a learning channel. Consequently IPRs can decrease the innovation incentives in my model and are thus not necessarily associated with higher R&D levels. Chen and Puttitanun (2005) model the trade-off between facilitating technology adoption and encouraging original R&D in a developing county's choice of IPRs to explain the U-shaped relationship between a country's level of development and IPRs. While I try to explain the same pattern in the data, my paper treats the relationship between IPRs from a different perspective: Whilst the causation in Chen and Puttitanun (2005) goes from the level of development to the strength of IPRs in a country, my theory explains how the same levels of IPRs can cause different levels of development.

3. Model

3.1. General set-up

Developed and developing countries are represented by two regions in this model: the North and the South. Firms in North and South hire labor for the production of consumption goods as well as for innovation and imitation. The two regions differ in their R&D activities. The North engages only in innovation and is subject to imitation by the South. The South imitates the North, engages in innovation and is not subject to imitation. As long as a northern variety has not been copied, its production takes place in the North, and the innovating firm charges the monopoly price on the global market. Once a northern variety has been copied by the South, its production shifts to the South and the northern firm shuts down. Labor is perfectly mobile within all sectors across one region, but immobile between the regions such that the same wage rate is paid to all workers within each region. Finally, trade between North and South is costless.

3.2. Households

Each region is endowed with a fixed number of households the size of which grows at a constant rate g_L so that the population size in North and South at time t is $\ell_t^* = l_0^* e^{g_L t}$ and $\ell_t = l_0 e^{g_L t}$. Throughout the model northern variables are indicated with a star. As households in both regions are symmetric in their preferences and face the same maximization problem, I restrict the outline to the southern households' problem in the following. Each member of the household is endowed with one unit of labor which he supplies inelastically to the labor market and earns a wage rate w. Agents maximize their life time utility which arises from the consumption of a basket of N_t different varieties available on the world market in each period:

$$U(t) = \int_t^{\infty} e^{-(\rho - g_L)t} \ln u(t) dt, \qquad u(t) = \left[\int_0^{N_t} x_{j,t}^{\alpha} dj \right]^{\frac{1}{\alpha}} \tag{1}$$

ρ it the rate of time preference and $g_L < \rho$, $x_{j,t}$ is the per capita quantity demanded of variety j, α is a measure of the degree of product differentiation, and $\varepsilon = \frac{1}{1-\alpha}$ is the intertemporal elasticity of substitution. Agents face the budget constraint $\dot{a}_t = (r_t - g_L)a_t + w_t - c_t$ which equates the change in per capita asset holdings a_t to the sum of income from interest payments r_t (adjusted by population growth g_L) and wage income w minus per capita consumption expenditures c_t. Maximizing (1) subject to the income constraint yields the average demand by the world consumer for variety j:

$$\bar{x}_t(j) = \frac{\bar{c}_t}{P_t}\left(\frac{p_t(j)}{P_t}\right)^{-\varepsilon}. \tag{2}$$

In this equation, average consumption expenditures are $\bar{c}_t = \frac{c_t\ell_t + c_t^*\ell_t^*}{L_t}$ with $L_t = \ell_t + \ell_t^*$, and the price index is defined as $P_t = \left[\int_0^{N_t} p(i)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$. Consumption expenditures in North and South grow at the rate $\frac{\dot{c}_t^*}{c_t^*} = r_t^* - \rho$ and $\frac{\dot{c}_t}{c_t} = r_t - \rho$, respectively. This means that northern (southern) per-capita consumption expenditures c_t^* (c_t) grow over time only if the market interest rate r_t^* (r_t) exceeds the individual discount rate ρ.

3.3. Innovation

Innovation takes place in both regions. The total number of varieties invented in the North (not imitated plus already imitated by the South) is $n_{R_t}^* + n_{C_t}$. As southern innovations do not face the risk of being imitated, the number of varieties invented in the South is simply n_{R_t}. Thus the total number of varieties N_t available on the world market is given by:

$$N_t = n_{R_t}^* + n_{C_t} + n_{R_t}. \tag{3}$$

Before a new variety can be produced, R&D firms in both regions have to hire researchers $\ell_{R_t}^*$ and ℓ_{R_t} for the development of the research blueprint. Northern and southern researchers invent new varieties according to the following R&D functions:

$$\dot{n}_{R_t}^* + \dot{n}_{C_t} = \frac{N_t^\theta}{a_R^*}\ell_{R_t}^* \tag{4a}$$

$$\dot{n}_{R_t} = \frac{N_t^\theta}{a_R\beta_t}\ell_{R_t}. \tag{4b}$$

a_R^* and a_R are the northern and southern R&D cost parameters. The knowledge capital used in the innovation process N_t^θ is an increasing function of the number of existing varieties in which the intertemporal knowledge spillover parameter θ is restricted to $0 < \theta < 1$ so that knowledge spillovers become weaker over time. While the knowledge capital is available to both regions, North and South differ in their ability to efficiently use it. In particular, the development of the southern research sector $1/\beta_t$ is endogenized by letting southern R&D firms benefit from the research environment in their region:

$$\frac{1}{\beta_t} = \frac{n_{R_t} + \phi n_{C_t}}{N_t}, \qquad \phi < 1. \tag{5}$$

This R&D efficiency function captures the following aspects: If the South's share in world innovation is high, the South is more experienced in conducting own R&D and more familiar with existing technologies which leads to a more efficient use of the available world knowledge capital N_t^θ. Further, the function also accounts for an efficiency gain from imitation: The more the South engages in reverse engineering, the more it is familiar with existing innovations and the easier is original R&D. However, knowledge creation is just a by-product of imitation so that the research efficiency benefits less from imitation than from original R&D ($\phi < 1$).

In the production of non-copied varieties, one unit of labor produces one unit of output. Innovators in both regions maximize profits $\pi_{R_t}^* = (p_{R_t}^* - w_t^*)\bar{x}_{R_t}^* L_t$ and $\pi_{R_t} = (p_{R_t} - w_t)\bar{x}_{R_t} L_t$ subject to the demand function (2). They charge a constant mark-up over marginal costs and earn monopoly profits as long as they are not copied:

$$p_R^* = \frac{w_t^*}{\alpha}, \quad \pi_R^* = \frac{1-\alpha}{\alpha} w_t^* \bar{x}_{R_t}^* L_t \tag{6a}$$

$$p_R = \frac{w_t}{\alpha}, \quad \pi_R = \frac{1-\alpha}{\alpha} w_t \bar{x}_{R_t} L_t. \tag{6b}$$

If an innovator is copied, he shuts down his firm and earns zero profits.

3.4. Imitation

Before an imitated variety can be produced, imitation firms have to hire workers who engage in reverse engineering. In modeling imitation as a costly activity I follow Mansfield et al. (1981) who report that the costs of imitation are on average as high as 65% of the cost of innovation.[5] Reverse engeneering is easier the more non-copied goods are currently available ($(n^*_{R_t})^\theta$) as imitators are likely to target the most technologically advanced innovations the latest.[6] The imitation function is thus given by:

$$\dot{n}_{C_t} = \frac{(n^*_{R_t})^\theta}{a_C \beta_t} \ell_{C_t}. \tag{7}$$

The parameter a_C captures the cost of imitation and is interpreted as the strength of intellectual property rights protection. The efficiency of the imitation sector should also benefit from the innovation environment in the country: if workers are able to better use the world knowledge capital in the innovation process, it should be also easier for them to discover how already existing varieties are constructed. Consequently, I let the R&D efficiency function $1/\beta_t$ as defined in (5) enter the imitation function.

In the production of copied varieties, one unit of labor also produces one unit of output.[7] Imitation of northern products takes advantage of the relatively low wage rate in the South,

[5] Further, they find that it takes 70% of the innovation time to conduct imitation.

[6] This is in the spirit of the model by Van Elkan (1996) in which imitation is easier the larger the difference between the total number of innovations and already copied goods. In my model, as southern inventions are not subject to imitation, it is more intuitive to define this distance as the number of northern innovations minus copied northern innovations which is $n^*_{R_t}$.

[7] In a previous version of the model, the model was solved under the assumption that production in the imitation sector is less efficient than in the innovation sector because one can argue that the imitator does not have access to the original blueprint and no support from the R&D firm to optimize the production process (Eicher and García-Peñalosa (2008)). This assumption guarantees that the profits from imitation are lower than those from innovation, and so will be the cost of developing the imitation blueprint in equilibrium. However, as none of the results change without this inefficiency assumption, I relaxed it in favor of an improved tractability of the model.

such that by limit pricing the imitator can expel the innovator from the market. I solve the model for an equilibrium in which the southern wage rate is lower than the northern one: $w^* > w$. If the wage difference is high, i.e. $w^* > w/\alpha$, the imitator's monopoly price is lower than the innovators marginal cost, so that the innovating firm has to shut down as soon as it is imitated. If the wage difference is small, i.e. $w^* < w/\alpha$, it would be profit maximizing for the imitator to engage in limit pricing and charge the innovator's marginal cost. Following Gustafsson and Segerstrom (2010) I assume that the reversal of the decision to shut down a firm is costly and that the maintenance of production facilities in the case of zero sales incurs a positive cost so that it is profit maximizing for the northern firm to shut down immediately once it is imitated. As a result, in both cases southern imitators maximize profits $\pi_{C_t} = (p_{C_t} - w_t)\bar{x}_{R_t} L_t$ subject to the demand function (2) and earn the following monopoly prices and profits:

$$p_{C_t} = \frac{w_t}{\alpha}, \quad \pi_{C_t} = \frac{1-\alpha}{\alpha} w_t \bar{x}_{C_t} L_t. \tag{8}$$

Southern innovations are not subject to imitation, because neither the North nor the South have an advantage in production costs which gives the incentive for imitation.[8]

3.5. Financial sectors

The value of an R&D or imitation firm v_{R_t}, $v^*_{R_t}$ or v_C is given by its expected discounted profits. As there is free entry into R&D and imitation, these expected discounted profits have to be equal to the cost of the respective activity. This cost is the wage paid to the innovators and reverse engineers. Using (4) and (7) to determine the amount of labor

[8] To explicitly analyze the increase in incentives the southern R&D sector gains from stronger IPRs, Lorenczik and Newiak (2011) relax this assumption by introducing process innovation into a similar framework.

required to develop one blueprint yields the following firm values:

$$v^*_{R_t} = \frac{a^*_R}{N^\theta_t} w^*_t \tag{9a}$$

$$v_{R_t} = \frac{a_R \beta_t}{N^\theta_t} w_t \tag{9b}$$

$$v_{C_t} = \frac{a_C \beta_t}{(n^*_t)^\theta} w_t. \tag{9c}$$

There is perfect capital mobility between the innovation and imitation sectors within one region, but financial autarky in North and South. Agents in the North choose from holding the market portfolio with return r^*_t or shares of the northern innovation firms which pay a return $\pi^*_{R_t}/v^*_{R_t}$. The return to innovation has to be adjusted by the change in the value of the firm $\dot{v}^*_{R_t}/v^*_{R_t}$ and the risk of being copied $\iota_t = \dot{n}_{C_t}/n^*_{R_t}$. Southern agents choose between gaining the market rate r_t and holding shares of southern innovation or imitation firms. Southern returns to innovation π_{R_t}/v_{R_t} and imitation π_{C_t}/v_{C_t} are adjusted by the firm value changes $\dot{v}_{R_t}/v_{R_t}$ and $\dot{v}_{R_t}/v_{R_t}$. No-arbitrage within these choices in each region implies:

$$r^*_t = \frac{\pi^*_{R_t}}{v^*_{R_t}} + \frac{\dot{v}^*_{R_t}}{v^*_{R_t}} - \frac{\dot{n}_{C_t}}{n^*_{R_t}} \tag{10a}$$

$$r_t = \frac{\pi_{R_t}}{v_{R_t}} + \frac{\dot{v}_{R_t}}{v_{R_t}} = \frac{\pi_{C_t}}{v_{C_t}} + \frac{\dot{v}_{C_t}}{v_{C_t}}. \tag{10b}$$

3.6. Labor markets

Finally, labor market clearing implies the following two conditions for North and South:

$$\ell^*_t = (\dot{n}^*_{R_t} + \dot{n}_{C_t}) \frac{a^*_R}{n^\theta_t} + n^*_{R_t} \bar{x}^*_{R_t} L_t \tag{11a}$$

$$\ell_t = \dot{n}_{R_t} \frac{a_R \beta_t}{n^\theta_t} + \dot{n}_{C_t} \frac{a_C \beta_t}{(n^*_{R_t})^\theta} + (n_{R_t} \bar{x}_{R_t} + n_{C_t} \bar{x}_{C_t}) L_t. \tag{11b}$$

These conditions say that the total labor force is allocated into innovation and production in the North and into innovation, imitation and production in the South.

4. Balanced growth path

4.1. Definition of an equilibrium

In this model, an equilibrium consists of wages in North and South and prices for the different varieties such that the allocation of (1) labor into innovation and production in the North and innovation, imitation and production in the South, (2) the number of varieties invented by both regions and copied by the South and (3) the amount of these varieties demanded by households and supplied by firms solves (A) the households' utility maximization problem and (B) the firms' profit maximization problem. Labor, goods and financial markets have to clear given free entry into innovation and imitation in both regions.

In a constant growth equilibrium, the variety shares $\xi_R^* = n_{R_t}^*/N_t$, $\xi_R = n_{R_t}/N_t$ and $\xi_C = n_{C_t}/N_t$, the shares of labor allocated into the different sectors in North ($\ell_{R_t}^*/\ell_t^*$, $\ell_{Y_t}^*/\ell_t^*$) and South (ℓ_{R_t}/ℓ_t, ℓ_{C_t}/ℓ_t, ℓ_{Y_t}/ℓ_t)[9], the South-North wage ratio $\omega = w/w^*$, the imitation rate $\iota = \dot{n}_{C_t}/n_{R_t}^*$ and per capita consumption expenditures c^* and c are constant. Constant consumption expenditures imply that the risk free rates r and r^* are equal to the rate of time preference ρ in equilibrium. Constant variety shares imply that the number of each kind of variety grows at the same constant rate g. When dividing the northern or southern innovation function by the total number of varieties N_t it thus follows that the equilibrium world growth rate is given by:

$$\frac{\dot{N}_t}{N_t} = \frac{\dot{n}_{R_t}^*}{n_{R_t}^*} = \frac{\dot{n}_{R_t}}{n_{R_t}} = \frac{\dot{n}_{C_t}}{n_{C_t}} = \frac{g_L}{1-\theta} \equiv g. \tag{12}$$

[9] Y denotes production sector.

As the knowledge spillover parameter θ is smaller than one, the growth rate is positive. From the semi-endogenous growth rate (12) follows that policy changes do not have a long-run effect on the growth rate.

4.2. Equilibrium characteristics

As there is free entry into R&D and imitation in both regions, the expected profits from selling a variety have to be equal to the cost of developing its blueprint and thus the firm values given in (9). As all varieties grow at a constant rate, (9) implies that the firm values grow at the rate $-\theta g$. Using these facts in the no-arbitrage conditions (10), rearranging with respect to the firm values and equating with (9) gives the cost-benefit conditions for innovation in the North (13a) and innovation and imitation in the South (13b) and (13c):

$$\frac{\pi^*_{R_t}}{\rho + \theta g + \iota} = \frac{a^*_R}{N_t^\theta} w^* \tag{13a}$$

$$\frac{\pi_{R_t}}{\rho + \theta g} = \frac{a_R \beta}{N_t^\theta} w \tag{13b}$$

$$\frac{\pi_{C_t}}{\rho + \theta g} = \frac{a_C \beta}{(n^*_{R_t})^\theta} w. \tag{13c}$$

The left-hand sides of the relations represent the benefit (appropriately discounted profits from innovation or imitation), while the right-hand sides represent the cost of the respective activities (wages paid to researchers and reverse engineers for the development of one blueprint). If the research efficiency $1/\beta$ was exogenous, then the effect of strengthening IPRs would clearly increase the costs of imitation and therefore make southern innovation comparatively more attractive. Note, however, that $1/\beta$ is a function of the imitative and innovative activity in the South, so that we cannot immediately infer from the cost-benefit condition whether stronger IPRs make imitation less attractive compared to innovation.

The relative demands for the different kinds of goods can be obtained from the demand equation (2). The demand for non-copied northern innovations relative to southern innovations is $\bar{x}^*_{R_t}/\bar{x}_{R_t} = (w^*/w)^{-\varepsilon} = \omega^\varepsilon$ and thus depends on the relative wage between South and North. The demand for southern innovations relative to imitations is $\bar{x}_{R_t}/\bar{x}_{C_t} = 1$. Substituting the profits (6b) and (8) into the southern cost benefit conditions (13b) and (13c) and combining them gives the share of non-copied northern inventions in all varieties $n^*_{R_t}/N_t = \xi^*_R$:

$$\xi^*_R = \left(\frac{a_C}{a_R}\right)^{\frac{1}{\theta}} \equiv R. \tag{14}$$

As the sum of the different variety shares has to add up to one, $1 = \xi^*_R + \xi_C + \xi^*_R$, the share of varieties produced in the South (own inventions and copied northern goods) is

$$\xi_R + \xi_C = 1 - R. \tag{15}$$

In a next step, I obtain the production quantity for a non-copied northern good $\bar{x}^*_{R_t}L_t$ from inserting the profit equation (6a) into the northern cost-benefit condition (13a) and use the resulting relation $\bar{x}^*_{R_t}L_t = \frac{\alpha}{1-\alpha}\frac{a^*_R}{N^\theta_t}(\rho+\theta g+\iota)$ in the northern labor market clearing condition (11a). Substituting for the imitation rate by $\iota = \dot{n}_C/n^*_R = g\xi_C/\xi^*_R = g\frac{1-\xi_R-R}{R}$ and dividing the resulting equation by the northern labor force ℓ^*_t then yields the following equilibrium relationship:

$$\delta = \frac{1-\alpha}{a^*_R\Big(g(1-\xi_R) + \alpha R(\rho - g_L)\Big)}, \tag{16}$$

in which δ is a measure of product variety and is defined as

$$\delta = \frac{N_t^{1-\theta}}{\ell^*_t}. \tag{17}$$

δ relates the difficulty of conducting research $1/N_t^\theta$ to the relative market size N_t/ℓ_t^* and is constant in equilibrium.[10] Equation (16) is the first equilibrium condition in δ and the share of southern inventions in the total number of varieties ξ_R. It yields a positive relationship between the two variables. As δ is an increasing function of the total number of varieties N_t and the labor force size is exogenous, this means that the number of varieties is higher the stronger the South's focus on innovation. As expression (17) is derived from the northern labor market clearing condition, this positive effect is driven by the increase of northern innovation incentives: If the southern research share increases, southern agents focus more on original R&D than on imitation so that the share of copied goods and the imitation rate decrease and the expected profits from northern innovation rise.

To analyze the second equilibrium condition, I insert the production quantities $\bar{x}_{R_t}L_t$ and $\bar{x}_{C_t}L_t$ obtained from the southern cost-benefit conditions into the southern labor market clearing condition (11b). Substituting for the research efficiency $1/\beta$ from (5), rewriting the imitation rate and dividing the resulting expression by the size of the northern labor force ℓ_t^* gives:

$$\delta = \frac{(1-\alpha)}{\Delta}\frac{\ell_t}{\ell_t^*}\frac{(1-\phi)\xi_R + \phi(1-R)}{a_R(1-R)}, \tag{18}$$

in which $\Delta = (1-\alpha)\frac{g_L}{1-\theta} + \alpha(\rho+\theta g)$. This second equilibrium condition also yields a positive relationship between the measure of product variety δ and the southern research share ξ_R. As the expression is derived from the southern labor market clearing condition, the effect results from the positive impact of the innovation share on the southern R&D efficiency which raises the incentives for the South to invent new varieties. Figure 1 illustrates the two equilibrium conditions and reveals the possibility of multiple equilibria. Equating the two

[10] See Gustafsson and Segerstrom (2011) for a more detailed introduction of δ. Gustafsson and Segerstrom (2011) refer to δ as the relative research difficulty in their paper. In the context of my paper, I find it more intuitive to label δ as the measure of product variety so that it cannot be confused with the research efficiency $1/\beta$.

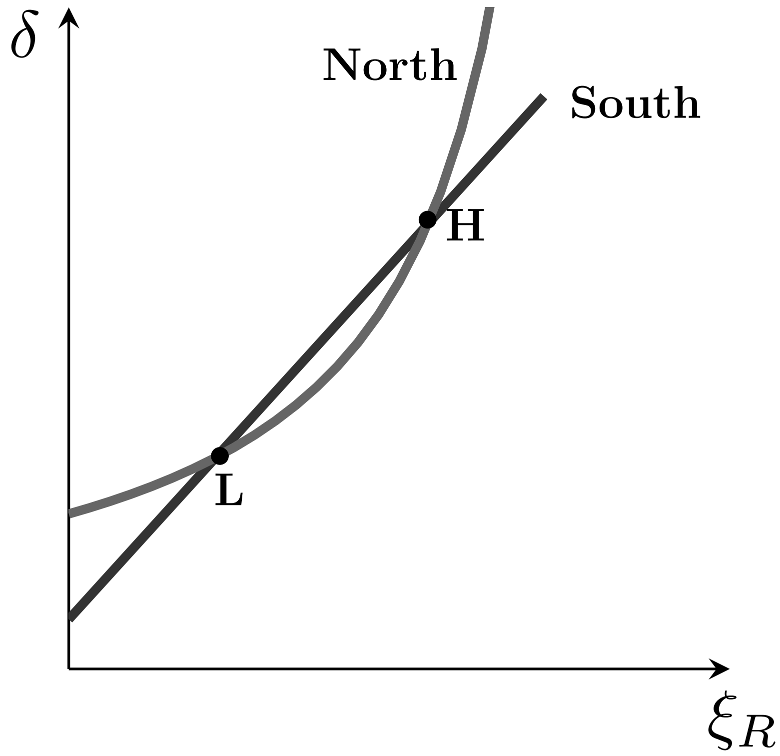

Figure 1: Southern research share ξ_R and measure of product variety δ. L refers to the imitation equilibrium, H refers to the innovation equilibrium.

equilibrium conditions gives the solution for the equilibrium southern research share(s):

$$\xi_R^2 = \left(\frac{1-\phi(2-R)}{1-\phi} + \alpha R \frac{\rho - g_L}{g}\right)\xi_R - \frac{1-R}{1-\phi}\left(\frac{a_R}{a_R^*}\frac{\Delta}{g}\frac{\ell_t^*}{\ell} - \phi\Big(\alpha R \frac{\rho - g_L}{g} + 1\Big)\right). \quad (19)$$

This quadratic equation can yield none, one or two equilibria associated with a positive southern research share ξ_R. As the aim of the paper is to relate IPRs to different stages of innovative activity and development in a country, I will focus on the multiple equilibria case in the following. Equation (19) has two positive solutions or no solution if the following condition is satisfied:

$$\frac{\frac{a_R}{a_R^*}\Delta\frac{\ell_t^*}{\ell_t}}{g + \alpha\left(\frac{a_C}{a_R}\right)^{\frac{1}{\theta}}(\rho - g_L)} > \phi. \quad (20)$$

This condition says that the following factors favor the possibility of multiple equilibria in this model: (1) An inefficient southern research sector (high a_R), (2) low initial IPRs (low a_C), (3) a relatively small southern labor force (small ℓ_t) and (4) small learning effects from imitation (small ϕ). This is equivalent to saying that for given labor force sizes, learning efficiency from imitation, level of IPRs and northern R&D efficiency, there exists an innovation inefficiency threshold for the South $\bar{a}_R$. If this research inefficiency threshold is surpassed (i.e. $a_R > \bar{a}_R$), the model yields multiple equilibria. The inefficiency threshold is higher the stronger IPRs, the larger the southern labor force and the less effective learning from imitation. If condition (20) is fulfilled, then a sufficient condition for two positive equilibria to exist is $\frac{1}{2-R} > \phi$.[11]

For the case in which the multiple equilibria condition (20) is not satisfied, the equilibrium with the lower southern innovation share ceases and only the equilibrium with the higher innovation share prevails. This means that for a South which does not face high research costs ($a_R < \bar{a}_R$) there exists a unique equilibrium with a higher southern research share. It is important to note that, as $a_C < a_R$ by (14), the equilibrium with low R&D activity cannot be ruled out by simply setting the level of IPRs a_C at a very high level: For the highest possible value of a_C, the denominator in (20) becomes $g + \alpha(\rho - g_L)$, so that the imitation equilibrium is still possible if southern R&D is very costly.

Proposition 1 *(i) If southern research is sufficiently costly ($a_R > \bar{a}_R$), the model features two equilibria associated with positive southern research activity. (ii) The inefficiency threshold $\bar{a}_R$ is increasing in the strength of IPR protection, in the size of the southern labor force and the northern research costs; it is decreasing in the intensity of learning from imitation.*

What are the characteristics of these two equilibria in terms of the economic outcomes? As both equilibrium conditions are increasing functions in ξ_R, the equilibrium with the high

[11] Naturally, the only interesting solutions are those in which the other variety shares are non-negative as well, so that from (15) follows $\xi_R < (1 - R)$ which I assume to be true in the following.

southern research share ξ_R is associated with a high measure of product variety δ. It is thus labeled as the "innovation equilibrium" (see intersection H in figure 1). In the equilibrium in which ξ_R is low, the product variety is low. As the share of goods produced in the South $1-R$ is the same in both equilibria, the second equilibrium is associated with a higher share of imitated goods than the innovation equilibrium and is therefore labeled "imitation equilibrium" (see intersection L in figure 1). Whilst the share of goods produced in the North ξ_R^* is thus the same in both equilibria, the South specializes in innovation or imitation. If it specializes in innovation (higher ξ_R, lower ξ_C), the absolute number of non-copied northern varieties and southern inventions will be higher in every period on the balanced growth path.[12] If it specializes in imitation (lower ξ_R, higher ξ_C), then these numbers will be smaller. The southern research efficiency is given by $1/\beta = (1-\phi)\xi_R + \phi(1-R)$ in equilibrium. From this relation follows that the South's research efficiency is higher in the innovation equilibrium and lower in the imitation equilibrium.

I now turn to the determination of the remaining important variables of the model. The relative wage rate $\omega = w/w^*$ between South and North is an indicator of how close the two regions are in their development. It is obtained by combining the northern cost-benefit condition (13a) with one of the southern cost-benefit conditions. Substituting for the research efficiency $1/\beta$ from (5) and the shares of copied and non-copied northern goods ξ_C and ξ_R^* from (14) and (15) gives a relation of the relative wage between South and North ω and the share of southern innovations ξ_R:

$$(\rho + \theta g)\omega^{\varepsilon} = \frac{a_R^*}{a_R}\Big((1-\phi)\xi_R + \phi(1-R)\Big)\left(\rho + \theta g + g\frac{1-R-\xi_R}{R}\right). \tag{21}$$

The first term in (21) on the right-hand side is increasing in the southern research share: When ξ_R increases, the South becomes more efficient in R&D and imitation. This effect

[12] This follows from the fact that a higher southern research share ξ_R is associated with a higher measure of product variety δ and thus with a higher total number of varieties N_t in every period.

increases the southern wage and thus the relative wage in (21). The second term is decreasing in the southern research share: When ξ_R increases, by (15) the share of copied northern goods decreases which decreases the risk of being copied for the North. This effect increases the northern wage rate and thereby decreases the relative wage in (21). To determine whether the relative wage is higher in the innovation or in the imitation equilibrium, I substitute the two solutions from (19) into the wage equation (21) and compare the expressions. The results reveal that the wage gap between the regions is lower in the innovation equilibrium.

Equilibrium utility, per-capita asset holdings and consumption in each region are determined in the next step. From the budget constraint, constant equilibrium wages w and w^* and per-capita asset holdings imply that per capita consumption in North and South is given by $c^* = w^* + (\rho - g_L)a^*$ and $c = w + (\rho - g_L)a$, respectively. As domestic savings finance domestic investments in this model, total asset holdings in the North are $A_t^* = n_{R_t}^* v_{R_t}^*$, and total asset holdings in the South are $A_t = n_{R_t} v_{R_t} + n_{C_t} v_{C_t}$. Substituting for the firm values from (9) and multiplying and dividing by the northern labor force size ℓ_t^*, per-capita asset holdings can be expressed as $a^* = Rw^* a_R^* \delta$ and $a = (1-R) a_R w \beta \delta \frac{\ell_t^*}{\ell_t}$. Substituting a^* and a back into the expressions for c^* and c gives the following per-capita consumption in North and South:

$$c^* = w^*(1 + (\rho - g_L) R a_R^* \delta) \tag{22a}$$

$$c = w \left(1 + (\rho - g_L)(1-R) a_R \beta \delta \frac{\ell_t^*}{\ell_t}\right). \tag{22b}$$

The northern wage rate can be used as the numeraire and therefore set equal to one. Then the relative wage ω is equal to the southern wage rate w. As ω is higher in the innovation equilibrium, substituting for δ and β reveals that per capita asset holdings and consumption expenditures in both regions are high in the innovation equilibrium and low in the imitation equilibrium. However, these quantities are nominal, and to obtain real consumption and thus equilibrium welfare, the price level has to be considered.

Substituting the solutions for the variety shares from (14) and (15) into the definition of the price index gives an expression of the price index as a function of wages and the number of varieties: $P_t = \frac{1}{\alpha}(R(w^*)^{1-\varepsilon} + (1-R)w^{1-\varepsilon})^{\frac{1}{1-\varepsilon}} n^{\frac{1}{1-\varepsilon}}$. According to Dixit and Stiglitz (1977), real consumption c^*/P_t and c/P_t then represents consumers' utility at time t, so that utilities in North and South are given by:

$$u_t^* = \frac{c^*}{P_t}, \qquad u_t = \frac{c}{P_t}. \tag{23}$$

Substituting for the southern consumption expenditures it can then be shown that the southern balanced growth path utility is higher in the innovation equilibrium than in the imitation equilibrium. Nominal per capita consumption expenditures c^* and c are constant, and the aggregate price level P_t is decreasing over time so that northern and southern utilities u_t^* and u_t are growing over time. As utility is proportional to consumption expenditures holding prices fixed, its growth rate can be interpreted as real consumption growth or economic growth. The equilibrium economic growth rate is thus given by $\dot{u}_t^*/u_t^* = \dot{u}_t/u_t = g/(\varepsilon - 1) > 0$. As utility grows constantly and at the same rate in both regions in equilibrium, looking at a one-period equilibrium utility is equivalent to looking at the long-run welfare changes.

I summarize the findings in the following proposition:

Proposition 2 *(i) In the innovation (imitation) equilibrium, the total number of existing varieties, non-copied northern goods and southern inventions as well as the southern research share and the southern research development are high (low), the share of copied goods is low (high), the imitation rate is low (high), the wage gap between the regions is small (large), and per capita consumption and assets in both regions as well as southern welfare are high (low). (ii) For a sufficiently efficient southern research sector ($a_R < \bar{a}_R$) the imitation equilibrium ceases, and the model has a unique innovation equilibrium.*

5. Equilibrium effects of stronger intellectual property rights

In this section, I analyze how stronger IPRs affect the distribution of production to North and South, both regions' R&D activities and world product variety depending on whether the South is in an innovation or imitation equilibrium. The effects on equilibrium utility will be analyzed numerically in section 6. Please note that the effects described in this section can be only interpreted as a comparison between two worlds which are in the innovation equilibrium (one with stronger and one with weaker IPRs) and a comparison between two worlds in the imitation equilibrium (again one with stronger and one with weaker IPRs), respectively. To analyze the effects of changes in IPRs on a single country would require a detailed stability analysis of the equilibria which proved to be not feasible for this paper.

Independently of the equilibrium of the model, the share of non-copied northern goods (ξ_R^*) as well as the share of goods produced in the South ($\xi_R+\xi_C$) is given by equations (14) and (15). Clearly, the share of non-copied southern goods is increasing in the level of IPR protection (a_C) and decreasing in the cost of southern R&D (a_R). As $\xi_R + \xi_C = 1 - \xi_R^*$, the effects go in the opposite direction for the share of varieties produced in the South. The intuition is as follows: when IPRs increase, imitation costs and therefore the labor requirement for imitation rises such that northern innovations are targeted less frequently, and a higher share of products is produced in the North. On the other hand, if research becomes more expensive in the South, imitations becomes more attractive relative to innovation, so the share of non-copied southern goods decreases which means that a higher share of products is produced in the South.

However, the decrease in the share of goods produced in the South caused by an increase in the level of IPRs can have several sources: Either both, the share of copied goods and southern inventions, decrease, or one share increases and the other share decreases more strongly. To analyze the effect of IPRs on the southern innovation share, I apply the implicit function theorem to the equilibrium southern research share equation (19) which reveals the following conditions:

$$\frac{\partial \tilde{\xi}_R}{\partial a_C} > 0 \quad \text{if} \quad \tilde{\xi}_R > \frac{g\big(1-\phi(2-R)\big)+\alpha R(\rho-g_L)(1-\phi)}{2g(1-\phi)} \tag{24a}$$

$$\frac{\partial \tilde{\xi}_R}{\partial a_C} < 0 \quad \text{if} \quad \tilde{\xi}_R < \frac{g\big(1-\phi(2-R)\big)+\alpha R(\rho-g_L)(1-\phi)}{2g(1-\phi)}. \tag{24b}$$

These conditions indicate that an increase in IPRs increases the southern research share if the South's initial research share surpasses a threshold level, and decreases it otherwise. Solving the quadratic equation in ξ_R (19) in the last section shows that condition (24a) is fulfilled in the innovation equilibrium, and condition (24b) holds in the imitation equilibrium.

The different effects of changes in IPRs on the research share can be intuitively explained by looking at the dominant source of research development in the South. The research efficiency function $1/\beta$ in (5) captures two sources of R&D development: innovation and imitation. If the economy is in the innovation equilibrium, R&D is mainly driven by ξ_R, such that higher IPRs ($a_C \uparrow$) decreases the incentives to conduct imitation (the minor source of development) and thereby increases the incentives for innovation (the major source of development). In the imitation equilibrium, the R&D development is more driven by imitation. In this case, increasing IPRs (=costlier imitation) leads to a deterioration in the research environment in both sectors by increasing β, but it hurts the imitation sector less than proportionately, because imitation becomes easier compared to innovation if the share of non-copied northern goods increases.

While the innovation and production shares give an idea of how the distribution of R&D in the world changes with stronger IPRs, the assessment of the actual research output requires a look at the total number of invented varieties in equilibrium. I therefore examine the equilibrium effect of a change in IPRs on $\delta = \frac{N_t^{1-\theta}}{\ell_t^*}$ by inserting the equilibrium southern innovation shares $\tilde{\xi}_R$ into one of the equilibrium conditions (16) and (18).[13] As $\tilde{\delta}$ is increasing in both IPRs and research share in (18), and $\frac{\partial \xi_R}{\partial a_C} > 0$ for the innovation equilibrium, it follows that $\frac{\partial \tilde{\delta}}{\partial a_C} > 0$, and thus IPRs increase the equilibrium total number of varieties if the economy is in the innovation equilibrium. As δ is increasing in ξ_R, but decreasing in IPRs in (18) and $\frac{\partial \tilde{\xi}_R}{a_C} < 0$ in the imitation equilibrium, IPRs decrease δ and therefore the total number of existing varieties in that case. Figure 2 depicts these equilibrium effects graphically. From the effect on the total number of varieties also immediately follows that the number of southern inventions increases (decreases) with stronger IPRs in the innovation (imitation) equilibrium. These results reveal a U-shaped relationship between research activity and IPRs: For economies whose major source of learning is imitation, stronger IPRs are c.p. associated with less own R&D efforts. For economies which rely less on the imitation of foreign goods, because their research sector has reached a critical size and is therefore sufficiently efficient, stronger IPRs are associated with a higher share in world R&D and a higher absolute research output.

Proposition 3: *(a) For innovation equilibria, stronger IPRs are associated with larger shares of southern inventions, higher total numbers of varieties and higher absolute numbers of southern inventions. (b) For imitation equilibria, stronger IPRs accompany smaller shares of southern inventions, lower total numbers of varieties and lower absolute numbers of southern inventions. (c) Stronger IPRs always increase the share of non-copied northern goods and decrease the share of products produced in the South.*

[13]The effect of an increase in IPRs is most easily to be seen if substituting the high-R&D-$\tilde{\xi}_R$ into (18) and the low-R&D-$\tilde{\xi}_R$ into (16).

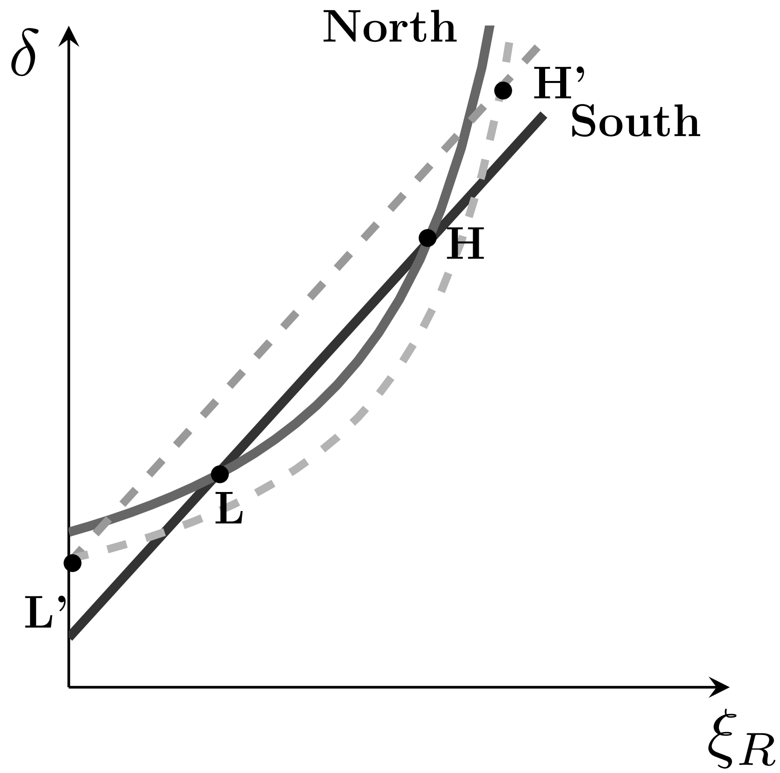

Figure 2: Effects of stronger IPRs ($a_C \uparrow$) on the southern research share ξ_R and the measure of product variety δ. H and L denote innovation equilibrium and imitation equilibrium for a low level of IPRs. H' and L' depict the innovation equilibrium and imitation equilibrium for a case with stronger IPRs.

6. Numerical welfare analysis

The effects of changes in IPRs on welfare in both regions are hard to obtain analytically so that I have to calibrate the model to look at them numerically. The World Bank (2009) reports that the ratio of low and middle income countries to high income countries was given by $\frac{\ell}{\ell^*} = 5.27$ in 2008 and the average world population growth rate between 1960 and 2008 was 1.68% ($g_L = 0.0168$). Analoguously to Gustafsson and Segerstrom (2010, 2011) and Lorenczik and Newiak (2011), I set the intertemporal knowledge spillover parameter to $\theta = 0.67$ to target the average US GDP per capita growth rate from 1950-1994 (Jones, 2005) and the measure of product differentiation to $\alpha = 0.714$ to target a 40% markup over marginal cost as estimated by Basu (1996) and Norrbin (1993). The rate of time preference is set to $\rho = 0.02$. The northern wage rate is used as the numeraire and thus set to $w^* = 1$. Also, the cost parameter in the northern R&D function is normalized to $a_R^* = 1$. The southern R&D cost parameter is set to $a_R = 2.5$ which leads to about five to six times higher R&D costs in the South depending on whether the innovation or imitation equilibrium is considered. The cost of imitation is set to $a_C = 1.5$ so that the costs of imitation (without accounting for knowledge capital) constitute 60% of the innovation cost in the same country which is slighly below the estimates reported by Mansfield et al. (1981). Further, I set the imitation learning parameter to $\phi = 0.2$ which says that learning from R&D is five times more efficient than learning from imitation. The parameterization fulfills the multiple equilibria condition (20), so that both the imitation and the innovation equilibrium exist. As utility grows constantly and at the same rate in both regions in equilibrium, the effects on single equilibrium period utility can be interpreted as long-run welfare effects.[14] Table 1 reports the effect of a marginal change in IPRs (a_C changes by 1%) on long-run welfare in North and South as well as relative consumption between South and North $u_t/u_t^* = c_t/c_t^*$.

Table 1: Welfare effects of stronger IPRs.

	innovation equilibrium		imitation equilibrium	
IPRs (a_C)	1.5	$a_C \uparrow$ by 1%	1.5	$a_C \uparrow$ by 1%
welfare South (u_0)	11.083	11.788	8.947	8.471
welfare North (u_0^*)	17.141	18.393	13.813	13.180
relative cons. (c/c^*)	0.647	0.641	0.648	0.643

First, notice that the northern long-run welfare is also higher in the innovation than in the imitation equilibrium which is mainly driven by the increased number of varieties supplied

[14] For a similar approach see, for example, Gustafsson and Segerstrom (2010, 2011). Note, however, that this approach does not take into account the short-run welfare effects for which a detailed dynamic analysis would be necessary, but which is beyond the scope of the paper.

in the innovation equilibrium due to a more efficient southern R&D sector (for the South, the higher welfare has been already established in the analytical part). How different levels of IPRs influence equilibrium utility depends on the kind of equilibrium. In the innovation equilibrium higher IPRs are accompanied by higher welfare for both regions. The North benefits slightly overproportionately compared to the South as relative consumption between South and North decreases. This happens because with stronger IPRs the North benefits from both, higher product variety and a lower risk of being imitated. In the imitation equilibrium, welfare is lower if IPRs are stronger, and the South is hurt more than proportionately compared to the North in this case. While both regions suffer from the decrease in product variety, the North is at least partially compensated for this loss by a lower risk of imitation. The results are thus in line with the empirically observed U-shaped relationship between the level of development and IPRs. They also imply that stronger IPRs in developing countries without sufficiently developed research sector do not only hurt these countries, but can have negative welfare implications for developed countries as well.

7. Conclusion

This paper endogenizes the southern research sector's development in a North-South increasing variety model of non-scale growth. It follows the evidence from East Asian countries that the development of a research sector can be positively affected by the imitation of foreign technologies, but also recognizes that, with a sufficiently developed research sector, own innovative efforts contribute more to the R&D efficiency in a country. The presented model allows the efficiency of the southern research sector to depend positively on how intensively southern firms engage in imitation and innovation. I show that the model can yield multiple equilibria associated with positive imitative and innovative southern activity if the southern research costs surpass a critical threshold level. In the imitation equilibrium, the southern research sector is small and inefficiently develops a small number of varieties, the southern welfare is low. In this equilibrium, the North faces a high risk of imitation, and the world research output is low. In contrast, the innovation equilibrium yields high product variety, a low imitation risk, a relatively large southern research sector which efficiently develops a large number of varieties, and high welfare in both regions.

Depending on the size of the southern innovation sector, stronger IPRs have different implications. If the southern R&D sector is small and its efficiency is thus mainly imitation driven, an increase in IPRs can dampen innovative activity and welfare in both, the developed and developing region. If the R&D sector is sufficiently large and its efficiency is therefore mainly driven by own innovative activity, then stronger IPRs are associated with higher innovation output and welfare in both regions. Consistently with the anecdotical and empirical evidence, the results imply a U-shaped relationship between R&D activity and IPRs on one hand and development and IPRs on the other.

References

Basu, S., 1996. Procyclical productivity: increasing returns or cyclical utilization? The Quarterly Journal of Economics 111 (3), 719–751.

Chen, Y., Puttitanun, T., 2005. Intellectual property rights and innovation in developing countries. Journal of Development Economics 78 (2), 474–493.

Currie, D., Levine, P., Pearlman, J., Chui, M., 1999. Phases of imitation and innovation in a North-South endogenous growth model. Oxford Economic Papers 51 (1), 60–88.

Deardorff, A. V., 1992. Welfare Effects of Global Patent Protection. Economica 59 (233), 35–51.

Dixit, A., Stiglitz, J., 1977. Monopolistic competition and optimum product diversity. The American Economic Review 67 (3), 297–308.

Eicher, T., García-Peñalosa, C., 2008. Endogenous strength of intellectual property rights: Implications for economic development and growth. European Economic Review 52, 237–258.

Glass, A., 2010. Imitation as a stepping stone to innovation.

Grossman, G., Helpman, E., 1991a. Endogenous Product Cycles. The Economic Journal 101 (408), 1214–1229.

Grossman, G., Helpman, E., 1991b. Quality ladders and product cycles. The Quarterly Journal of Economics, 557–586.

Gustafsson, P., Segerstrom, P. S., 2010. North-south trade with increasing product variety. Journal of Development Economics, 97–106.

Gustafsson, P., Segerstrom, P. S., 2011. North-south trade with multinational firms and increasing product variety. International Economic Review forthcoming.

Helpman, E., 1993. Innovation, imitation, and intellectual property rights. Econometrica, 1247–1280.

Jones, C. I., 2005. Growth and ideas. In: Handbook of Economic Growth. P. Aghion and S. Durlauf, pp. 1063–1111.

Kawaura, A., La Croix, S. J., 1995. Japan's Shift from Process to Product Patents in the Pharmaceutical Industry, an Event Study of the Impact on Japanese Frimsl. Economic Inquiry 33 (1), 88–103.

Kim, L., 2001. The dynamics of industrial learning in industrialisation. International Social Science Journal.

Kim, Y. K., Lee, K., Park, W. G., 2011. Appropriate Intellectual Property Protection and Economic Growth at Different Levels of Development. Research Policy, forthcoming.

Kumar, N., 2003. Intellectual property rights, technology and economic development: Experiences of Asian countries. Economic and Political Weekly, 209–226.

Lorenczik, C., Newiak, M., 2011. Imitation and Innovation Driven Development under Imperfect Intellectual Property Rights. Working Paper.

Mansfield, E., Schwartz, M., Wagner, S., 1981. Imitation costs and patents: an empirical study. The Economic Journal 91 (364), 907–918.

Maskus, K., 2000. Intellectual property rights in the global economy. Institute for International Economics.

Norrbin, S., 1993. The relation between price and marginal cost in US industry: a contradiction. The Journal of Political Economy 101 (6), 1149–1164.

OECD, 2009. Main Science and Technology Indicators.

OECD, 2010. Science, Technology and Industry Outlook 2010.

Park, W. G., Ginarte, J., 1997. Intellectual Property Rights and Economic Growth. Contemporary Economic Policy 15, 51–61.

Segerstrom, P., Anant, T., Dinopoulos, E., 1990. A Schumpeterian Model of the Product Life Cycle. American Economic Review 80 (5), 1077–91.

UNESCO, 2010. UNESCO Science Report 2010, The current status of Science around the World. UNESCO Publishing.

Van Elkan, R., 1996. Catching up and slowing down: Learning and growth patterns in an open economy. Journal of International Economics 41 (1-2), 95–111.

World Bank, 2009. World development indicators 2009.

World Competitiveness Yearbook, 2009. World competitiveness yearbook 2009.