# Intellectual Property Rights and Rent Protection in a North-South Product-Cycle Model[*]

by

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## Abstract

This paper constructs a North-South product cycle model of trade and explores the effects of Intellectual Property Rights (IPR) protection on innovation and imitation. In the model, Northern entrepreneurs undertake innovation, and Southern entrepreneurs undertake imitation. Successful innovators in the North are engaged in rent protection activities to deter the innovation and imitation efforts of their rivals. Endogenously determined rent protection activities remove the scale effects from the growth structure in the spirit of Dinopoulos and Syropoulos (2001).

A strengthening of IPR protection in the South raises imitation costs and reduces the equilibrium rate of imitation in the South. It also decreases the rent protection outlays of successful Northern innovators. With less exposure to imitation and less expenditure on rent protection, Northern entrepreneurs are expected to undertake more R&D. Nevertheless, this effect is overturned by the labor market effects. Stronger IPR protection in the South encourages more final goods manufacturing in the North, tightening the labor markets in that region. The resulting surge in Northern wages more than offsets the positive impact on R&D incentives, reducing the equilibrium rate of innovation.

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## 1. INTRODUCTION

The TRIPS (Trade Related Aspects of IPRs) agreement, which has been signed under the WTO (World Trade Organization) umbrella in 1995, initiated a process that called for establishing at least minimum standards of IPR protection across the globe by 2006 the latest.[1] Given the developed countries (the North) had stronger IPR protection to begin with, it was effectively the developing countries (the South) that were subject to the obligations dictated by TRIPS. With innovation mostly taking place in the North and imitation mostly taking place in the South, many Southern countries were concerned that TRIPS would essentially make Northern innovation more profitable at the expense of Southern imitation.

In this paper I construct a North-South product cycle model of trade with endogenous growth and argue that a strengthening of IPR protection in the South can reduce not only the rate of imitation but also the rate of innovation. This finding has been readily proposed in a number of theoretical models with a similar setting.[2] However, my model differs from the existing literature on two accounts. First, in the model, successful Northern innovators can engage in rent protection activities that are aimed at safeguarding their innovations. Consequently, the framework for IPR protection has an endogenous component. Second, in the model, the steady-state rates of innovation and imitation remain constant despite positive population growth. Therefore, the model is not subject to the scale effects critique of Jones, an issue completely ignored in the relevant literature with the exception of Dinopoulos and Segerstrom (2003).[3]

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[1] See Maskus (2000) for an extensive review of the literature on IPR protection in the global economy.

[2] The literature consists of various models with innovation, imitation and FDI (Foreign Direct Investment). The results are mixed. Grossman and Helpman (1991a and 1991b) consider settings with endogenous innovation and imitation. In their quality-ladders growth model (1991a), they find that the effects of strengthening Southern IPR protection may differ depending on the extent of differences in R&D productivity among Northern entrepreneurs. In their variety-expansion growth model (1991b), on the other hand, Grossman and Helpman find that stronger IPR protection in the South decreases the rates of innovation and imitation. In a variety-expansion model with endogenous innovation and FDI but with exogenous imitation, Lai (1998) finds that stronger IPR protection in the South stimulates innovation and FDI. In contrast to Lai, using a quality-ladders model with endogenous innovation, imitation and FDI, Glass and Saggi (2002) find that stronger IPR protection in the South leads to lower rates of innovation, imitation and FDI. Lastly, Dinopoulos and Segerstrom (2003) construct a scale-free quality-ladders growth model with endogenous innovation and imitation but no FDI. They find that tightening IPR protection in the South temporarily reduces the innovation rate with no steady-state effect, and leads to a permanent decline in the imitation rate. See also Helpman (1993) for a model that investigates the transitional welfare effects and also Young and Maskus (2001) for a model that considers licensing as the channel of North-South technology transfer.

[3] Early endogenous growth models predicted a positive relationship between the rate of innovation and the scale of an economy, measured by the size of the population. In two influential papers, Jones (1995a, 1995b) forcefully

As in other scale-free growth models, I remove the scale effects by introducing research difficulty. However, unlike Dinopoulos and Segerstrom (2003), Segerstrom (1998), and Jones (1995b), where the level of research difficulty is linked to the level of technology, I follow the spirit of Dinopoulos and Syropoulos (2001) and assume that the level of research difficulty is proportional to the level of rent protection activities. In my model, each successful innovator chooses the level of rent protection activity to maximize its stock market return net of rent protection costs. Hence, the model provides a market-based mechanism to determine the level of research difficulty.[4] The empirical relevance of rent protection activities as discussed below forms the basis for using this approach to remove the scale effects.

In their closed economy growth model, Dinopoulos and Syropoulos (2001) define rent protection activities as all incumbent firm activities aimed at raising the difficulty of rival innovation. Activities along these lines can involve patent enforcement, engaging in lobbying or corrupt activities to influence the legal/political environment, practicing trade secrecy, increasing the complexity of products and so on. Dinopoulos and Syropoulos (2001) and the references therein provide further details on the scope and extent of such activities.[5] In the two-country framework of the present paper, where the North is specialized in innovation and the South is specialized in imitation, successful Northern innovators are engaged in two types of rent protection activities: *innovation-deterring activities* aimed reducing the

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argues that this prediction, pinned down as the scale effects property, is not consistent with the post-war time series evidence from industrialized countries.

[4] See Dinopoulos and Sener (2004) for a recent analysis of the scale-free growth literature. It should be noted that another strand of this literature [for instance, Young (1998), Aghion and Howitt (1998, chapter 12) and Dinopoulos and Thompson (1998)] has proposed a variety-expansion based mechanism for removing the scale effects by which the equilibrium level of research difficulty is linked to the number varieties. In these models and the rent protection based models, the steady-state growth rate is endogenous—in the sense that it responds to policy changes. On the other hand, in Dinopoulos and Segerstrom (2003), Segerstrom (1998) and Jones (1995b) the steady-state growth rate is exogenous—in the sense that policy changes exert only a transitional effect.

[5] In particular, Dinopoulos and Syropoulos (2001) present anecdotal evidence from a wide range of companies including Coca-Cola, Microsoft, Intel, DuPont and so on. See also Boldrin and Levine (2004) for detailed evidence along these lines. For systematic survey based evidence from US manufacturing industries, see Levin et al. (1987) and Cohen et al. (2000). Some empirical evidence from the US can be briefly presented here. According to AIPLA (1997) direct legal costs of patent litigation range between $1.0 and $3.0 million (in 1997 dollars) for each side through the trial. Lerner (1995, p. 470) reports that the costs of patent litigation cases started in 1991 will account for 27% of total R&D expenditures of US companies in that year. Time series analysis of Somaya (2002, Figures 3 and 5) suggests that patent litigation has been pervasive in all six broad industries as classified by the USPTO. Evidence suggests that litigation efforts can indeed be effective. In a survey of biotech firms Lerner (1995) finds that 55 percent of small firms and 33 percent of large firms cite litigation as a *deterrent* to innovation. Levin et al. (1987) report that patents raise imitation costs by 40 percentage points for new drugs, 25-30 percentage points for new chemical products and 7 to 15 percentage points for electronics products. These figures are in line with the results from an earlier study by Mansfield et al. (1981).

innovation success of Northern rivals (as in Dinopoulos and Syropoulos, 2001) and *imitation-deterring activities* aimed at reducing the imitation success of Southern rivals.

Despite lack of systematic empirical evidence, there appears to be ample stylized and anecdotal evidence for various types of costly imitation-deterring activities in a North-South context. For instance, Lanjouw and Cockburn (2000) report that the lobbying activities of the US companies heavily influenced the US efforts to promote IPR protection in both bilateral and multilateral negotiations.[6,7] In addition, patent litigation cases in the South involving Northern companies have been increasing and receiving more attention recently. The most prominent North-South case was probably the case between South Africa and the international drug industry.[8] Other examples include Lego, Intel, Microsoft, Adobe, Unilever in China and Pfizer in Russia (see various issues of *Managing Intellectual Property*).[9] With

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[6] A case in point is the US pharmaceutical industry which had a lobbying and campaign contribution budget in 1999 and 2000 of $197 million. The industry has a total of 625 registered lobbyists—more than the number of Congress members [*New York Times*, November 4, 2001, "A Muscular Lobby Rolls Up Its Sleeves", 3.1 ]. Confidential documents obtained by the *New York Times* show that for the year 2004 its trade group, Phrma, has set aside $17.5 million out of a budget of $150 million "to fight price controls and protect patent rights in foreign countries and in trade negotiations" [*New York Times*, June 1, 2003, "Drug Companies Increase Spending on Efforts to Lobby Congress and Governments", 1.33]. Reporting in the popular press suggests that the industry's lobbying efforts have been effective. For instance, during the 2002 US Congress Elections, the drug industry has reportedly provided more than $50 million to Republicans and one quarter of this amount to Democrats in various forms of campaign contributions. Following the November 2001 WTO Doha agreement, which allowed the developing countries to ignore patent protection and import generic drugs when faced with acute diseases, the drug industry has turned to the Congress for help citing concerns about the ambiguous language in the agreement—in particular the lack of specific names for the acute diseases. In response, 34 Congress members (comprised of both Democrats and Republicans) along with two dozen drug company CEOs signed individual and group letters to Mr. Zoellick, the US trade representative, urging for clarification of the language in a way that addresses the industry's concerns [for further details and also for specific contribution amounts received by some signature owner Congress members, see *Wall Street Journal*, February 6, 2003, "U.S. Flip on Patents Shows Drug Makers' Growing Clout", A.4].

[7] A number of multinational associations, funded mostly by Northern industries, actively promote global IP protection [for an extensive list see www.ipmenu.com/iporganisations.htm]. Of course, national trade associations can also be involved in advocating global IP protection.

[8] In 1997, following the outburst of the AIDS epidemic, the South African government passed a law which allowed the importation and domestic production of generic drugs without the consent of the original patent holder. In February 1998, 39 major international drug companies, including four AIDS drugs producers Merck, Glaxo Smith Kline, Bristol-Myers Squibb, Boehringer Ingelheim GmbH and Abbott, filed a law suit claiming that the law legitimizes patent infringement and violates international treaties. The hearing of the law suit was opened in March 2000 in a South African court. After a one year legal procedure with heavy media exposure, the law suit was eventually dropped in April 2001, mostly in response to pressure from international and domestic AIDS activists. For an unfolding of the events during the trial, including the lobbying efforts of drug companies, the involvement of non-governmental organizations, see, among others, *Wall Street Journal*, March 2, 2001 "Patents Pending: AIDS Epidemic Traps Drug Firms in a Vise: Treatment vs. Profits", A1.

[9] Some cases have also found coverage in the popular press. See, for instance, *Fortune*, October 2, 2000, "Knocking out the knock offs", 213-214 for a detailed analysis of the case between a Danish furniture maker "Bo Concept" and

substantial demand for patents, trademarks and copyrights in the South by foreigners, [see Maskus et. al. 2004], law firms in many developing countries now offer a wide range of services in IP related areas.[10, 11]

Motivated by the empirical relevance of rent protection activities, I investigate the effects of strengthening Southern IPR protection in a quality-ladders North-South model similar to Grossman and Helpman (1991a) that also incorporates innovation and imitation deterring activities in the spirit of Dinopoulos and Syropoulos (2001). I find that strengthening IPR protection in the South reduces the rates of both Southern imitation and Northern innovation while raising the North-South wage gap. The intuition is as follows. Stronger IPR protection in the South raises imitation costs and leads to a decline in the rate of imitation and the frequency of imitations per industry. It also reduces the total rent protection outlays of successful Northern innovators per unit cost of innovation. With less exposure to imitation and less expenditure on rent protection, Northern entrepreneurs are expected to undertake more innovation. Nevertheless, this effect is overturned by labor market effects. Stronger IPR protection in the South increases the proportion of industries with Northern producers and stimulates more final goods

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its Chinese imitators. See *Wall Street Journal*, January 2, 1996, "Texas Instrument (TI) sues to force Samsung to pay patent fees", B2, for a patent infringement case between two electronic companies, TI of US and Samsung of Korea, on memory chips.

[10] The web site http://www.ipmenu.com/, provides a global guide to IP law firms and patent attorneys in a total of 125 countries, including many developing countries ranging from Vietnam to El Salvador. It should be noted that obtaining global coverage for a patent by itself may involve substantial costs. It is estimated that for a single invention the total cradle to grave costs of patent coverage in 52 countries is roughly $472,414 [Berrier, 1996]. The costs range from a high of $40,000 in Japan to a low of about $2,000 in South Africa with an average of $9,085. To get a rough idea of the total costs involved, consider the following calculation. In 2000, the total number of US patent applications filed by US residents was equal to 175,582. Using Berrier's (1996) numbers one can calculate that seeking 5 year global protection for these patents, on top of the US protection, would imply a cost of $28.883 billion.

[11] In most of the developing countries patent litigation may still be problematic due to underdeveloped legal infrastructure. However, evidence from China suggests that firms can rely on other available channels. In China, IP owners can pursue their cases via two actions: judicial action and administrative action. When pursuing judicial action, the plaintiff can take the case to the court and follow the litigation procedure. When pursuing administrative action, the plaintiff requests administrative authorities to take appropriate measures, which may lead to organizing raids and then imposing sanctions (fines, imprisonment or disgorgement of illicit profits). Clarke (1999) points out that in China "most foreign complainants of IPR infringement use whatever administrative remedies are available instead of resorting to courts and private remedies as the former are quicker, cheaper, and generally more effective". Further, the administrative raids are more readily available in the case of trademark and copyright violations rather than patent infringements. Hence, most patent holders choose the trademark and copyright protection whenever possible [Clarke (1999) and Maskus et al. (2004)]. To pursue administrative action, foreign companies usually hire investigation or law firms to make the case to various Chinese government organs [see *Managing Intellectual Property*, Sep. 2003, "How to Litigate in China", p.1]. Clarke (1999, p.34 ) points out that administrative action, like any other government action, is prone to corruption. Hence, its frequent utilization over the litigation route can be suggestive of significant corrupt activities. In any case, either by hiring legal firms and/or bribing government officials, both judicial and administrative actions entail significant costs for IP owners.

manufacturing in the North, tightening the labor markets in that region. The resulting surge in Northern wages increases both innovation and production costs, leading to a net reduction in the profitability of innovation. Thus, at the new equilibrium, the rate of innovation is lower.

Using the model, one can also study the effects of an expansion in the relative size of the South, which is interpreted as one form of globalization by Dinopoulos and Segerstrom (2003).[12] The model implies that an increase in the relative size of the South reduces the rate of innovation, leads to an increase in the rate of imitation, and decreases the wage of Northern labor relative to Southern labor [details available in the working paper version Sener (2003)]. These results differ starkly from those of Dinopoulos and Segerstrom (2003). They find that globalization temporarily raises the innovation rate with no steady-state effect, leads to a permanent increase in the imitation rate and decreases the wage of Northern labor relative to Southern labor.

The rest of the paper is organized as follows. Section 2 introduces the building blocks of the model and establishes the steady-state equilibrium. Section 3 presents the comparative steady-state results. Section 4 concludes the paper.

## 2. THE MODEL

The setting is a quality-ladders model of product-cycle similar to Grossman and Helpman (1991a) with endogenous innovation and imitation. The world economy consists of two countries the North and the South, indexed by $i \in \{N, S\}$. The variables and parameters with no country index are common to both countries. Each country has a fixed number of identical households, normalized to one. Let $N_{0i}$ denote the size of the population and also the labor force of country $i$ at time zero. Each country's population grows at a rate of $n > 0$. Hence, the size of the population in country $i$ at time $t$ equals $N_{0i}e^{nt}$.

### 2.1. Household behavior

The representative household maximizes the utility function

$$U(t)_i = \int_0^\infty N_{0i}\, e^{-(\rho - n)t} \log u_i(t)\, dt, \qquad \text{for } i = N, S, \qquad (1)$$

where $\rho$ is the subjective discount rate. Note that $\rho - n > 0$ for the integral to converge. The term $\log u_i(t)$ represents the instantaneous utility of each household member

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[12] Dinopoulos and Segerstrom (2003) argue that the standard North-South model essentially represents a world economy that consists of three regions: an Open North, an Open South, and a Closed South that has no contact with the open regions. They interpret the recent integration of many large developing countries such as India and China as an increase in the relative size of the Open South.

$$\log u_i(t) \equiv \int_0^1 \log \left[\sum_j \lambda^j \, x_i(j,\omega,t)\right] d\omega, \qquad \text{for } i = N, S, \qquad (2)$$

where $x_i(j,\omega,t)$ denotes per capita demand for a product with quality $j$ in industry $\omega$ at time $t$, and $\lambda > 1$ measures the size of improvements in quality.

Let $c_i(t)$ stand for per capita consumption expenditure. Treating product prices as given, the representative household allocates $c_i(t)$ to maximize $u_i(t)$. Observe that products enter the instantaneous utility function symmetrically; thus, the household spreads $c_i(t)$ evenly across product lines. In addition, products within each industry are perfect substitutes; hence, the household purchases only the product with the lowest quality-adjusted price. The resulting per capita demand for product line $\omega$ is $x_i(\omega,t) = c_i(t)/p(\omega,t)$, where $p(\omega,t)$ is the market price for the purchased product.

Given the static demand functions, the household's problem is simplified to maximizing

$$\int_0^\infty N_{0i} \, e^{-(\rho-n)t} \log c_i(t) \, dt, \qquad \text{for } i = N, S, \qquad (3)$$

subject to the intertemporal budget constraint $\dot{B}_i(t) = W_i(t) + r(t)B_i(t) - c_i(t)N_i(t)$, where $B_i(t)$ denotes the financial assets owned by the household, $W_i(t)$ is the household's wage income and $r(t)$ is the instantaneous rate of return in the global market. This exercise gives the familiar differential equation

$$\frac{\dot{c}_i(t)}{c_i(t)} = r(t) - \rho, \qquad \text{for } i = N, S. \qquad (4)$$

At the steady-state equilibrium, $c_i$ remains constant; thus, $r(t) = \rho$. In the paper, I restrict attention to steady states and henceforth drop the time index for the variables that remain constant in equilibrium.

### 2.2. Labor and activities

Labor is the only factor of production and is immobile across countries. In each country, the labor force consists of general-purpose and specialized workers. The proportion of general-purpose labor in country $i$ is given by $(1 - s_i)$ and that of specialized labor is given by $s_i$, where $s_i \in (0, 1)$. In the North there are three types of activities: innovation, manufacturing of final goods and rent-protection. General-purpose workers can be employed in manufacturing or innovation, whereas specialized workers are only employed in rent protection activities.[13] In the South, there are three types of activities: imitation,

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[13] With specialized labor, I basically mean lawyers, lobbyists and other individuals who possess rent-protection-activity-specific expertise which is not applicable to manufacturing or R&D. This particular labor assignment scheme is also adopted in the closed economy model of Dinopoulos and Syropoulos (2001). Using numerical

manufacturing of final goods and rent protection. General-purpose workers can be employed in manufacturing or imitation, whereas specialized workers are only employed in rent protection.

### 2.3. Product Markets

The world economy consists of a continuum of structurally identical industries indexed by $\omega \in [0, 1]$. In the North, entrepreneurs participate in innovation races to discover the technology of producing *next* generation products, which are of higher quality than the existing ones. In the South, entrepreneurs participate in imitation races to acquire the technology of producing *current* generation products, which refer to the existing top-quality products manufactured in the North. In the product markets, free trade prevails. Producer firms compete to offer the lowest quality-adjusted price given their state of technology and regional factor prices. Northern entrepreneurs target their innovation efforts at *all* industries in the continuum. Southern entrepreneurs target their imitation efforts *only* at industries with Northern producers.[14]

In both countries, production of one unit of final good requires one unit of general-purpose labor, regardless of the quality level of the manufactured good. Let $w_{LN}$ represent the wage rate of general-purpose labor in the North. Normalize the wage rate of general-purpose labor in the South to $1$. Hence, unit cost of production is $w_{LN}$ in the North and $1$ in the South. In equilibrium, positive rates of innovation and imitation require that $\lambda > w_{LN} > 1$. Whenever a higher quality product is discovered by a Northern entrepreneur, the technology of producing the previous generation product becomes available to all followers in the global economy.[15] Such a structure implies that Northern followers cannot effectively compete in product markets, since they will be undercut by their Southern counterparts.

For each industry, there are two possible structures at each point in time. Whenever a Northern entrepreneur discovers a next generation product, the resulting structure is a *Northern industry*, where a Northern quality leader competes with Southern followers that have access to the discarded technology.

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simulations, I find that the paper's results are robust to assuming one type of labor that is mobile between all activities.

[14] If a Southern firm targets an industry with a Southern producer and becomes successful in its imitation efforts, two Southern producers with identical cost functions and product qualities will emerge. Due to price competition in product markets, the profits of both firms will be driven down to zero. Thus, no Southern firm has an incentive to target a Southern market.

[15] See Glass (1997) for a detailed discussion on this assumption of costless diffusion of discarded technology. This assumption has been adopted in both North-South and North-North contexts. For the former see Glass (1997) and Glass and Saggi (1998) and for the latter see Dinopoulos and Segerstrom (1999).

The Northern firm can manufacture a product that is $\lambda$ times better than a typical Southern follower's. Thus, if the Southern followers price at marginal cost $1$, the Northern leader can offer a lower quality-adjusted price by charging $\lambda - \varepsilon$, where $\varepsilon$ is an infinitely small amount. Therefore, by engaging in limit pricing the Northern leader can start realizing monopoly profits from product sales

$$\pi_N^P(t) = \frac{(\lambda - w_{LN})}{\lambda} c(N_N(t) + N_S(t)) , \tag{5}$$

where $c=(c_N N_N(t)+ c_S N_S(t))/(N_N(t)+N_S(t))$ represents the per capita consumption expenditure of a representative world citizen, $\lambda - w_{LN} > 0$ is the profit margin per unit and $c(N_N(t)+ N_S(t))/\lambda$ is the quantity sold in the global market.

Whenever a Southern entrepreneur acquires the technology of producing a current generation product, the resulting structure is a *Southern industry*, where a successful Southern imitator competes with a Northern incumbent. Both firms have access to the technology of producing the state-of-the-art quality product. Nevertheless, the Southern firm has a cost advantage in manufacturing. Thus, if the Northern incumbent prices at marginal cost $w_{LN}$, the Southern firm can offer a lower quality-adjusted price by charging $w_{LN} - \varepsilon$ and starts realizing monopoly profits

$$\pi_S(t) = \frac{(w_{LN} - 1)}{w_{LN}} c(N_N(t) + N_S(t)) , \tag{6}$$

where $w_{LN} - 1 > 0$ is the profit margin per unit and $c(N_N(t)+ N_S(t))/w_{LN}$ is the quantity sold in the global market. I denote the fraction of Northern industries in the continuum with $n_N$ and the fraction of Southern industries with $n_S$. Note that by construction $n_N + n_S = 1$.

While Northern quality leaders earn monopoly profits, they simultaneously expend resources to safeguard their monopoly positions against their rivals across the globe. I classify these rent protection efforts into two categories: *imitation-deterring activities* aimed at reducing the imitation success of Southern rivals and *innovation-deterring activities* aimed at reducing the innovation success of Northern rivals.[16] For innovation-deterring activities, each Northern incumbent hires *Northern* specialized labor at a wage rate of $w_{HN}$. The cost of performing $X_i(t)$ units of innovation-deterring activity is given by

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[16] As in the standard quality ladders growth model, it is not profitable for the incumbent producer to undertake further R&D aimed at widening its lead [see for instance Grossman and Helpman (1991c), p. 93]. It should be noted that when an entrepreneur with a higher quality product emerges, the incumbent firm cannot generate positive profits and stops all innovation and imitation deterring activity. This mechanism forms the basis for the costless diffusion of the discarded technology assumption.

$w_{HN}\gamma_\iota X_\iota(t)$, where $\gamma_\iota$ is the unit labor requirement of such activities. For imitation-deterring activities, each Northern incumbent hires *Southern* specialized labor at wage rate of $w_{HS}$.[17] The cost of performing $X_\mu(t)$ units of imitation-deterring activity is given by $w_{HS}\gamma_\mu X_\mu(t)$, where $\gamma_\mu$ is the unit labor requirement of such activities. A typical Northern incumbent's profit flow *net* of rent protection costs then equals:

$$\pi_N(t) = \pi_N^P(t) - [w_{HN}\gamma_\iota X_\iota(t) + w_{HS}\gamma_\mu X_\mu(t)]. \tag{7}$$

## 2.4. Technology of innovation and imitation

Innovation is a costly activity that involves uncertainty. The arrival of innovations in each industry is governed by a stochastic Poisson process, whose intensity is determined by the profit maximizing decisions of Northern entrepreneurs. Let $R_j(\omega, t)$ represent the innovation intensity of a typical Northern entrepreneur indexed by $j$ targeting industry $\omega$. The instantaneous probability of success by firm $j$ is given by $\iota_j(\omega, t) = R_j(\omega, t)/D_\iota(\omega, t)$, where $D_\iota(\omega,t)$ measures the difficulty of conducting innovation in industry $\omega$. I model $D_\iota(\omega,t)$ as a stock variable that evolves according to

$$\dot{D}_\iota(\omega,t) = n_N \delta_\iota X_\iota(\omega,t), \tag{8}$$

where $X_\iota(\omega,t)$ is the flow of innovation-deterring activity undertaken by the Northern incumbent currently manufacturing in industry $\omega$, and $\delta_\iota > 0$ is a parameter that measures the effectiveness of innovation-deterring activity.[18] Whenever an industry is registered as a Northern industry—the probability of which is equal to $n_N$ in equilibrium—the Northern incumbents undertake rent protection activities and the stock of innovation difficulty in that industry expands by $\delta_\iota X_\iota(\omega,t)$.[19] At the steady-state equilibrium, a bounded

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[17] As discussed in the introduction, there may also be situations in which Northern firms hire Northern specialized labor to conduct imitation-deterring activities (through lobbying, campaign contributions and such). It can be analytically shown that the main results would hold when Northern firms hire Northern labor instead of Southern labor for these activities.

[18] Modeling of innovation and imitation difficulty as stock variables differs from Dinopoulos and Syropoulos (2001), in which innovation difficulty is treated as a flow variable. The present paper adopts the stock approach to capture the persistence of the institutional and legal framework surrounding IPR protection. Lobbying efforts and also patent litigation cases have longer term effects that persist over time and can raise the difficulty of conducting research for future entrepreneurs. In the context of advanced countries (especially the US), where the legal system evolves on a case by case basis and legislation is heavily influenced by lobbying, the stock approach can provide a better approximation to the real world [see Gallini (2002, pp. 133-135)].

[19] Depreciation concerns for innovation and imitation difficulty are left aside to economize on the notation. All findings are robust to assuming a constant depreciation rate, *DEPR*, for innovation and imitation difficulty where $0\% \leq DEPR < 100\%$.

rate of innovation requires $\dot{D}_{\iota}(\omega,t)/D_{\iota}(\omega,t)=n$. Using this relationship and (8) one can obtain an expression for the stock of innovation difficulty as:

$$D_{\iota}(\omega,t)=\frac{\delta_{\iota}X_{\iota}(\omega,t)n_{N}}{n}. \tag{9}$$

The probability of innovation success is distributed independently across firms and industries. Thus, the instantaneous probability of innovation success at the industry level equals

$$\iota(\omega,t)=\sum_{j}\iota_{j}(\omega,t)=\frac{R(\omega,t)}{D_{\iota}(\omega,t)}=\frac{R(\omega,t)n}{\delta_{\iota}X_{\iota}(\omega,t)n_{N}}, \tag{10}$$

where $R(\omega,t) = \Sigma_j R(\omega,t)_j$. Observe that $\iota(\omega,t)$ measures the frequency of innovations in industry $\omega$. Given that Northern entrepreneurs target *all* industries for innovation and that the measure of structurally-identical industries is one, it follows that the rate of innovation in the North equals $\iota$.

Like innovation, imitation is a costly activity that involves uncertainty. The arrival rate of imitations in each industry is governed by a stochastic Poisson process, whose intensity is determined by the profit maximizing decisions of Southern entrepreneurs. Let $M_j(\omega,t)$ denote the imitation intensity of a typical Southern entrepreneur indexed by $j$ targeting industry $\omega$. The instantaneous probability of imitation success by firm $j$ is given by $\mu_j(\omega, t) = M_j(\omega, t)/D_\mu(\omega, t)$, where $D_\mu(\omega,t)$ measures the difficulty of conducting imitation. I model $D_\mu(\omega,t)$ as a stock variable that evolves according to

$$\dot{D}_{\mu}(\omega,t)=n_{N}\delta_{\mu}X_{\mu}(\omega,t), \tag{11}$$

where $X_\mu(\omega, t)$ is the flow of imitation-deterring activity undertaken by the Northern incumbent and $\delta_\mu > 0$ is a parameter that measures the effectiveness of imitation-deterring activity. Whenever an industry is registered as a Northern industry, the stock of imitation difficulty in that industry expands by $\delta_\mu X_\mu(\omega,t)$. At the steady-state equilibrium, a bounded rate of imitation requires $\dot{D}_{\mu}(\omega,t)/D_{\mu}(\omega,t)=n$. Combining this relationship with (11) one can obtain an expression for the stock of imitation difficulty as

$$D_{\mu}(\omega,t)=\frac{\delta_{\mu}X_{\mu}(\omega,t)n_{N}}{n}. \tag{12}$$

Probability of imitation success is distributed independently across firms and industries. Thus, the instantaneous probability of imitation success at the industry level is

$$\mu(\omega,t)=\sum_j \mu_j(\omega,t)=\frac{M(\omega,t)}{D_\mu(\omega,t)}=\frac{M(\omega,t)n}{\delta_\mu X_\mu(\omega,t)n_N}, \tag{13}$$

where $M(\omega,t) = \Sigma_j M(\omega,t)_j$. Observe that $\mu(\omega,t)$ measures the frequency of imitations in industry $\omega$. Let $m$ denote the economy-wide imitation rate in the South. Given that Southern entrepreneurs target only Northern industries, which accounts for a fraction $n_N$ of the industries, it follows that $m = \mu n_N$. In the rest of the paper I omit the industry index $\omega$ to simplify notation.

### 2.4.c. Optimal Innovation and Imitation Decisions

To conduct innovation, Northern firms hire general-purpose labor. The cost of conducting $R_j(t)$ units of innovative activity is given by $w_{LN}a_\iota R_j(t)$ where $a_\iota$ is the unit labor requirement of innovation. A typical Northern entrepreneur indexed by $j$ chooses the intensity of innovation to maximize the expected profits

$$\upsilon_N[R_j(\omega,t)/D_\iota(\omega,t)]dt - w_{LN}a_\iota(1-\phi_\iota)R_j(t)dt,$$

where $\upsilon_N$ shows the value of a successful Northern innovator and $\phi_\iota$ represents the rate of innovation subsidy offered by the Northern government. Free entry into innovation drives the expected profits down to zero. Using (9), this implies:

$$\frac{\upsilon_N(t)n}{\delta_\iota X_\iota(t)n_N}=w_{LN}a_\iota(1-\phi_\iota). \tag{14}$$

In the South, entrepreneurs hire general-purpose labor to conduct imitative activity. With Southern wage normalized to one, the cost of conducting $M_j(t)$ units of imitative activity is given by $a_\mu M_j(t)$ where $a_\mu$ is the unit labor requirement of imitative activity. A typical Southern entrepreneur indexed by $j$ chooses the intensity of imitation $M_j(t)$ to maximize the expected profits

$$\upsilon_S[M_j(t)/D_\mu(t]dt\,dt - a_\mu(1-\phi_\mu)M_j(t)dt,$$

where $\upsilon_S$ shows the value of a successful Southern imitator, and $\phi_\mu$ represents the rate of imitation subsidy by the Southern government. Free entry into imitation drives the expected profits down to zero. Using (12), this implies:

$$\frac{\upsilon_S(t)n}{\delta_\mu X_\mu(t)n_N}=a_\mu(1-\phi_\mu). \tag{15}$$

### 2.5. Stock markets

There is a global stock market that channels the savings of consumers to firms. Consider first the stock market valuation of a successful Northern innovator $\upsilon_N(t)$. Over a time interval $dt$, the stockholders of the Northern producer receive $\pi_N(t)$ in the form of dividend payments. During the same time, with probability $(\iota + \mu)dt$, the Northern incumbent loses its monopoly position, and the stockholders face a loss of $\upsilon_N(t)$. With probability $(1 - (\iota + \mu)dt)$, the Northern incumbent maintains its monopoly position, and the stockholders experience a change in their investment given by $\dot{\upsilon}_N(t)$. The absence of any arbitrage opportunities implies that the expected return from a stock issued by a successful innovator $\pi_N(t)dt + (0 - \upsilon_N(t))(\iota + \mu)dt + \dot{\upsilon}_N(1 - (\iota + \mu)dt)dt$ must equal the return generated by the risk-free market interest rate $r\upsilon(t)dt$. Imposing this condition as $dt \to 0$ yields:

$$\upsilon_N(t) = \frac{\pi_N(t)}{r + \iota + \mu - (\dot{\upsilon}_N / \upsilon_N)} \tag{16}$$

Consider next the stock market valuation of a successful Southern imitator $\upsilon_S$. Over a time interval $dt$, the stockholders of the Southern producer receive $\pi_S(t)$ in the form of dividend payments. During the same time, with probability $\iota dt$, the Southern incumbent loses its monopoly position and the stockholders face a decline in their investment from $\upsilon_S$ to zero. With probability $(1 - \iota dt)$, the Southern incumbent maintains its monopoly position, and the stockholders experience a change in their investment given by $\dot{\upsilon}_S(t)$. Again, imposing the no arbitrage condition $\pi_S(t)dt + (0 - \upsilon_S(t))\iota dt + \dot{\upsilon}_S(1 - \iota dt)dt = r\upsilon_S(t)$ as $dt \to 0$ yields:

$$\upsilon_S(t) = \frac{\pi_S(t)}{r + \iota - (\dot{\upsilon}_S / \upsilon_S)}. \tag{17}$$

### 2.6. Optimal rent protection decisions by Northern incumbents

Each Northern incumbent chooses its optimal level of rent activity by maximizing the expected return on its stocks net of rent protection costs. Consider a Northern incumbent that increases its innovation-deterring activity by $dX_\iota > 0$ units. The increased level of $X_\iota$ induces a decline in the intensity of innovation targeting the firm, which equals $d\iota = -[\iota/X_\iota(t)]dX_\iota < 0$ via equation (10). The lower innovation exposure prolongs the incumbent's tenure, raising the expected returns on its stocks. Differentiating $\pi_N(t)dt + (0 - \upsilon_N(t))(\iota + \mu)dt + \dot{\upsilon}_N(1 - (\iota + \mu)dt)dt$ with respect to $\iota$ and substituting for $d\iota = -[\iota/X_\iota(t)]dX_\iota < 0$ yields the incremental gain in the expected return: $\upsilon_N(t)[\iota/X_\iota(t)]dX_\iota dt +$

$\dot{\upsilon}_N\,[\iota/X_\iota(t)]dX_\iota dtdt$. At the optimal level of $X_\iota$, this must equal the incremental cost on innovation-deterring activity, $w_{HN}\gamma_\iota dX_\iota\, dt$. Imposing this condition as $dt \to 0$ yields:

$$X_\iota(t)=\frac{\iota\upsilon_N(t)}{\gamma_\iota w_{HN}}\,. \tag{18}$$

In an analogous fashion, I derive the optimality condition for imitation-deterring activities $X_\mu$. Consider a Northern incumbent that increases its imitation-deterring activity by $dX_\mu > 0$ units. The increased level of $X_\mu$ induces a decline in the intensity of imitation targeting the firm, which equals $d\mu = -\,[\mu/X_\mu(t)]dX_\mu < 0$ via equation (13). The lower imitation exposure extends the incumbent firm's duration of monopoly power, raising the expected return on its stocks. Differentiating $\pi_S(t)dt + (0 - \upsilon_S(t))\iota dt + \dot{\upsilon}_S\,(1 - \iota dt)dt$ with respect to $\mu$ and using $d\mu = -\,[\mu/X_\mu(t)]dX_\mu < 0$ yields the incremental gain in the expected return: $\upsilon_S(t)[\mu/X_\mu(t)]dX_\mu dt + \dot{\upsilon}_S\,[\mu/X_\mu(t)]dX_\mu dtdt$. At the optimal level of $X_\mu$, this must equal the incremental cost on imitation-deterring activity $w_{HS}\gamma_\mu dX_\mu dt$. Imposing this condition as $dt \to 0$ yields: [20]

$$X_\mu(t)=\frac{\mu\upsilon_N(t)}{\gamma_\mu w_{HS}}\,. \tag{19}$$

### 2.7. Labor Markets

In the North, total demand for manufacturing labor is $n_N c(N_N(t) + N_S(t))/\lambda$. With Northern entrepreneurs targeting their innovation efforts at all industries, total labor demand coming from innovation labor equals $a_\iota R(t)$. Using $R(t) = \iota\delta_\iota X_\iota(t)n_N/n$ from equation (10) one can express the equilibrium condition for Northern general-purpose labor as:

$$\frac{c(N_N(t)+N_S(t))}{\lambda}n_N + a_\iota\delta_\iota X_\iota(t)\iota\frac{n_N}{n} = (1-s_N)N_N(t)\,. \tag{20}$$

Total demand for Northern specialized labor is $\gamma_\iota X_\iota(t)n_N$. Thus, one can express the equilibrium condition for Northern specialized labor as:

$$\gamma_\iota X_\iota(t)n_N = s_N N_N(t). \tag{21}$$

In the South, total demand for manufacturing labor is $n_S c(N_N(t) + N_S(t))/w_{LN}$. With Southern entrepreneurs targeting their imitation efforts only at Northern industries, total labor demand coming from

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[20] It is straightforward to show that the second order conditions for maximization are satisfied. See Sener (2003) for details.

imitation equals $n_N a_\mu M(t)$. Using $M(t) = \mu\delta_\mu X_\mu(t)n_N/n$ from equation (13), one can state the equilibrium condition for Southern general-purpose labor as:

$$\frac{c(N_N(t)+N_S(t))}{w_{LN}} n_S + a_\mu \delta_\mu X_\mu(t)\mu \frac{n_N^{\,2}}{n} = (1-s_S)N_S(t)\,. \tag{22}$$

Total demand for Southern specialized labor is $\gamma_\mu X_\mu(t)n_N$. Thus, one can express the equilibrium condition for Southern specialized labor as:

$$\gamma_\mu X_\mu(t)n_N = s_S N_S(t). \tag{23}$$

**2.8. Steady-State Equilibrium**

At the steady-state equilibrium, Northern entrepreneurs capture industry leadership from Southern firms at a rate of $\iota n_S$, whereas Southern entrepreneurs capture industry leadership from Northern firms at a rate of $\mu n_N$. Constancy of industry shares requires:

$$\iota n_S = \mu n_N. \tag{24}$$

Using $n_N + n_S = 1$, it follows from (24) that $n_N = \iota/(\iota + \mu)$ and $n_S = \mu/(\iota + \mu)$. At the balanced growth path, the endogenous variables $c$, $\iota$, $\mu$, $w_{LN}$, $w_{HN}$ and $w_{HS}$ remain constant, whereas $M(t)$, $R(t)$, $\pi_S(t)$, $\pi_N(t)$, $X_\iota(t)$, $X_\mu(t)$, $\upsilon_N(t)$ and $\upsilon_S(t)$ grow at a rate of $n$. The equilibrium levels of $c$, $\iota$, $\mu$, $w_{LN}$, $w_{HN}$, *and* $w_{HS}$ are determined by a system of six equations [see Appendix for the derivation of the equations]:[21]

$$w_{HN} = A_\iota(1-\phi_\iota)\frac{\iota^2}{(\iota+\mu)} w_{LN}\,, \tag{25}$$

$$w_{HS} = \frac{s_N A_\iota(1-\phi_\iota)}{s_S\eta_S}\,\frac{\mu\iota}{(\iota+\mu)} w_{LN}\,, \tag{26}$$

$$\frac{c(1+\eta_S)\big(1-(w_{LN}/\lambda)\big)}{\rho+2\iota+2\mu-n} = A_\iota(1-\phi_\iota)s_N w_{LN}\,, \tag{27}$$

$$\frac{c(1+\eta_S)\big(1-(1/w_{LN})\big)}{\rho+\iota-n} = A_\mu(1-\phi_\mu)s_S\eta_S\,, \tag{28}$$

$$\frac{\iota}{(\iota+\mu)}\,\frac{c(1+\eta_S)}{\lambda} + A_\iota s_N\iota = (1-s_N)\,, \tag{29}$$

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[21] Under the assumption that $(\rho - n)$ is sufficiently small and $(1 - s_N)(\lambda - 1) > A_\mu s_S\eta_S(1 - \phi_\mu) + A_\iota s_N(1 - \phi_\iota)$, there exists a unique steady-state equilibrium in which $c$, $\iota$, $m$, $w_{LN}$, $w_{HN}$ and $w_{HS}$ are strictly positive and remain constant [see Sener (2003) for details].

$$\frac{\mu}{\mu+\iota}\left(\frac{c(1+\eta_s)}{w_{LN}}+A_\mu s_S\eta_S\iota\right)=(1-s_S)\eta_S, \tag{30}$$

where $A_\iota = a_\iota\delta_\iota/n\gamma_\iota$, $A_\mu = a_\mu\delta_\mu/n\gamma_\mu$, and $\eta_S = N_S(t)/N_N(t)$. Equations (25) and (26) determine the wages of specialized labor in the North and the South, respectively. Equations (27) and (28) represent the free-entry conditions for innovation and imitation, respectively. Equations (29) and (30) establish the labor market equilibrium conditions for general-purpose labor in the North and the South, respectively.

## 3. THE EFFECTS OF STRENGTHENING IPR PROTECTION IN THE SOUTH

In this model, stronger IPR protection in the South can materialize via three channels: [22] an increase in the unit labor requirement of imitative activity $a_\mu$, a decrease in the unit labor requirement of imitation-deterring activity $\gamma_\mu$, and an improvement in the effectiveness of imitation-deterring activity $\delta_\mu$.[23] Observe that these parameters enter the system of equations (25)-(30) exclusively via $A_\mu = a_\mu\delta_\mu/n\gamma_\mu$ and that each specific adjustment stated above leads to an increase in $A_\mu$.[24]

**Proposition 1:** *A strengthening of IPR protection in the South captured by an increase in* $A_\mu$

- *decreases the global rate of imitation m, and the frequency of imitations per industry* $\mu$,
- *decreases the global rate of innovation* $\iota$,
- *increases the wage of general-purpose labor in the North relative to that in the South* $w_{LN}$,
- *increases the fraction of Northern industries* $n_N$,
- *exerts an ambiguous impact on per capita consumption expenditure c.*

**Proof.** See Appendix.

The intuition is as follows. Ceteris paribus, a higher $A_\mu$ increases the resource requirement in imitative activity and generates two direct distortions in the South. First, it raises the cost of imitative activity and thereby discourages the Southern entrepreneurs from undertaking imitation [see equation

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[22] An alternative channel is a reduction in the subsidy rate to imitators $\phi_S$. It is straightforward to show that the qualitative effects of a decline in $\phi_S$ on $\iota$, $\mu$ and $w_{LN}$ are identical to those of an increase in $A_\mu$.

[23] It should be noted that imitation activity in the product-cycle literature, as well as in this model, refers to legal efforts of firms to acquire state-of-the-art technologies. Thus imitation differs from pirating and counterfeiting activities, which refer to illegal, and in most cost cases, imperfect reproduction of brand name products, copyrighted materials and so forth.

[24] In the literature, the standard way of increasing IPR protection is via an increase in $a_\mu$. The model shows that increased IPR protection driven by a change in $a_\mu$ generates the same qualitative effects as does increased IPR protection triggered by changes in the rent protection parameters $\gamma_\mu$ and $\delta_\mu$.

(28)]. Second, for a given level of employment, a higher $A_\mu$ implies a reduction in the intensity of imitation [see equation (30)]. At the new equilibrium, the global rate of imitation $m$ and the frequency of imitations per industry $\mu$ both attain lower levels.

The fall in the frequency of imitations per industry obviously benefits Northern incumbents, since they can now enjoy longer tenures in the product markets. This, by itself, should generate stronger incentives for Northern entrepreneurs to engage in innovation. Hence, one expects to observe an increase in the arrival rate of innovations $\iota$. However, the analysis indicates that there is actually a *decline* in the equilibrium rate of innovation.

To see the mechanism, I first transform the free-entry in innovation condition (14) such that the profit flow from sales and total rent protection outlays are expressed relative to sunk innovation costs. This implies:[25]

$$\frac{\left[\dfrac{c(1+\eta_S)}{A_\iota(1-\phi_\iota)s_N}\left(\dfrac{1}{w_{LN}}-\dfrac{1}{\lambda}\right)\right]-\left[\dfrac{w_{HN}}{w_{LN}}\dfrac{(\iota+\mu)}{A_\iota(1-\phi_\iota)\iota}+\dfrac{w_{HS}}{w_{LN}}\dfrac{s_S\eta_S(\iota+\mu)}{A_\iota(1-\phi_\iota)s_N\iota}\right]}{(\rho+\iota+\mu-n)}=1. \qquad (31)$$

In the numerator, the first term in brackets is the profit flow from sales per unit cost of innovation, and the second term in brackets is the total flow of rent protection expenditure per unit cost of innovation. The denominator shows the discount factor adjusted for the firm's replacement rate.

Next, I consider the general equilibrium effects of tightening Southern IPR protection on $w_{LN}$ and rent protection expenditures. Stronger IPR protection in the South discourages imitation and causes a contraction in Southern manufacturing. This leads to a collapse in the demand for Southern general-purpose labor and a boost in the demand for Northern general-purpose labor. Consequently, the relative wage of Northern general-purpose labor $w_{LN}$ increases.[26] To evaluate the change in total rent protection

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[25] To obtain (31), first combine (14) and (16). Then substitute for: $D_\iota$ from (9), $\pi_N(t)$ from (7) using (5), $X_\iota$ from (21), and $X_\mu$ from (23). Dividing both sides of the resulting expression by $A_\iota(1-\phi_\iota)s_N w_{LN}$ using $n_N = \iota/(\iota+\mu)$ and $n_S = \mu/(\iota+\mu)$ gives (31).

[26] To see the intuition from a different perspective, one can focus on the initial responses of wages, holding all else constant. First, through equation (28) a larger $A_\mu$ reduces the profitability of imitation. To restore the free-entry condition two general equilibrium effects come into play: upward pressure on Southern product prices and downward pressure on Southern manufacturing costs. Recall that due to price competition, successful Southern imitators charge a price just below the marginal cost in the North, which equals the relative wage of Northern labor $w_{LN}$. Hence, in general equilibrium, the upward pressure on Southern product prices translate into increased relative wage of Northern labor. On the other hand, the downward pressure on Southern manufacturing costs directly exerts a negative impact on the relative wage of Southern labor. Consequently, the North-South wage gap tends to

expenditure per unit cost of innovation, I substitute for $w_{HN}/w_{LN}$ from (25) and $w_{HS}/w_{LN}$ from (26) into (31).[27] This simplifies total rent protection expenditure per unit cost of innovation to $(\mu + \iota)$. Hence, for given level of $\iota$, stronger IPR protection in the South decreases the level of rent protection expenditure per unit cost of innovation by decreasing $\mu$.

I am now in a position to fully illustrate the forces that affect innovation profitability, holding $\iota$ constant. First, as mentioned above, the reduction in imitation exposure captured by the fall in $\mu$ prolongs the market tenure of Northern incumbents, raising the profitability of innovation. Second, the rise in the relative wage of Northern general-purpose labor $w_{LN}$ decreases the profit flow from sales per unit cost of innovation, reducing the profitability of innovation. Third, the reduction in the total rent protection outlays per unit cost of innovation raises the profitability of innovation. Finally, there is an ambiguous effect stemming from changes in per capita consumption expenditure $c$. The comparative steady-state analysis indicates that the net impact is a decline in the profitability of innovation; hence, the equilibrium rate of innovation $\iota$ decreases. Note also that at the new equilibrium, the fraction of Northern industries $n_N = \iota/(\iota + \mu)$ attains a higher level. Apparently, the tighter IPR regime in the South fortifies Northern industry leadership in manufacturing. Nevertheless, this is not driven by increased innovation, but instead due to the rate of innovation $\iota$ decreasing proportionally less than the rate of imitation $\mu$.[28]

With these findings, the present paper sides with the literature that emphasizes the negative effects of strengthening Southern IPR protection on the rates of technological progress and transfer [see Dinopoulos and Segerstrom (2003), Glass and Saggi (2002), Helpman (1993), the *wide gap* case of Grossman and Helpman (1991b) and the *inefficient followers* regime of Grossman and Helpman (1991a)]. Nevertheless, the present paper has a number of differentiating features. First, this paper establishes these

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increase. Second, through equation (30), a larger $A_\mu$ raises the level of employment required for a given level of imitative activity. To restore labor market equilibrium, there must be a contraction in manufacturing employment, which reinforces the upward pressure on product prices. Using the same logic as above, this translates into a higher relative wage of Northern labor, further widening the North-South wage gap.

[27] In the main text I focus the discussion on changes in $w_{LN}$, which I consider to be the main indicator of the North-South wage gap. Using (25) and (26), one can also show that both $w_{HN}/w_{LN}$ and $w_{HS}/w_{LN}$ decrease in response to an increase in $A_\mu$ [see Sener (2003) for details].

[28] In addition, one can analyze the employment effects within each economy. In the North with $d\iota/dA_\mu < 0$, innovation employment contracts and manufacturing employment increases [see equation (29)]. In the South, there are two opposite forces on employment in imitation activity $A_\mu m$. The fall in $m$ generates a negative effect, whereas the increase in $A_\mu$ causes a positive effect. One can show that $d(A_\mu m)/dA_\mu > 0$; hence, in the South, employment in imitation increases whereas employment in manufacturing declines [see equation (30)].

findings in a richer framework that allows for rent protection activities and in a more empirically relevant setting that removes the scale effects. Second, the analysis emphasizes the role of factor price movements in affecting innovation incentives. This is, for instance, downplayed in Glass and Saggi (2002) where the Northern wage relative to the South is exclusively determined by labor productivity parameters in manufacturing and does not respond to variations in IPR regimes.[29] Third, the present paper considers a more flexible framework in which all Northern innovators have access to the same technology of innovation. This is in contrast to the *inefficient followers* regime used by Grossman and Helpman (1991a) and Glass and Saggi (2002), where only ex-industry leaders in the North can participate in innovation races and no follower in the North undertakes innovation. In such a regime, the rate of innovation must be equated to the rate of imitation to generate constant industry shares for each region. Thus, by construction, the inefficient followers regime embodies a rigid feedback between innovation and imitation, forcing them to move together in response to any exogenous shock.

How robust is Proposition 1 to the inclusion of FDI as another channel of technology transfer? After all, if strengthening Southern IPR induces more FDI and thus more Southern production, this could reduce the labor market pressure in the North. To check for this, I extended the model by incorporating endogenous FDI and also rent-protection by multinational firms. The resulting model was substantially complicated, and it was not feasible to obtain clear analytical results. Therefore, I ran numerical simulations of the model.[30] I found that strengthening Southern IPR protection reduces the rates of innovation, imitation and multinationalization while raising the Northern relative wage. Hence, the results are robust to the inclusion of FDI.[31] These findings are in line with Glass and Saggi's (2002) quality-ladders model but in contrast to Lai's (1998) variety-expansion model. The intuition of my results is as

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[29] In fact, in a section of their paper, Glass and Saggi (2002, pp. 405-406) consider a case in which no FDI takes place and imitation serves as the only channel of technology diffusion. In their setting, wages are flexible; but , stronger IPR protection in the South leads to *a decline* in the Northern relative wage, which is exactly the opposite of this paper's prediction.

[30] When running the simulations, I used the following methodology. First, I searched the existing empirical and simulation studies to obtain values for the parameters. I then generated a benchmark model in which the endogenous variables are consistent with empirical observations. Finally, I checked the robustness of the results by considering high and low values for all parameters. The programs used to simulate the model require Mathematica version 4.1 and are available from the author upon request.

[31] When incorporating FDI, I followed Lai (1998) and considered two versions: one in which only multinationals are subject to imitation and another in which both Northern firms and multinationals are subject to imitation. The qualitative results of the simulations were the same under both versions.

follows. Stronger IPR protection in the South reduces the rate of imitation and thus the fraction of imitation industries. Even though the fraction of multinational industries increases, the equilibrium measure of Southern industries (imitation and multinational industries combined) declines. Consequently, the fraction of Northern industries must increase. With the rise in the resource requirement for imitation, the profitability of innovation relative to imitation increases and hence the North-South wage gap.[32] The rise in the Northern relative wage reduces the absolute profitability of innovation despite the reductions in rent protection expenditure and imitation exposure. We can therefore conclude that the main mechanisms identified in the innovation/imitation model remain intact and quantitatively strong when FDI is added.

## 4. CONCLUSION

In this paper, I have constructed a North-South product cycle model of trade that incorporates the rent protection activities of incumbent firms. The introduction of such activities captures a well-documented aspect of firm behavior and enriches the scope of the existing North-South product-cycle models. In addition, the model restores the empirical relevancy of product cycle models based on endogenous growth by eliminating the scale effects. The present paper introduces a simple adaptation of the rent protection mechanism of Dinopoulos and Syropoulos (2001) in a North-South setting, which can be a useful template to study further issues in a two-country endogenous growth context.[33] In addition, the paper complements an emerging literature that models rent protection/seeking under different settings.[34]

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[32] In fact, this outcome is due to one of the key differences between my approach and that of Lai (1998). In the present model, the rates of both Northern innovation and Southern imitation are endogenous. Taking the ratio of the zero profit conditions (29) and (30) implies that the North-South relative wage $w_{LN}$ is an increasing function of the profitability of innovation relative to imitation. When FDI is added to the model, this relationship is slightly modified but again embodies the predominant mechanism that determines the variation in $w_{LN}$. On the other hand, in Lai's (1998) model with endogenous innovation but exogenous imitation, the response of $w_{LN}$ is determined by different relationships. In the version without FDI, $w_{LN}$ is an increasing function of the relative price of Northern goods. Hence, an exogenous reduction in the imitation rate increases $w_{LN}$ by raising the fraction of Northern industries relative to the Southern industries and thereby increasing the Northern relative goods prices. In the version with FDI, $w_{LN}$ is an increasing function of the profitability of innovation relative to multinationalization. Therefore, an exogenous reduction in the imitation exposure, which is only faced by the multinationals, decreases $w_{LN}$ by reducing the relative profitability of innovation.

[33] In particular, I derive the optimality condition for rent protection activities from a simple rate of return maximization problem, preserving the *R&D race* setting of the standard quality-ladders growth model. In contrast, Dinopoulos and Syropoulos (2001) consider rent protection activities in a substantially complex *R&D contest* setting where the strategic interactions between an incumbent firm and challengers are modeled as a differential game for Poisson jump processes.

[34] In a partial equilibrium setting that treats innovation as exogenous, Boldrin and Levine (2004) consider the welfare effects of private rent seeking (through secrecy) vs. public rent seeking (through the legal system). They model both activities as *ex-post* activities following successful innovation, similar to the spirit of the present paper.

Contrary to common wisdom, I argue that a strengthening of IPR protection in the South reduces the equilibrium rates of *both* Northern innovation and Southern imitation. The key mechanism is the tightening of Northern labor markets and the resulting surge in North-South relative wage, which generates a negative effect on innovation profitability and dominates the other positive effects.

Several extensions of the model still remain to be explored. For instance, one can allow for Southern innovation and study the global effects of increasing IPR protection [see for instance Grossman and Lai (2002)]. Alternatively, one can differentiate between imitation and pirating activities in the South and investigate the effects of specific IPR policies. Another fruitful extension can be to merge the rent protection approach with the diminishing research opportunity approach to the removal of scale effects—as suggested by Dinopoulos and Segerstrom (2003) and Segerstrom (1998)—in a North-South setting.

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On the other hand, in a product cycle model with scale effects, Thoenig and Verdier (2003) allow for *ex-ante* rent protection efforts whereby entrepreneurs choose between directing their R&D efforts at skill-intensive products that are resistant to imitation and less-skilled intensive products that can be more easily copied. Using this setting, they study the effects of globalization on the relative wages of skilled workers. See also Taylor (1993) for a model that considers rent protection and imitation in a static North-South framework

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## Appendix

I first derive the steady-state equations (25) through (30). Using (18) and (19), one can obtain

$$X_{\iota} = \frac{\gamma_{\mu}}{\gamma_{\iota}} \frac{\iota}{\mu} \frac{w_{HS}}{w_{HN}} X_{\mu} . \qquad \text{(A.1)}$$

Using (21) and (23), one can derive

$$X_{\mu} = \frac{\gamma_{\iota}}{\gamma_{\mu}} \frac{s_S \eta_S}{s_N} X_{\iota} \qquad \text{(A.2)}$$

Combining (A.1) and (A.2) yields:

$$w_{HS} = \frac{\mu}{\iota} \frac{s_N}{s_S \eta_S} w_{HN} . \qquad \text{(A.3)}$$

Substituting for $\upsilon_N$ from (14) into (18) using $n_N = \iota/(\iota + \mu)$ yields (25). Combining (A.3) and (25) yields (26). Substituting for $w_{HS}$ from (A.3) and $X_{\mu}$ from (A.2) into (7) gives:

$$\pi_N = c(N_N + N_S)\left(1 - \frac{w_{LN}}{\lambda}\right) - w_{HN} \gamma_{\iota} X_{\iota} \left(\frac{\mu + \iota}{\iota}\right) . \qquad \text{(A.4)}$$

Substituting for $\pi_N$ from (A.4), $\upsilon_N$ from (16) into (14), using (25) for $w_{HN}$ and (21) for $X_{\iota}$ yields (27). Substituting for $\pi_S^P(t)$ from (6), $\upsilon_S(t)$ from (17) and $X_{\mu}$ from (23) into (15) gives (28). Substituting for $n_N = \iota/(\iota + \mu)$ and $X_{\iota}$ from (21) into (20) yields (29). Similarly, substituting for $n_N = \iota/(\iota + \mu)$ and $X_{\mu}$ from (23) into (22) yields (30).

I now obtain reduced form steady-state equations in terms of $\mu$ and $\iota$. First, I derive an expression for $w_{LN}$ by substituting for $c$ from (27) into (28):

$$w_{LN} = 1 + \frac{(\lambda - 1)}{(1 + \lambda A_R)} , \qquad \text{(A.5)}$$

where $A_R = [A_{\iota}(1 - \phi_{\iota}) s_N(\rho + 2\iota + 2\mu - n)] / [A_{\mu}(1 - \phi_{\mu}) s_S \eta_S(\rho + \iota - n)]$. In equilibrium, with $\iota > 0$ and $\mu > 0$, it follows that $\lambda > w_{LN} > 1$.

Substituting for $c$ from (27) into (30) using (A.5) yields:

$$\frac{\mu}{\iota + \mu}\left[A_{\mu} s_S \eta_S \left(D'(\rho + \iota - n) + \iota\right) + E' s_N(\rho + 2\iota + 2\mu - n)\right] = (1 - s_S)\eta_S \qquad \text{(A.6)}$$

where $D' = (1 - \phi_{\mu})/(\lambda - 1)$ and $E' = A_{\iota}(1 - \phi_{\iota})\lambda/(\lambda - 1)$. Substituting for $c$ from (27) into (29) using (A.5) gives:

$$\iota\left[\frac{A_\mu s_S \eta_S D'(\rho+\iota-n)}{(\iota+\mu)} + A_\iota s_N\left(\frac{E(\rho+2\iota+2\mu-n)}{(\iota+\mu)}+1\right)\right] = 1 - s_N\ , \qquad \text{(A.7)}$$

where $E = (1 - \phi_\iota)/(\lambda - 1)$.

To characterize the steady-state in terms of $\iota$ and $m$, I first obtain $\mu = m\iota/\,(\iota - m)$ by using $m = \mu n_N$ and $n_N = \iota/(\iota + \mu)$. In equilibrium with $\mu > 0$ it follows that $(\iota - m) > 0$. Substituting for $\mu$ into (A6) and (A7) and taking logs gives:

$$ln\, m - ln\,\iota + ln\left[A_\mu s_S \eta_S\left(D'(\rho+\iota-n)+\iota\right) + E' s_N\left(\rho+\frac{2\iota^2}{\iota-m}-n\right)\right] - ln(1-s_S) - ln\,\eta_S = 0 \qquad \textbf{(S1)}$$

$$ln\left[A_\mu s_S \eta_S D'(\rho+\iota-n)(\iota-m) + A_\iota s_N\left[E\left(\rho+\frac{2\iota^2}{\iota-m}-n\right)(\iota-m)+\iota^2\right]\right] - ln(1-s_N) - ln\,\iota = 0 \qquad \textbf{(S2)}$$

Next, I totally differentiate (S1) and (S2). As is common practice in the literature, I evaluate the derivates when $(\rho - n) \to 0$ [See for instance Glass and Saggi (2002)]. Note that this is consistent with the assumptions required for existence and uniqueness. Total differentiation gives:

$$\begin{bmatrix} S1_m & S1_\iota \\ S2_m & S2_\iota \end{bmatrix}\begin{bmatrix} dm \\ d\iota \end{bmatrix} = \begin{bmatrix} -S1_{A_\mu} & -S1_{\phi_\mu} & -S1_{\eta_S} \\ -S2_{A_\mu} & -S2_{\phi_\mu} & -S1_{\eta_S} \end{bmatrix}\begin{bmatrix} dA_\mu \\ d\phi_\mu \\ d\eta_S \end{bmatrix} \qquad \text{(A.8)}$$

where $S1_m = \frac{1}{m} + \frac{2E's_N\iota}{(\iota-m)^2 G} > 0$, $S1_\iota = -\frac{2E's_N m}{(\iota-m)^2 G} < 0$, $S1_{A_\mu} = \frac{s_S\eta_S(1+D')}{G} > 0$, $S1_{\phi_\mu} = -\frac{A_\mu s_S \eta_S}{(\lambda-1)G} < 0$,

$S1_{\eta_S} = -\frac{2E's_N\iota}{(\iota-m)\eta_S G} < 0$, $S2_m = -\frac{A_\mu s_S\eta_S D'}{H} < 0$, $S2_\iota = \frac{A_\mu s_S \eta_S D' + A_\iota s_N(1+2E)}{H} > 0$,

$S2_{A_\mu} = \frac{s_S\eta_S D'(\iota-m)}{H} > 0$, $S2_{\phi_\mu} = -\frac{A_\mu s_S\eta_S(\iota-m)}{(\lambda-1)H} < 0$, $S2_{\eta_S} = \frac{A_\mu s_S D'(\iota-m)}{H} > 0$,

$G = A_\mu s_S\eta_S(1 + D') + [2E's_N\iota/(\iota - m)]$ and $H = A_\mu s_S\eta_S D'(\iota - m) + \iota A_\iota s_N(1 + 2E)$. The determinant $\Delta = S1_m S2_\iota - S1_\iota S2_m = [(A_\mu s_S\eta_S D' + A_\iota s_N(1 + 2E))/(mH)] + [(2E's_N)/(G(\iota - m)^2)] > 0$.

**Proof of Proposition 1**

Using Cramer's rule and (A.8), one can show that

$$\frac{dm}{dA_\mu} = \frac{-S1_{A_\mu}S2_\iota + S2_{A_\mu}S1_\iota}{\Delta} < 0 \qquad \text{(A.9)}$$

$$\frac{d\iota}{dA_\mu} = \frac{-S1_m S2_{A_\mu} + S2_m S1_{A_\mu}}{\Delta} < 0 . \qquad \text{(A.10)}$$

To investigate the change in $\mu$, first totally differentiate $\mu = m\iota/(\iota - m)$. This yields:

$$d\mu = \frac{1}{(\iota - m)^2}\left[\iota^2 dm - m^2 d\iota\right]. \qquad \text{(A.11)}$$

Substituting for $dm$ from (A.9), $d\iota$ from (A.10) into (A.11) gives:

$$\frac{d\mu}{dA_\mu} = \frac{1}{(\iota - m)^2 \Delta}\left[- S1_{A_\mu}(\iota^2 S2_\iota + m^2 S2_m) + S2_{A_\mu}(\iota^2 S1_\iota + m^2 S1_m)\right]. \qquad \text{(A.12)}$$

Substituting the relevant terms from (A.8) and simplifying implies that $sign\ (d\mu/dA_\mu) = sign\ [-A_\mu s_S \eta_S D'\iota(\iota - m) - A_\iota s_N(1 + 2E)] < 0$. Thus, it follows that $d\mu/dA_\mu < 0$.

To investigate the change in $w_{LN}$, I totally log differentiate $A_R$ in (A.5) with respect to $A_\mu$ using $\mu = m\iota/(\iota - m)$. This yields:

$$\frac{d\ln A_R}{dA_\mu} = \frac{1}{(\iota - m)}\frac{dm}{dA_\mu} - \frac{m}{\iota(\iota - m)}\frac{d\iota}{dA_\mu} - \frac{1}{A_\mu} . \qquad \text{(A.13)}$$

Using (A.10) and substituting the relevant expressions from (A.8), one can show that for $-[m/\iota(\iota - m)]d\iota/dA_\mu - (1/A_\mu) < 0$, we need $2E's_N\iota s_S\eta_S D''/GHm > 0$, a condition which always holds. Given $1/(\iota - m)(dm/dA_\mu) < 0$ from (A.9), it follows that $d\ln A_R/dA_\mu < 0$. Differentiating (A.5) with respect to $A_\mu$ then immediately gives:

$$\frac{dw_{LN}}{dA_\mu} = -\frac{(\lambda - 1)\lambda}{(1 + \lambda A_R)^2}\frac{dA_R}{dA_\mu} > 0 . \qquad \text{(A.14)}$$

Finally, to investigate the change in $n_S$, first note that $n_S = m/\iota$ by $\mu = m\iota/(\iota - m)$ and $n_S = \mu/(\iota + \mu)$. Totally log differentiating $n_S$ gives $d\ln n_S = (1/m)/dm - (1/\iota)d\iota$. Using (A.9) and (A.10) along with the explicit expressions for $E$, $E'$ and $D$, one can derive:

$$\frac{d\ln n_S}{dA_\mu} = -\frac{s_S \eta_S s_N}{\Delta m GH}\left[2(1 - \phi_\iota)\phi_\mu + (\lambda - 1) + (1 - \phi_\mu)\right] < 0 . \qquad \text{(A.15)}$$