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 global effects of strengthening Southern Intellectual Property Rights (IPRs) protection. 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. I find that a stronger Southern IPR regime reduces the rates of innovation and imitation while leading to a larger North-South wage gap. With regards to multinationalization, I find that a stronger Southern IPR regime raises both the fraction of Multinational industries and the share of production shifted to the South within each Multinational firm.

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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.[2] In the meanwhile, TRIPs held the premise of accelerating technology transfer to the South through increased Foreign Direct Investment (FDI).

TRIPS came after a decade of intense negotiations and resulted in noticeable shifts in IPR regimes in the developing world. In the 1990-2000 period, the degree of IPR protection, as measured by the Ginarte and Park index, of countries with income per capita levels below $10,000 has on average increased by 56 percent (Table 1). In the five-year period following the TRIPS agreement, China increased its measure of IPR protection from 1.55 to 2.48, and India increased its measure from 1.51 to 2.58. With advanced countries constantly pushing for increased global IPR protection and more countries attaining full membership in the WTO, the movement towards stronger IPR protection is likely to continue in the upcoming decades.[3]

To investigate the global consequences of increased IPR protection I construct a dynamic product cycle model of trade with endogenous innovation, imitation and multinationalization. The North specializes in innovation, and the South specializes in imitation. High quality products are first innovated and manufactured in the North. Then production can shift to the South either through multinationalization of Northern firms or imitation by Southern entrepreneurs. Further innovation by the North triggers a shift of production back to the North. This product cycle framework—first proposed by Vernon (1966) and later formalized by Segerstrom et al. (1990), Grossman and Helpman (1991c), among others—offers a suitable setting to think about global IPR issues. My goal is to investigate the implications for innovation, imitation, multinationalization and the North-South wage gap.

The model differs from the existing literature on three accounts. First, successful Northern innovators can engage in rent protection activities to safeguard their innovations and thereby prolong the duration of their monopoly power. Consequently, the framework for IPR protection has an *endogenous*

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

[2] McCalman (2001) calculates that TRIPS imply substantial rent transfers from the South to Northern patent holders.

[3] See Bhagwati (2005, pp. 182-85) for a discussion on the advanced countries' efforts to promote stronger global IPR protection under the WTO as well as in other bilateral/multilateral platforms.

component. Second, at the steady-state equilibrium, the rates of innovation, imitation and multinationalization remain constant despite positive population growth. Therefore, the model provides an empirically relevant setting that is not subject to the scale effects critique of Jones, an issue which received relatively sparse attention in the relevant product-cycle literature.[4,5] Third, the steady-state innovation rate is a function of the fraction of resources allocated to R&D. Hence, the model predicts fully-endogenous Schumpeterian growth, an outcome which is consistent with the empirical evidence provided by Ha and Howitt (2006) and Zachariadis (2003, 2004) as discussed in detail in section 3.10.

I incorporate rent protection activities in the spirit of Dinopoulos and Syropoulos (2006), who were the first to incorporate such activities into a closed economy growth model. In my North-South product cycle model, successful Northern innovators conduct two types of rent protection activities: *innovation-deterring activities* aimed at reducing the innovation success of Northern rivals (as in Dinopoulos and Syropoulos) and *imitation-deterring activities* aimed at reducing the imitation success of Southern rivals (a new line of rent protection stemming from the North-South structure). Empirical evidence on the nature and extent of rent protection activities are detailed in the following section. Taylor (1993) was the first to model firm-level activities aimed at raising imitation barriers in a static North-South partial-equilibrium setting. To my knowledge, no attempt has been made in the literature to account for these activities in a dynamic North-South general-equilibrium setting; hence, the paper seeks to fill in this gap.

In terms of modeling, I depart from Dinopoulos and Syropoulos (2006) by proposing a rate of return maximization approach to the optimal choice of rent protection activities. Compared to Dinopoulos and Syropoulos, this approach offers a much simpler two-step process and hence constitutes one of the main analytical contributions of the paper. This new method can be easily utilized to investigate further issues in dynamic settings where institutions evolve endogenously and firms play an active role in governing this process.

I begin the paper by developing a basic product-cycle model with endogenous innovation and imitation. I find that a strengthening of Southern IPR protection, in the form of an increase in imitation resource requirement, reduces the rates of both Southern imitation and Northern innovation and leads to a rise in the North-South wage gap. I then extend the basic model to allow for endogenous multinationalization (FDI) as an additional channel of technology transfer. In this setting, success in

[4] 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 argues that this prediction, pinned down as the scale effects property, is inconsistent with the post-war time series evidence from industrialized countries.

[5] See Dinopoulos and Segerstrom (2005a, 2005b), Parello (2005) and Grieben (2006) for scale-free North-South models.

multinationalization implies a complete shift of production to the South within the firm. In other words, the degree of production fragmentation within the multinational firm is set to one in an exogenous fashion as in Glass and Saggi (2002) and Branstetter et al (2005b). With endogenous FDI and exogenous fragmentation, I again find that strengthening Southern IPR protection reduces the rates of innovation and imitation, and raises the North-South wage gap. With regards to multinationalization, I focus on two indicators. The first is the rate of multinationalization measured by the success probability in technology transfer times the fraction of Northern industries. The second is the fraction of Multinational industries in the global economy. I find that strengthening Southern IPR protection increases the fraction of Multinational industries despite reducing the rate of multinationalization.

Lastly, I endogenize the extent of fragmentation *within* each multinational firm. This brings the model closer to the real world and allows me to study the intra-firm response to IPR regime shifts. To my knowledge this is the first such attempt in the R&D-based product-cycle literature. When both multinationalization and fragmentation decisions are endogenous, I once again find that a strengthening of Southern IPR protection reduces the rates of innovation, imitation, and multinationalization while raising the North-South wage gap. Moreover, I find that a stronger Southern IPR regime increases not only the fraction of Multinational industries (the extensive margin) but also the portion of production shifted to the South within each multinational firm (the intensive margin). Numerical simulations reveal that the quantitative responses of multinationalization indicators are much larger in the case of endogenous fragmentation vis-à-vis exogenous fragmentation.

In all three versions, the reduction in the rates of *both* innovation and imitation, and the widening North-South wage gap emerge as robust results. Hence, the paper predicts that TRIPs can hinder technological progress not only for the South but also for the North. At the same time, TRIPS can be a force of wage divergence between the North and the South. With regards to multinational firm activity, the paper's predictions are more optimistic. TRIPS can foster shifting of production to the South via multinationals—at both extensive and intensive margins. The model thus provides theoretical foundations for the empirical evidence provided by Branstetter et al. (2005a, b).[6] Using firm level data, Branstetter et al. (2005a, b) investigate the responses of US multinational firms to IPR reforms in sixteen developing countries. They find that multinational firms respond to stronger IPR protection by increasing the scope of their activities measured by sales, employment, affiliate R&D activity and intra-firm royalty payments.

[6] Branstetter et al (2005b) also provide theoretical foundations for their empirical findings using a variety-expansion based North-South growth model. However, their model exhibits scale effects and does not allow for endogenous fragmentation.

The related literature on IPRs has expanded substantially in the past decade.[7] The paper most closely related to the present work is the influential work of Glass and Saggi (2002) which was the first to offer a product-cycle model with endogenous innovation, imitation and FDI. From a theoretical perspective, my paper differs from Glass and Saggi (2002) on three accounts. First, I incorporate rent protection activities and offer a scale-free product cycle model. Second, I consider a more flexible product-cycle scheme by allowing for Northern entrepreneurs to target all industries in the continuum. Third, I allow for the possibility of endogenous fragmentation within each multinational firm. In terms of results, there are both commonalities and major departures. Like this paper, Glass and Saggi (2002) also find that strengthening Southern IPR protection reduces the rates of innovation and imitation. However, in their imitation-only model, the tighter IPR regime *reduces* the North-South wage gap, and in their imitation/FDI model it exerts *no influence* on the wage gap. In the context of the imitation/FDI model, this stark difference stems from my considering of imitation-deterring activities (as detailed in Section 4.8). Lastly, I find that a stronger Southern IPR regime increases the proportion of Multinational industries, whereas Glass and Saggi (2002) predict a decline in this measure.

The paper is organized as follows. Section 2 provides evidence on innovation and imitation deterring activities. Section 3 introduces the basic model with endogenous innovation and imitation. Section 4 extends the basic model to allow for endogenous multinationalization. Section 5 adds endogenous fragmentation within-multinationals. Section 6 concludes. It should be noted that the extensions are presented in an incremental fashion to facilitate the paper's comparison with the existing literature. Proofs of all propositions are relegated to Appendices (available at http://www1.union.edu/~senerm/ and from the author upon request).

2. EMPIRICAL EVIDENCE ON RENT PROTECTION ACTIVITIES

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[7] The first generation scale-dependent growth models offer mixed results on the effects of stronger IPRs protection. 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), they find that stronger IPR protection in the South decreases the rates of innovation and imitation. Extending the quality-ladders model with endogenous innovation and imitation to allow for FDI, Glass and Saggi (2002) find that stronger Southern IPR protection leads to lower rates of innovation, imitation and FDI. Using a variety expansion model with similar structure (endogenous innovation/imitation/FDI) Branstetter et al (2005b) have challenged the results of Glass and Saggi (2002). Their numerical simulations showed that increased IPR protection in the South may stimulate innovation and FDI. In a recent paper, Glass and Wu (2006) provide a comparative analysis of the quality-ladders vs. variety expansion models with exogenous imitation. Taking a slight departure from this literature, Taylor (1994) constructs a North-South model that incorporates the Ricardian continuum goods framework into a quality-ladders growth setting. He finds that symmetric treatment of IPRs can lead to a more efficient allocation of world resources and thereby foster growth and multinational activity. See also Helpman (1993) for a model that investigates the transitional welfare effects of increased Southern IPR protection and also Young and Maskus (2001) for a model that considers licensing as the channel of North-South technology transfer.

What exactly defines rent protection activities and how important are they in the real world, especially in a North-South context? Rent protection activities can involve patent enforcement, practicing trade secrecy, lobbying the government to promote stronger IPR protection, engaging in corrupt activities to influence the legal/political system, and so on. Dinopoulos and Syropoulos (2006) present anecdotal evidence for such activities from a wide range of companies including Coca-Cola, Microsoft, Intel, DuPont, and others. Levin et al. (1987) and Cohen et al. (2000) provide systematic survey based evidence from US manufacturing industries, showing that firms rely heavily on patents and trade secrecy, among other methods, to appropriate rents from their innovations. Patent enforcement and litigation involve substantial costs which are comparable to R&D expenditures. According to AIPLA (1997) the 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) calculates that the direct costs of patent suits started in 1991 is expected to equal 27 percent 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.[8] Patent litigation efforts can be quite 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).

Imitation-deterring activities in a North-South context are also empirically relevant phenomena. Lanjouw and Cockburn (2000) examine the lobbying activities of US companies and report that such activities heavily influenced the US government's efforts in promoting IPR protection in both bilateral and multilateral negotiations.[9] 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. 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".[10] Reporting in the popular press suggests that the industry's lobbying efforts have been

[8] Somaya (2002) reports that the total number of patents suits filed in the US between 1986 and 1995 is 12954 with the following breakdown: 895 (design), 1889 (chemicals), 1366 (drugs and medical technology), 2757 (electronics, computer, optical and nuclear), 3576 (mechanicals) and 2461 (others) .

[9] See also Bhagwati (2005, pp. 182-85). 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.

[10] See *New York Times*, November 4, 2001, "A Muscular Lobby Rolls Up Its Sleeves", 3.1; and *New York Times*, June 1, 2003, "Drug Companies Increase Spending on Efforts to Lobby Congress and Governments", 1.33.

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 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.[11]

Patent litigation cases in the South involving Northern companies have been on the rise and appear to be receiving more attention recently. The most publicized North-South patent litigation case was probably the case between South Africa and the international drug industry. 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 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.[12] Other examples of North-South patent suits include Lego, Intel, Microsoft, Adobe, Unilever in China, and Pfizer in Russia (see various issues of *Managing Intellectual Property*).[13] With substantial demand for patents, trademarks and copyrights in the South by foreigners (Maskus et. al., 2004), law firms in many developing countries now offer a wide range of services in intellectual property related areas.[14]

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[11] For further details including the specific contribution amounts received by some signatory Congress members, see *Wall Street Journal*, February 6, 2003, "U.S. Flip on Patents Shows Drug Makers' Growing Clout", A.4.

[12] For an unfolding of the events during the trial, including the lobbying efforts of drug companies, the involvement of non-governmental organizations, see *Wall Street Journal*, March 2, 2001 "Patents Pending: AIDS Epidemic Traps Drug Firms in a Vise: Treatment vs. Profits", A1.

[13] 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 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.

[14] 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 total number of US patent applications filed by US residents in 2000, which was equal to 175,582. Using numbers from Berrier (1996) one can calculate that seeking only 5 year global protection for half of these patents, on top of the US protection, would imply a cost of $14.44 billion.

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 alternative channels. In China, IP owners can pursue their cases via two actions: judicial action and administrative action [Clarke (1999) and Maskus et al. (2004)]. 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) states 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". To pursue administrative action, foreign companies usually hire investigation or law firms to make the case to various Chinese government organs.[15] Clarke (1999, p.34) points out that administrative action is prone to corruption to the extent that any other government action is. 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 intellectual property owners.

The bottom line is that *i)* Northern firms engage in activities to safeguard their intellectual property *ii)* These activities are observed in a Northern as well as in a North-South context *iii)* These activities are costly but appear to be effective. Hence the motivation for modeling rent protection activities in a North-South growth setting.

3. THE MODEL WITH ENDOGENOUS IMITATION

I first construct is a quality-ladders model 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 L_{0i} denote the

[15] See *Managing Intellectual Property*, Sep. 2003, "How to Litigate in China", p.1.

size of the population and also the labor force of country *i* at time zero. Each country's population grows at a rate of $n > 0$. Thus, the size of the population in country *i* at time *t* equals $L_{0i}e^{nt}$.

3.1. Household behavior

The consumer's optimization is standard in the literature and hence I will be brief.[16] In each country, the representative household maximizes the utility function

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

where ρ is the subjective discount rate with $\rho - n > 0$. The term $\log u_i(t)$ represents the instantaneous utility of each household member

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

where $x_i(j,\omega,t)$ denotes per capita demand for a product with quality *j* in industry ω 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 $u_i(t)$. 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 ω 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 dynamic 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 $\dot{B}_i(t) = W_i(t) + r(t)B_i(t) - c_i(t)L_i(t)$, 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, $r(t) = \rho$. The transitional dynamics of the model are analytically intractable; hence I restrict attention to steady states, an approach which is adopted by the entire North-South growth literature summarized in footnote 7. I henceforth drop the time index for the variables that remain constant at the steady state.

3.2. Labor and activities

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[16] See Dinopoulos and Segerstrom (1999) and Glass and Saggi (2002) among others for details.

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.[17] In the South, there are three types of activities: imitation, 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.

3.3. 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.[18]

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.[19] Such a structure implies that Northern followers cannot effectively compete in product markets, since they will be undercut by their Southern counterparts.

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[17] 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 (2006).

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

[19] See Glass (1997) for a detailed discussion on the instantaneous diffusion of inferior technology. This assumption has been adopted in both North-South and North-North contexts. For the former, see Glass (1997), Glass and Saggi (1998), Sayek and Sener (2006) and for the latter, see Dinopoulos and Segerstrom (1999).

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*, in which a Northern quality leader competes with Southern followers that have access to the discarded technology. The Northern firm can manufacture a product that is λ 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 ε is an infinitely small amount. This limit pricing forces the Southern followers out of the market. Northern leader then starts realizing monopoly profits from product sales

$$\pi_N^P(t) = \frac{(\lambda - w_{LN})}{\lambda} c[L_N(t) + L_S(t)] , \tag{5}$$

where $c=[c_N L_N(t) + c_S L_S(t)]/[(L_N(t) + L_S(t)]$ represents the per capita consumption expenditure of a representative world citizen, $\lambda - w_{LN} > 0$ is the profit margin per unit and $c[L_N(t) + L_S(t)]/\lambda$ 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*, in which 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 $w_{LN} - \varepsilon$. This limit pricing drives the Northern incumbent out of the market. The Southern firm than starts realizing monopoly profits

$$\pi_S(t) = \frac{(w_{LN} - 1)}{w_{LN}} c[L_N(t) + L_S(t)] , \tag{6}$$

where $w_{LN} - 1 > 0$ is the profit margin per unit of output and $c[L_N(t) + L_S(t)]/w_{LN}$ 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.[20] For innovation-deterring activities, each Northern incumbent hires *Northern* specialized labor at a wage rate of w_{HN}. The cost of performing $X_t(t)$ units of innovation-deterring activity is given by $w_{HN}\gamma_t X_t(t)$, where γ_t is the unit labor requirement of such activities. For imitation-deterring activities, each

[20] 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].

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

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

3.4. 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 ω. 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 ω. 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 ω, and $\delta_\iota > 0$ is a parameter that measures the effectiveness of innovation-deterring activity.[21] 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 $\delta_\iota X_\iota(\omega,t)$.[22] At the steady-state equilibrium, a bounded rate of innovation requires $\dot{D}_\iota(\omega,t)/D_\iota(\omega,t) = n$. Using this relationship and (8) I 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

$$\iota(\omega,t) = \sum_j \iota_j(\omega,t) = \frac{R(\omega,t)}{D_\iota(\omega,t)} \tag{10}$$

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[21] Modeling of innovation and imitation difficulty as stock variables differs from Dinopoulos and Syropoulos (2006), in which innovation difficulty is treated as a flow variable. I adopt 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 common law practicing countries, incumbents may direct more of their efforts at influencing the legislation, whereas in civil law practicing countries, incumbents may spend more of their resources in influencing the judicial system. In either context it is reasonable to assume that firms strive to impact the evolution of *both* legislative and judicial institutions. See Gallini (2002, pp. 133-135) on the impact of particular IPR cases in shaping up the US legal system.

[22] 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 $0\% < DEPR < 100\%$.

where $R(\omega,t) = \Sigma_j R(\omega,t)_j$. Observe that $\iota(\omega,t)$ measures the frequency of innovations in industry ω. 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 ι.

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 ω. 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) I 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

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

where $M(\omega,t) = \Sigma_j M(\omega,t)_j$. Observe that $\mu(\omega,t)$ measures the frequency of imitations in industry ω. Let m denote the economy-wide imitation rate in the South. Given that the Southern entrepreneurs target only Northern industries, which accounts for a fraction n_N of the industries, it follows that $m \equiv \mu n_N$. In the rest of the paper I omit the industry index ω to simplify notation. Figure 1 illustrates the product-cycle dynamics in a schematic fashion.

3.5. 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_ι is the unit labor requirement of innovation. A typical Northern entrepreneur indexed by j chooses the intensity of innovation to maximize the expected profits

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

where υ_N shows the value of a successful Northern innovator and σ_ι represents the rate of innovation subsidy offered by the Northern government. Free entry into innovation drives the expected profits down to zero:

$$\upsilon_N(t) = w_{LN} a_\iota D_\iota(t)(1-\sigma_\iota). \tag{14}$$

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_μ 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

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

where υ_S shows the value of a successful Southern imitator, and σ_μ represents the rate of imitation subsidy by the Southern government. Free entry into imitation drives the expected profits down to zero:

$$\upsilon_S(t) = a_\mu D_\mu(t)(1-\sigma_\mu). \tag{15}$$

3.6. Stock markets

There is a global stock market that channels the savings of consumers to firms. At the steady-state ι and μ will remain constant; hence, I drop the time index for these variables. 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 υ_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 ιdt, the Southern producer loses its monopoly position and the stockholders face a decline in their investment from υ_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:

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

3.7. Optimal rent protection decisions by Northern incumbents

Northern incumbents choose the level of rent activities to maximize the expected return on their stocks. Consider a Northern incumbent that increases its innovation-deterring activity by $dX_\iota > 0$ units. The increased level of X_ι induces a decline in the intensity of innovation targeting the incumbent, which equals $d\iota = -[\iota/X_\iota(t)]dX_\iota < 0$ via (9) and (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 ι 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_ι, 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:[23]

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

In an analogous fashion, I derive the optimality condition for imitation-deterring activities X_μ. Consider a Northern incumbent that increases its imitation-deterring activity by $dX_\mu > 0$ units. The increased level of X_μ induces a decline in the intensity of imitation targeting the firm, which equals $d\mu = -[\mu/X_\mu(t)]dX_\mu < 0$ via (12) and (13). The lower imitation exposure extends the incumbent firm's duration of monopoly power, raising the expected return 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 μ and using $d\mu = -[\mu/X_\mu(t)]dX_\mu < 0$ yields the incremental gain in the expected return: $\upsilon_N(t)[\mu/X_\mu(t)]dX_\mu dt + \dot{\upsilon}_N[\mu/X_\mu(t)]dX_\mu dtdt$. At the optimal level of X_μ, 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:[24]

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

Lemma 1: *It follows from (18) and (19) that the incumbent firm's optimal rent protection expenditures must satisfy* $w_{HN}\gamma_\iota X_\iota(t) + w_{HS}\gamma_\mu X_\mu(t) = (\iota + \mu)\upsilon_N(t)$.

Equation (18) implies that $w_{HN}\gamma_\iota X_\iota(t)$ increases with ι and $\upsilon_N(t)$. Intuitively, the Northern incumbent responds to an increase in threat of replacement coming from Northern entrepreneurs ι by

[23] The first order condition is the same as that in Dinopoulos and Syropoulos (2006). The set up of the problem though differs markedly. I derive the optimal rent protection condition from a simple two-step rate of return maximization problem, preserving the *R&D race* setting of the standard quality-ladders growth model. In contrast, Dinopoulos and Syropoulos (2006) consider rent protection activities in a substantially more 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.

[24] It is straightforward to show that the second order conditions for maximization are satisfied. See Appendix A for details.

raising its innovation-deterring activities. On the other hand, an increase in the incumbent firm's market value $\upsilon_N(t)$ also leads to a rise in innovation-deterring activities, because a higher $\upsilon_N(t)$ raises the cost of capital loss in case successful outside innovation materializes. An analogous argument can be made to examine the optimal level of imitation-deterring activities using (19).

3.8. Labor Markets

In the North, total demand for manufacturing labor is $n_N c[L_N(t) + L_S(t)]/\lambda$. With Northern entrepreneurs targeting their innovation efforts at all industries, total labor demand coming from innovation labor equals $a_\iota R(t)$. Using $R(t) = \iota D_\iota(t)$ from (10) I express the equilibrium condition for Northern general-purpose labor as:

$$\frac{c[L_N(t)+L_S(t)]}{\lambda}n_N + a_\iota \iota D_\iota(t) = (1-s_N)L_N(t). \qquad (20)$$

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

$$\gamma_\iota X_\iota(t) n_N = s_N L_N(t). \qquad (21)$$

In the South, total demand for manufacturing labor is $n_S\, c[L_N(t) + L_S(t)]/w_{LN}$. With Southern entrepreneurs targeting their imitation efforts only at Northern industries, total labor demand coming from imitation equals $n_N a_\mu M(t)$. Using $M(t) = \mu D_\mu(t)$ from (13), I state the equilibrium condition for Southern general-purpose labor as:

$$\frac{c[L_N(t)+L_S(t)]}{w_{LN}}n_S + a_\mu D_\mu(t)\mu n_N = (1-s_S)L_S(t). \qquad (22)$$

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

$$\gamma_\mu X_\mu(t) n_N = s_S L_S(t). \qquad (23)$$

3.9. Steady-State Equilibrium Equations

Northern entrepreneurs capture industry leadership from Southern firms at a rate of ιn_S, whereas Southern entrepreneurs capture industry leadership from Northern firms at a rate of μn_N. Constancy of industry shares requires $\iota n_S = \mu n_N$. Combining this with $n_N + n_S = 1$, implies

$$n_N = \iota/(\iota + \mu) \quad \text{and} \quad n_S = \mu/(\iota + \mu). \qquad (24)$$

For future use, note that $\partial n_N/\partial\iota > 0$, $\partial n_N/\partial\mu < 0$, $\partial n_S/\partial\iota < 0$, $\partial n_S/\partial\mu > 0$. At the balanced growth path, the endogenous variables c, ι, μ, 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. Thus, the model is free of scale effects. Let $A_\iota \equiv a_\iota\delta_\iota/n\gamma_\iota$, $A_\mu \equiv a_\mu\delta_\mu/n\gamma_\mu$, and $\eta_S \equiv L_S(t)/L_N(t)$. From this point on I drop the time index for all variables. Using the equation pairs (18) and (19), and (21) and (23) respectively I obtain:

$$X_\iota = \frac{\gamma_\mu}{\gamma_\iota}\frac{\iota}{\mu}\frac{w_{HS}}{w_{HN}}X_\mu \qquad \text{and} \qquad X_\mu = \frac{\gamma_\iota}{\gamma_\mu}\frac{s_S\eta_S}{s_N}X_\iota . \tag{25}$$

It follows from (25) that the Northern specialized wage relative to Southern specialized wage is:

$$\frac{w_{HN}}{w_{HS}} = \frac{\iota}{\mu}\frac{s_S\eta_S}{s_N} . \tag{26}$$

Intuitively, as the threat of replacement coming from innovation relative to imitation ι/μ increases, Northern producers increase their innovation-deterring efforts relative to their imitation-deterring efforts and thus the North-South specialized wage increases. Substituting for υ_N from (14) into (18) using (24) for n_N and (9) for D_ι defines the *Northern specialized wage* in terms of ι, μ and w_{LN}:

$$w_{HN} = A_\iota(1-\sigma_\iota)\frac{\iota^2}{(\iota+\mu)}w_{LN} . \qquad \textbf{NSW } (\boldsymbol{w_{HN}}\ \boldsymbol{\iota},\ \boldsymbol{\mu},\ \boldsymbol{w_{LN}}) \tag{27}$$

Combining (26) and (27) defines the *Southern specialized wage* in terms of ι, μ and w_{LN}:

$$w_{HS} = \frac{s_N A_\iota(1-\sigma_\iota)}{s_S\eta_S}\frac{\mu\iota}{(\iota+\mu)}w_{LN} . \qquad \textbf{SSW}(\boldsymbol{w_{HS}},\ \boldsymbol{\iota},\ \boldsymbol{\mu},\ \boldsymbol{w_{LN}}) \tag{28}$$

Substituting for $w_{HN}\gamma_\iota X_\iota + w_{HS}\gamma_\mu X_\mu$ from Lemma 1 into (7) implies $\pi_N = c[N_N + N_S][1 - (w_{LN}/\lambda)] - \upsilon_N(\iota + \mu)$. Substituting this into (16) and solving for υ_N gives:

$$\upsilon_N(t) = \frac{c(N_N+N_S)[1-(w_{LN}/\lambda)]}{\rho+2\iota+2\mu-n} . \tag{29}$$

Equation (29) implies that the total rent protection expenditure *per unit of time* $(\iota+\mu)\upsilon_N$ effectively translates into an increase in the replacement rate faced by the Northern incumbent from $\iota + \mu$ to $2\iota + 2\mu$. Substituting υ_N from (29) into (14), using (9) for D_ι and (21) for X_ι yields a simplified version of the *free-entry in innovation condition*:

$$\frac{c(1+\eta_S)[1-(w_{LN}/\lambda)]}{\rho+2\iota+2\mu-n} = A_\iota(1-\sigma_\iota)s_N w_{LN} . \qquad \textbf{FEIN}(\boldsymbol{\iota},\ \boldsymbol{\mu},\ \boldsymbol{w_{LN}},\ \boldsymbol{c}) \tag{30}$$

Substituting for π_S^P from (6), υ_S from (17) into (15), using (12) for D_μ and (23) for X_μ gives a simplified version of the *free-entry in imitation condition*:

$$\frac{c(1+\eta_S)[1-(1/w_{LN})]}{\rho+\iota-n} = A_\mu(1-\sigma_\mu)s_S\eta_S , \qquad \textbf{FEIM}(\boldsymbol{\iota},\ \boldsymbol{\mu},\ \boldsymbol{w_{LN}},\ \boldsymbol{c}) \tag{31}$$

Figure 2a shows the FEIM and FEIN equations in (w_{LN}, c) space, for given levels of ι and μ. The FEIN curve is upward sloping because a higher w_{LN} raises both production and innovation costs, and restoring the zero-profit condition requires a rise in c. The FEIM curve is downward sloping because a higher w_{LN} raises the limit price that can be charged by successful Southern imitators, and restoring the zero profit condition entails a lower c.

Eliminating w_{LN} in FEIN by using FEIM and solving for c yields:

$$c(\iota,\mu;A_{\mu})=\frac{\lambda[A_{\iota}s_{N}(\rho-n+2\iota+2\mu)(1-\sigma_{\iota})+A_{\mu}(\rho-n+\iota)s_{S}\eta_{S}(1-\sigma_{\mu})]}{(1+\eta_{S})(\lambda-1)}, \qquad \mathbf{c(\iota,\mu)} \quad (32)$$

For future use, note that $\partial c/\partial\mu > 0$ and $\partial c/\partial\iota > 0$. Intuitively, a higher ι increases the pace of creative destruction and thereby reduces the rewards from both innovation and imitation. For a given w_{LN}, restoring the zero profit condition require a higher c. Thus the FEIM and FEIN curves shift upwards, leading to an increase in c. In the case of an increase in μ, analogous reasoning applies; this time only FEIM curve shifts up.

Substituting for c from (32) into either FEIN or FEIM and solving for w_{LN} yields:

$$w_{LN}(\iota,\mu;A_{\mu})=1+\frac{(\lambda-1)}{1+\lambda A_{R}(\iota,\mu)}, \qquad \mathbf{w_{LN}(\iota,\mu)} \qquad (33)$$

where $A_{R}\equiv\frac{A_{\iota}(1-\sigma_{\iota})s_{N}(\rho+2\iota+2\mu-n)}{A_{\mu}(1-\sigma_{\mu})s_{S}\eta_{s}(\rho+\iota-n)}$ and $\partial w_{LN}/\partial A_R < 0$.

Lemma 2: *The North-South wage gap as measured by w_{LN} is increasing in the relative profitability of innovation with respect to imitation.*

Observe that A_R captures the cost of innovation relative to imitation (adjusted for the relevant discount rate). Thus, any decline in A_R implies an increase in the profitability of innovation relative to imitation. This raises the returns to Northern labor (the factor exclusively used in innovation) relative to the returns to Southern labor (the factor exclusively used in imitation).

For future use, note that $\partial w_{LN}/\partial\mu < 0$, and $\partial w_{LN}/\partial\iota > 0$ if and only if $2\mu > \rho - n$. Intuitively, a lower μ reduces the imitation threat faced by Northern incumbents. This increases the rewards from innovation, creating room for w_{LN} to increase. On the other hand, a lower ι reduces the threat of replacement for both Northern and Southern producers, increasing the rewards for both innovation and imitation. For a sufficiently low discount rate, the rise in imitation profitability dominates the rise in innovation profitability, leading to a lower w_{LN}.

I can now plug in $n_N(\iota,\mu)$ and $n_S(\iota,\mu)$ from (24), $c(\iota,\mu)$ from (32) and $w_{LN}(\iota,\mu)$ from (33) into the general-purpose labor market conditions and obtain a system of two equations in two unknowns ι and μ. Let "*" stand for steady-state equilibrium values. Once ι^* and μ^* are determined c^*, w_{LN}^*, w_{HS}^*, w_{HN}^* can be obtained recursively using (27) through (33). Substituting D_ι from (9) into (20) using X_ι from (21), and noting the relationships implied by (24) and (32) yields the *Northern general- purpose labor market condition* solely in terms of ι and μ:

$$\frac{c(\iota,\mu;A_{\mu})(1+\eta_{S})}{\lambda}n_{N}(\iota,\mu)+A_{\iota}s_{N}\iota=1-s_{N}, \qquad \mathbf{LN}\ (\iota,\mu) \qquad (34)$$

Substituting D_μ from (12) into (22) using X_μ from (23), and noting the relationships implied by (24), (32) and (33) yields a *Southern general- purpose labor market condition* solely in terms of ι and μ:

$$\frac{c(\iota,\mu;A_\mu)[1+(1/\eta_S)]}{w_{LN}(\iota,\mu;A_\mu)}n_S(\iota,\mu)+A_\mu s_S\mu n_N(\iota,\mu)=1-s_S. \qquad \mathbf{LS}\ (\iota,\mu) \qquad (35)$$

Figure 2b illustrates the steady-state equilibrium with the intersection of the LN and LS curves.[25] The LN curve is upward sloping in (ι,μ) space. In the North, an increase in ι raises the labor demand coming from both manufacturing (by raising both c and n_N) and innovation activity (by its direct effect). Restoring equilibrium requires an increase in μ. This reduces n_N and at the same time increases c. The net impact on Northern labor demand turns out to be negative and thus equilibrium is reestablished.

The LS curve is downward sloping in (ι, μ) space. In the South, an increase in μ raises the labor demand coming from manufacturing (by raising both c and n_S). This is reinforced by the lower w_{LN}, which is triggered by the increase in μ. In addition, the higher μ directly increases the labor demand coming from aggregate imitative activity (by increasing μn_N). Thus, an excess demand for Southern labor emerges. Restoring equilibrium requires a fall in ι. This actually exerts multiple effects. First, a lower ι reduces the demand for manufacturing labor by reducing c. This is counteracted by the fall in w_{LN} (if and only if $2\mu > \rho - n$) and also the rise in n_S (both of which are indirectly triggered by the lower ι). Second, a lower ι reduces the labor demand coming from imitation (by reducing μn_N). The net impact works to reduce Southern labor demand if and only if $\mu > (\rho - n)[(1/\lambda)+(A_\iota s_N/A_\mu s_S\eta_S)]$. For illustrative purposes I will confine the analysis to this range for μ. Observe that as $(\rho - n)$ approaches zero, an assumption commonly invoked in the literature, the presumed inequality for μ holds. The main results depend neither on this condition nor $(\rho - n)$ converging to zero.

3.10. Comparative Steady-State Analysis

In this setting, stronger IPR protection in the South can materialize via three channels:[26] an increase in the unit labor requirement of imitative activity a_μ, a decrease in the unit labor requirement of imitation-deterring activity γ_μ, and an improvement in the effectiveness of imitation-deterring activity δ_μ.[27] Observe that these parameters enter the system of equations (27)-(35) exclusively via $A_\mu \equiv a_\mu\delta_\mu/n\gamma_\mu$ and that each specific adjustment stated above leads to an increase in A_μ.[28]

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[25] There exists a unique equilibrium under the following sufficient conditions: *i)* $(1 - s_N)(\lambda - 1) > A_\mu s_S\eta_S(1 - \sigma_\mu) + A_\iota s_N(1 - \sigma_\iota)$, *ii)* $(\rho - n)$ is sufficiently small [see Appendix A for details].

[26] An alternative channel is a reduction in the subsidy rate to imitators σ_μ. It is straightforward to show that the qualitative effects of a decline in σ_μ on ι, μ and w_{LN} are identical to those of an increase in A_μ.

[27] 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

Proposition 1: *A strengthening of IPR protection in the South captured by an increase in* A_μ

- *decreases the aggregate rate of imitation m, and the frequency of imitations per industry* μ*,*
- *decreases the aggregate rate of innovation* ι*,*
- *increases the wage of general-purpose labor in the North relative to that in the South* w_{LN}*,*
- *increases per capita consumption expenditure c,*
- *increases the fraction of Northern industries* n_N *and the wage of Northern specialized labor relative to Southern specialized labor* w_{HN}/w_{LN} *if and only if* $(\rho - n) < A_\iota \iota s_N \lambda(\iota + \mu) / [A_\mu \iota s_S \eta_S + A_\iota(\iota + \mu)]$.

To uncover the intuition, I first investigate the impact on $c(\iota,\mu)$ and $w_{LN}(\iota,\mu)$ holding ι and μ constant. A higher imitation resource requirement A_μ directly reduces the profitability of imitation. For a given w_{LN} this puts upward pressure on the level of c that maintains the zero-profit condition. Consequently, the FEIM curve shifts up to FEIM′ as illustrated in Figure 3a, and the levels of $c(\iota,\mu)$ and $w_{LN}(\iota,\mu)$ both increase.

I now investigate the shifts in the LN and LS curves. In the Northern labor market, the increase in c induced by the higher A_μ raises the demand for Northern manufacturing labor. This puts a crunch on Northern resources, and for a given μ restoring equilibrium entails a decline in the intensity of innovation ι. This works by reducing the levels of both manufacturing labor demand (through a fall in n_N and c) and innovation labor demand (through its direct effect). As a result the LN curve shifts down.

In the Southern labor market, the higher c induced by the higher A_μ raises the demand for manufacturing labor. At the same time, the higher w_{LN} again induced by the higher A_μ raises Northern production costs. This generates room for Southern producers to raise their prices, an effect which works to reduce manufacturing demand. Using (33) and (32) it can be easily shown that the net effect works to increase the aggregate labor demand coming from manufacturing (that is, c/w_{LN} increases). Finally, a higher A_μ directly increases the labor demand coming from imitative activity. To sum up, the demand for both manufacturing and imitation labor increase, creating a crunch on Southern resources. For a given ι, restoring equilibrium requires a fall in the intensity of imitative activity per industry μ. This reduces the levels of both manufacturing labor demand (through the combined impact on cn_S/w_{LN}) and imitation labor demand (through its direct effect). As a result the LS curve shifts to the left.

It follows clearly from Figure 3b that ι^* goes down. Using standard comparative statics techniques it can be shown that the leftward shift in LS dominates the rightward shift of in LN and thus

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activities, which refer to illegal, and in most cost cases, imperfect reproduction of brand name products, copyrighted materials and so forth.

[28] In the literature, the standard way of increasing IPR protection is via an increase in a_μ. The model shows that increased IPR protection driven by a change in a_μ generates the same qualitative effects as does increased IPR protection triggered by changes in the rent protection parameters γ_μ and δ_μ.

μ* also goes down.[29] Using (24) and $m \equiv \mu n_N$, I can express the aggregate rate of imitation as $m = [(1/\iota) + (1/\mu)]^{-1}$. With both ι and μ decreasing, m* also goes down. The impact on North-South industry configuration is ambiguous. The lower μ increases the fraction of Northern industries n_N, whereas the lower ι increases it. One can show that n_N* increases if and only if $(\rho - n) < A_\iota \iota s_N \lambda(\iota + \mu) / [A_\mu \iota s_S \eta_S + A_\iota(\iota + \mu)]$. This condition holds when $(\rho - n)$ converges to zero and is feasible within the structure of the model. If n_N and thus ι/μ indeed increase, then Northern incumbents increase their innovation-deterring efforts relative to their imitation-deterring efforts. It then follows from equation (26) that the North-South specialized wage w_{HN}/w_{HS} increases.

I can examine the changes in c* and w_{LN}* with the help of Figure 3a. I have already identified the upward shift from FEIM to FEIM′. At the same the decline in ι* and μ* induced by the higher A_μ exert indirect effects. More specifically, the lower levels of ι* and μ* reduce the replacement rate faced by both Northern and Southern producers. For a given w_{LN}, this puts downward pressure on the level of c that maintains the free-entry conditions. Hence, the FEIM and FEIN curves both shift down. These indirect shifts turn out to be of smaller magnitude and the equilibrium point unambiguously moves in a north-east direction; thus, both c* and w_{LN}* increase.

To gain further insight on the change in w_{LN}*, I utilize Lemma 2 and (33). Strengthening Southern IPR protection exerts three effects on the profitability of innovation *relative* to that of imitation. First, a larger A_μ directly raises imitation costs, increasing the relative profitability of innovation. Second, the lower μ* implies a decline in the threat of imitation faced by Northern producers, further increasing the relative profitability of innovation. Third, the fall in ι* implies a lower pace of creative destruction and raises the value of both Southern and Northern producers. The Southern producers' gain is larger relative to that of Northern producers if and only if $2\mu > \rho - n$. This condition holds when $\rho - n$ converges to zero and is feasible within the structure of the model. Hence, a lower ι* may indeed trigger an impact that works against the first two effects. Despite the indeterminacy coming from ι*, comparative statics exercises imply that the aggregate effect of A_μ is an *unambiguous* increase in the relative profitability of innovation and thus the North-South wage gap w_{LN} increases.

The most striking result in Proposition 1 arguably is the decline in the innovation rate. The preceding analysis, which proved this result by focusing on the resource effects, can be complemented by investigating the impact on the *absolute* profitability of innovation. Common sense suggests that when the South provides stronger IPR protection and the threat of imitation falls, Northern entrepreneurs should intensify their innovation efforts because successful innovators can now enjoy longer monopolistic tenures in product markets. However, Proposition 1 dictates otherwise. So what exactly happens to

[29] See Appendix D for technical details of Proposition 1.

Northern innovation incentives? To answer this question, I fully investigate the direct and indirect effects of an increase in A_μ on the FEIN condition, holding ι constant. First, the reduction in imitation exposure μ^* prolongs the duration of monopoly power for successful innovators, capturing the common sense effect. Second, the lower μ^* reduces the imitation-deterring expenditures of successful innovators, raising their stock market valuations [Recall that the additional $\iota + \mu$ term in the discount factor captures the impact of total rent protection costs on firm value]. Third, the higher c^* increases the profit flows of successful innovators. Clearly, these three forces raise the innovation incentives of Northern entrepreneurs. The only negative effect comes from the rise in the Northern relative wage w_{LN}, which increases both production and innovation costs. This negative wage effect dominates all three positive effects; consequently, the net profitability of innovation and hence the equilibrium rate of innovation ι^* decreases.[30]

Corollary 1: *A strengthening of Southern IPR protection reduces the innovation incentives of Northern firms and thus leads to a fall in the rate of innovation. The positive effects on R&D incentives (lower imitation exposure, lower imitation-deterring expenditures and higher product sales) are dominated by the negative effects (higher innovation and production costs due to increased Northern relative wage).*

With these findings, the present paper sides with the literature that emphasizes the negative effects of strengthening Southern IPR protection on innovation and imitation when both are endogenously determined [see Dinopoulos and Segerstrom (2005a), Glass and Saggi (2002), the *wide gap* case of Grossman and Helpman (1991b), and the *inefficient followers* regime of Grossman and Helpman (1991a)]. Nevertheless, my paper has a number of differentiating features. First, the paper establishes these 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 rising Northern relative wage in affecting innovation incentives. For instance, in Glass and Saggi's (2002, pp. 405-406) comparable quality-ladders based imitation model, strengthening Southern IPR protection leads to *a decline* in the Northern relative wage; thus, the negative effects on innovation profitability work through other channels. 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

[30] To see why the wage effect dominates from a different perspective, consider the model's general equilibrium structure. Stronger IPR protection induces manufacturing to move from the South to the North. In other words, holding ι constant, the expression $c(1 + \eta_S)\iota/(\iota + \mu)$ in the LN equation (34) increases. This leaves fewer resources for innovation, putting downward pressure on ι. At the same time, in general equilibrium, the zero profit condition in innovation FEIN (30) must hold. This implies that the competing forces on innovation profitability identified above should work to reduce the net discounted rewards from research, and hence ι goes down.

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.

Simultaneously with and *independently from* this paper, two papers have recently investigated the impact of IPRs in scale-free North-South growth settings. These papers have adopted different approaches to remove scale effects without incorporating rent protection activities. Dinopoulos and Segerstrom (2005a) eliminate the scale effects by assuming that product complexity increases with every innovation and therefore targeted innovation/imitation becomes more difficult over time [as in Li (2003) and Segerstrom (2006)]. They find that stronger IPR protection in the South temporarily reduces the innovation rate with no steady-state effect, permanently reduces the imitation rate, and permanently raises the North-South wage gap.[31] Parello (2005) eliminates the scale effects by assuming that innovation/imitation difficulty levels increase with cumulative research effort [as in Segerstrom (1998)]. He differentiates between skilled and unskilled labor, assigning skilled workers to innovation/imitation and unskilled workers to manufacturing. With regards to innovation and imitation, he finds the exact same results as Dinopoulos and Segerstrom (2005a). As for the wage effects, he finds that stronger IPRs increase the wages of both skilled and unskilled workers in the North relative to their Southern counterparts.

The findings of Dinopoulos and Segerstrom (2005a) and Parello (2005) are in line in with my findings. The major departure is that my model predicts a *permanent* decline in the innovation rate, whereas Dinopoulos and Segerstrom (2005a) and Parello (2005) find a *transitory* decrease in this measure. This difference in steady-state outcomes is due to the difference in the way scale effects are removed. The models of Dinopoulos and Segerstrom (2005a) and Parello (2005) imply "semi-endogenous growth" in the sense that the steady-state rate of growth is exclusively pinned down by the rate of population growth and the exogenous research difficulty parameter. However, my model implies "fully endogenous growth" in the sense that the steady-state growth rate is a function of the fraction of resources allocated to innovation, which is endogenously determined. Even though there is no consensus at the moment about which approach is empirically more relevant, recent work by Ha and Howitt (2006) and Zachariadis (2003, 2004) suggest that the predictions of the fully endogenous growth models are more consistent with time series data from advanced countries.[32]

[31] Grieben (2006) introduces labor market frictions into the setting of Dinopoulos and Segerstrom (2005) and finds that the effects of raising Southern IPR protection depends on the flexibility of Northern labor markets.
[32] See Ha and Howitt (2006) and the references therein for a thorough exposition on this debate. See Dinopoulos and Sener (2004) for a recent analysis of scale-free growth theory.

How robust is Proposition 1 to further modifications/extensions of the model? As discussed in Section 2, there may be situations in which Northern firms hire Northern specialized labor to perform imitation-deterring activities (through lobbying, campaign contributions and such). It can be analytically shown that the results in Proposition 1 still hold when Northern firms hire Northern labor instead of Southern labor for these activities. Another robustness check involves dropping the specialized/general purpose labor distinction and instead considering one type of labor that is mobile between activities. This could mitigate the strong negative effects of higher Northern wage on innovation profitability by allowing for substitution between rent-protection and innovation/manufacturing labor. The resulting model was substantially complex, and therefore I ran numerical simulations. I found that the results obtained in Proposition 1 still hold for a wide range of parameters (see Appendix C for details).

4. EXTENSION A: ENDOGENOUS FDI

How robust are the findings to inclusion of FDI as another channel of technology transfer? What are the effects of stronger IPR protection on multinational firm activity? To answer these questions, I incorporate endogenous FDI following closely Glass and Saggi (2002). I provide a sketch of the FDI model as most of the derivations are analogous to the imitation model.

4. 1. Product Cycle Dynamics with FDI

As before Northern entrepreneurs target their innovation efforts at all industries in the continuum. A successful Northern innovator starts production in the North and at the same engages in FDI to shift production to the low-cost South. Like innovation and imitation, FDI is modeled as a costly activity that involves uncertainty. Northern firms successful in their FDI efforts become Multinationals and shift their entire manufacturing facilities to the South. Southern entrepreneurs target their imitation efforts separately at both Northern and Multinational industries. In this setting, the continuum of industries is divided into four categories: Northern industries (*N-type*), Multinational industries (*F-type*), Southern industries that succeed Multinational producers (*SF-type)*, and Southern industries that succeed Northern producers (*SN-type)*. Let n_k represent the fraction of each industry type for $k = N, F, SN$ and SF.

4. 2. Product Markets

In *N-type* and *F-type* industries, the quality leaders compete with Southern followers who can produce the one-step-down quality product with a marginal cost of one. Hence, like Northern firms the Multinationals can establish monopoly power by charging the limit price $\lambda - \varepsilon$. The Multinational's marginal cost is α. Following Glass and Saggi (2002), I assume that $w_{LN} > \alpha > 1$, that is, Multinationals enjoy lower costs compared to the Northern firms but suffer a cost disadvantage relative to the their Southern counterparts. This reflects the additional costs incurred by Multinationals due to their operating in a non-familiar environment. Let $\pi_k(t)$ stand for the profit flow of a producer firm operating in industry k. The profit flows of a Northern producer and a Multinational from product sales can be stated as:

$$\pi_N{}^P = \frac{\lambda - w_{LN}}{\lambda} c(L_N + L_S) \text{ and } \pi_F{}^P = \frac{\lambda - \alpha}{\lambda} c(L_N + L_S) \quad (36)$$

In *SN* type industries where a Southern entrepreneur successfully imitates in Northern industry, the imitator can charge $w_{LN} - \varepsilon$ and drive the Northern firm out of the market. In *SF*-type industries where a Southern entrepreneur successfully imitates in a Multinational industry, the imitator can charge $\alpha - \varepsilon$ and force the Multinational out of the market. Hence, the profit flows of Southern producers in *SN* and *SF* type industries can be stated as:

$$\pi_{SN} = \frac{w_{LN} - 1}{w_{LN}} c(L_N + L_S) \text{ and } \pi_{SF} = \frac{\alpha - 1}{\alpha} c(L_N + L_S) \quad (37)$$

Since Southern entrepreneurs target both Northern and Multinational industries for imitation, *both* Northern and Multinational producers undertake innovation and imitation deterring activities. Innovation-deterring activities use Northern specialized labor, whereas imitation-deterring activities use Southern specialized labor. The flow of rent-protection costs for Northern and Multinational firms respectively can be stated as:

$$RPA_N = w_{HN}\gamma_\iota X_{\iota N} + w_{HS}\gamma_{\mu N}X_{\mu N} \quad \text{and} \quad RPA_F = w_{HN}\gamma_\iota X_{\iota F} + w_{HS}\gamma_{\mu F}X_{\mu F}, \quad (38)$$

where $\gamma_{\mu N}$ and $\gamma_{\mu F}$ represent the unit-labor requirements in imitation deterring for Northern firms and Multinationals; $X_{\iota N}$ and $X_{\mu N}$ stand for the levels of innovation and imitation deterring activities undertaken by Northern firms; $X_{\iota F}$ and $X_{\mu F}$ stand for the levels of innovation and imitation deterring activities undertaken by Multinationals.

4. 3 Technology of Innovation, Imitation and FDI

The instantaneous probability of innovation success by firm *j* targeting industry ω is given by $\iota_j = R_j/D_\iota$. The evolution of D_ι now responds to both Northern and Multinational innovation-deterring activity according to: $\dot{D}_\iota = n_N\delta_\iota X_{\iota N} + n_F\delta_\iota X_{\iota F}$. At the steady-state $\dot{D}_\iota / D_\iota = n$. This implies

$$D_\iota = \delta_\iota X_\iota / n, \quad (39)$$

where $X_\iota = X_{\iota N}n_N + X_{\iota F}n_F$. It the follows that the innovation rate in a typical industry is $\iota = \sum_j \iota_j = R/D_\iota$.

The instantaneous probability of imitation success by a Southern entrepreneur *j* targeting a *N-type* industry is given by $\mu_{jN} = M_{jN}/D_{\mu N}$, where $D_{\mu N}$ stands for the stock of imitation difficulty faced by the Southern entrepreneur. The evolution of $D_{\mu N}$ responds to imitation-deterring activities undertaken by Northern incumbents according to $\dot{D}_{\mu N} = n_N\delta_{\mu N}X_{\mu N}$, where $\delta_{\mu N} > 0$ is a constant efficiency parameter. At the steady-state $\dot{D}_{\mu N}/D_{\mu N} = n$. This implies

$$D_{\mu N} = \delta_{\mu N}X_{\mu N}n_N/n. \quad (40)$$

It follows that the imitation intensity targeting a typical Northern industry is $\mu_N = \sum_j \mu_{jN} = M_N/D_{\mu N}$.

The instantaneous probability of imitation success by a Southern entrepreneur j targeting a *F-type* industry is given by $\mu_{jF} = M_{jF}/D_{\mu F}$, where $D_{\mu F}$ stands for the stock of imitation difficulty faced by the Southern entrepreneur. The evolution of $D_{\mu F}$ responds to imitation-deterring activities undertaken by Multinationals according to: $\dot{D}_{\mu F} = n_F \delta_{\mu F} X_{\mu F}$, where $\delta_{\mu F} > 0$ is a constant efficiency parameter. At the steady-state $\dot{D}_{\mu F} / D_{\mu F} = n$. This implies

$$D_{\mu F} = \delta_{\mu F} X_{\mu F}\, n_F / n. \tag{41}$$

It follows that the imitation intensity targeting a typical Multinational industry is $\mu_F = \sum_j \mu_{jF} = M_F/D_{\mu F}$.

The instantaneous probability of FDI success by a Northern producer indexed by j is given by $\phi_j = F_j/D_\phi$, where D_ϕ stands for the level of technology transfer difficulty faced by the Northern firm. I assume that D_ϕ is proportional to the level of global sales of the Multinational firm:

$$D_\phi = cN/\lambda. \tag{42}$$

It follows that the Multinationalization rate for a typical Northern producer is $\phi = \sum_j \phi_j = F/D_\phi$.

4. 4. Optimal Innovation, Imitation and FDI Decisions

I denote with υ_k the stock market valuation of a producer firm in industry k. For Northern entrepreneurs free-entry in innovation implies:

$$\upsilon_N = w_{LN} a_\iota (1 - \sigma_\iota) D_\iota \tag{43}$$

For Southern entrepreneurs, free-entry in imitation targeting *N-type* and *F-type* industries implies:

$$\upsilon_{SN} = a_{\mu N}(1 - \sigma_\mu) D_{\mu N} \quad \text{and} \quad \upsilon_{SF} = a_{\mu F}(1 - \sigma_\mu) D_{\mu F}, \tag{44}$$

where $a_{\mu N}$ and $a_{\mu F}$ represent the relevant unit labor requirements in imitation.

To engage in technology transfer (FDI) to the South, Northern firms hire Southern general-purpose labor. The cost of conducting F_j units of FDI activity is given by $a_\phi F_j$ where a_ϕ is the unit labor requirement of FDI. A typical Northern entrepreneur indexed by j chooses the intensity of FDI to maximize the expected profits

$$(\upsilon_F - \upsilon_N)[F_j/D_\phi]\,dt - a_\phi F_j\,(1 - \sigma_\phi)(t)dt,$$

In equilibrium, a finite level of ϕ_j requires that the expected gains from engaging in technology transfer be driven down to zero. This implies:

$$(\upsilon_F - \upsilon_N) = a_\phi\,(1 - \sigma_\phi)\, D_\phi. \tag{45}$$

4. 5. Stock Markets

Each industry is targeted by Northern entrepreneurs with intensity ι. In addition, *N-type* industries are targeted by Southern entrepreneurs with intensity μ_N, and *F-type* industries are targeted by Southern entrepreneurs with intensity μ_F. Figure 4 illustrates the resulting product-cycle dynamics. It is straightforward to identify the replacement rate for each industry and obtain the stock market valuations at the steady-state equilibrium as:[33]

$$\upsilon_N = \frac{\pi_N - RPA_N}{\rho + \iota + \mu_N - n}, \tag{46a}$$

$$\upsilon_F = \frac{\pi_F - RPA_F}{\rho + \iota + \mu_F - n}, \tag{45b}$$

$$\upsilon_{SN} = \frac{\pi_{SN}}{\rho + \iota + - n}, \tag{45c}$$

$$\upsilon_{SF} = \frac{\pi_{SF}}{\rho + \iota - n}. \tag{45d}$$

4. 6. Optimal Rent Protection Activities

For Northern firms' innovation deterring activities $X_{\iota N}$, the first order condition (foc) is $-\upsilon_N d\iota = w_{HN}\gamma_\iota dX_{\iota N}$. Given $\iota = Rn/\delta_\iota X_\iota$ and $X_\iota = X_{\iota N}n_N + X_{\iota F}n_F$, it follows that $d\iota/dX_{\iota N} = -\iota n_N/X_\iota$. Substituting this into the foc gives:

$$\gamma_\iota w_{HN} X_\iota / n_N = \iota \upsilon_N. \tag{47}$$

For Northern firms' imitation-deterring activities $X_{\mu N}$, the foc is $-\upsilon_N d\mu_N = w_{HS}\gamma_{\mu N} dX_{\mu N}$. Given $\mu_N = M_N n/\delta_{\mu N} X_{\mu N} n_N$, it follows that $d\mu_N/dX_{\mu N} = -\mu_N/X_{\mu N}$. Substituting this into the foc above gives:

$$\gamma_{\mu N} w_{HS} X_{\mu N} = \mu_N \upsilon_N. \tag{48}$$

For Multinationals' innovation-deterring activities $X_{\iota F}$, the foc is $-\upsilon_F d\iota = w_{HN}\, \gamma_\iota\, dX_{\iota F}$. Given $\iota = Rn/\delta_\iota X_\iota$ and $X_\iota = X_{\iota N}n_N + X_{\iota F}n_F$, it follows that $d\iota/dX_{\iota F} = -\iota n_F/X_\iota$. Substituting this into the foc above gives:

$$\gamma_\iota w_{HN} X_\iota / n_F = \iota \upsilon_N \tag{49}$$

For Multinationals' imitation-deterring activities $X_{\mu F}$, the foc is $-\upsilon_F d\mu_F = w_{HS}\gamma_{\mu F} dX_{\mu F}$. Given $\mu_F = M_F n/\delta_{\mu F} X_{\mu F} n_F$, it follows that $d\mu_F/dX_{\mu F} = -\mu_F/X_{\mu F}$. Substituting this into the foc above gives:

$$\gamma_{\mu F} w_{HS} X_{\mu F} = \mu_F \upsilon_F. \tag{50}$$

4. 7. Labor Markets

The equilibrium condition for Northern general-purpose labor market is:

$$\frac{c(L_N + L_S)}{\lambda} n_N + a_\iota \iota D_\iota = (1 - s_N) L_N, \tag{51}$$

where the first term is the labor demand from manufacturing and the second tem is the labor demand from innovative activity. The equilibrium condition for Northern specialized labor is:

$$\gamma_\iota [n_N X_{\iota N} + n_F X_{\iota F}] = s_N L_N. \tag{52}$$

[33] Note that in 45(a), the numerator actually has $\phi_j(\upsilon_F - \upsilon_N) - \phi_j\, a_\phi\, (1 - \sigma_\phi)\, D_\phi(\omega, t)$ to capture the probability of transition to being a Multinational firm and the costs associated with multinationalization efforts. It follows from (44) that this expression equals zero.

where the LHS measures the labor demand coming from Northern and Multinational producers to conduct innovation-deterring activities.

The equilibrium condition for Southern general-purpose labor market is:

$$c(L_N + L_S)\left(\frac{n_{SN}}{w_{LN}} + \frac{n_{SF}}{\alpha} + \frac{n_F}{\lambda}\right) + a_{\mu N}\mu_N n_N D_{\mu N} + a_{\mu F}\mu_F n_F D_{\mu F} + a_\phi \phi n_N D_\phi = (1 - s_S)L_S. \tag{53}$$

The first term is the labor demand from manufacturing (Southern producers and Multinationals combined). The second and third terms measure the labor demand associated with imitative activity targeting *N-type* and *F-type* industries, respectively. The fourth term measures the labor demand associated with technology transfer efforts of Northern producers. The equilibrium condition for Southern specialized labor is:

$$\gamma_{\mu N}\, n_N X_{\mu N} + \gamma_{\mu F}\, n_F X_{\mu F} = s_S L_S. \tag{54}$$

where the LHS measures the labor demand coming from Northern and Multinational producers to conduct imitation-deterring activities.

Finally, at the steady-state, the flows in and out of each industry must exactly be balanced to generate constant industry shares. This implies for *N*, *F* and *SF* type industries, respectively:

$$\iota(n_F + n_{SF} + n_{SN}) = (\phi + \mu_N)n_N, \tag{55}$$

$$\phi n_N = n_F(\mu_F + \iota),$$

$$\mu_F n_F = \iota n_{SF},$$

$$n_{SF} + n_{SN} + n_N + n_F = 1,$$

where the last equation imposes the measure one restriction on the continuum of industries.

4. 8. Comparative Steady-State Analysis

The FDI model is sufficiently complicated to obtain analytical results thus I ran numerical simulations. I choose the following as benchmark parameters: [34]

$\lambda = 1.25$, $\alpha = 1.05$, $\rho = 0.07$, $n = 0.014$, $\eta_S = 2$, $s_S = 0.02$, $s_N = 0.04$,

$a_\iota = 0.9$, $a_{\mu N} = 16$, $a_{\mu F} = 8$, $a_\phi = 0.6$, $\gamma_\iota = 1$, $\gamma_{\mu N} = 8$, $\gamma_{\mu F} = 8$, $\delta_\iota = 1$, $\delta_{\mu N} = 1$, $\delta_{\mu F} = 2$.

I define the aggregate imitation rate as $m \equiv \mu_N n_N + \mu_F n_F$ and the aggregate FDI rate as $F \equiv \phi n_N$. The simulation results are shown in Table 2a. The findings imply that strengthening Southern IPR protection, in the form of a proportional increase in both $a_{\mu N}$ and $a_{\mu F}$, leads to a reduction of ι and m while raising

[34] See Appendix B for details on the choice of benchmark parameters and Appendix E for the software program used to run the simulations. For all numerical 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 simulation in which the levels of endogenous variables are consistent with empirical observations. Finally, I checked the robustness of the results by considering high and low values for all parameters.

w_{LN}. The threat of imitation separately faced by Multinationals and Northern firms, μ_N and μ_F respectively, decrease. Hence, the results in Proposition 1 are robust to the inclusion of FDI.

To investigate the effects on Multinational activity I focus on two indicators: the aggregate rate of FDI F and the fraction of Multinational industries n_F. The simulations imply that n_F increases despite a decline in F. This is because with both μ_F and ι falling, the decline in the outflow rate from n_F turns out to be larger than the decline in the inflow rate F. At the new equilibrium, the fraction of Northern industries n_N decreases; however the proportion of industries commanded by the North $n_N + n_F$ increases, which of course comes at the expense of aggregate Southern industries measured by $n_{SN} + n_{SF}$.[35]

One can uncover the intuition of the main results by focusing on the model's central relationships. To facilitate the exposition, I will henceforth assume that $a_\phi = 0$. This endogenizes ϕ through a simple indifference condition $\upsilon_N = \upsilon_F$ as implied by (45).[36] I begin by deriving expressions for $D_{\mu N}$ and $D_{\mu F}$. Using (48) and (50), I obtain $X_{\mu N} n_N \gamma_{\mu N} / X_{\mu F} n_F \gamma_{\mu F} = \mu_N / \mu_F$. Using this along with (40), (41) and (54), the stock of imitation difficulty faced by *N-type* and *F-type* targeting Southern entrepreneurs can be simplified to:

$$D_{\mu N} = \frac{\delta_{\mu N} s_S L_S}{\gamma_{\mu N} n} \frac{\mu_N}{\mu_F + \mu_N} \qquad \text{and} \qquad D_{\mu F} = \frac{\delta_{\mu F} s_S L_S}{\gamma_{\mu F} n} \frac{\mu_F}{\mu_F + \mu_N}. \tag{56}$$

where $\partial D_{\mu N}/\partial \mu_N > 0$ and $\partial D_{\mu F}/\partial \mu_F > 0$. As the intensity of *N-type* targeting imitation increases, Northern incumbents increase their corresponding imitation-deterring efforts, raising the stock of imitation difficulty for the Southern entrepreneurs. The same reasoning applies to *F-type* targeting imitation. Using (39) and (52), the stock of innovation difficulty can be simplified to:

$$D_\iota = \frac{\delta_\iota s_N L_N}{\gamma_\iota n}. \tag{57}$$

The next step is to work on the free-entry conditions. I substitute for $w_{HS}\gamma_{\mu N}$ from (48) into (46a) using (38) for RPA_N and solve for υ_N. Substituting this expression for υ_N and D_ι from (57) into (43) using (36) gives the *free-entry in innovation condition*:

$$\upsilon_N = \frac{[1-(w_{LN}/\lambda)]c(L_N + L_S) - w_{HN}\gamma_\iota X_{\iota N}}{\rho + \iota + 2\mu_N - n} = \frac{a_\iota \delta_\iota s_N L_N w_{LN}}{n\gamma_\iota} \tag{58}$$

I substitute υ_{SN} and υ_{SF} from (46c) and (46d) into (44) using $D_{\mu N}$ and $D_{\mu F}$ from (56). This gives *the free-entry in imitation conditions* for *N-type* targeting and *F-type* targeting entrepreneurs as:

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[35] It is straightforward to uncover the forces that govern the changes for each industry pool by focusing on the inflow and outflow rates, an exercise which I conducted only for n_F and left aside for the others due to space considerations.

[36] Simulations reveal that qualitative results are robust to setting $a_\phi = 0$. This indifference simplification is commonly used in the literature. See among others Glass (2004), Glass and Wu (2005) and Branstetter et al. (2005).

$$\upsilon_{SN} = \frac{[1-(1/w_{LN})]c(L_N + L_S)}{\rho + \iota - n} = \frac{a_{\mu N}\delta_{\mu N} s_S L_S}{n\gamma_{\mu N}} \frac{\mu_N}{(\mu_N + \mu_F)} \tag{59}$$

$$\upsilon_{SF} = \frac{[1-(1/\alpha)]c(L_N + L_S)}{\rho + \iota - n} = \frac{a_{\mu F}\delta_{\mu F} s_S L_S}{n\gamma_{\mu F}} \frac{\mu_F}{(\mu_N + \mu_F)}. \tag{60}$$

Taking the ratio of (58) to either (59) or (60) implies that the North-South relative wage w_{LN} is increasing in the profitability of innovation relative to imitation. Hence Lemma 2 prevails.

I can now examine the effects of strengthening Southern IPR protection. First, I focus on the changes in w_{LN}. An increase in imitation resource requirements $a_{\mu N}$ and $a_{\mu F}$ directly reduce the profitability of both types of imitation activities (*N-type* and *F-type* targeting). Simulations imply that these effects prevail in spite of general-equilibrium effects (coming from other endogenous variables c, ι, μ_N, μ_F, w_{HN} and $X_{\iota N}$). At the new equilibrium, the profitability of innovation relative to imitation increases and with it the North-South wage gap w_{LN}* (via Lemma 2).

Second, I focus on the changes in F and m. It follows from (53) that an increase in $a_{\mu N}$ and $a_{\mu F}$ leaves fewer Southern resources for all activities in the South. This puts downward pressure on F and m, as well as all manufacturing that takes place in the South. In particular, it is reasonable to expect a decline in the intensity of both imitation activities μ_N and μ_F. Simulations imply that this is indeed the case and that μ_N* and μ_F* both go down, with the decline in μ_F* being larger than the decline in μ_N* proportionally. To see this, take the ratio of *N-type* and *F-type* imitation targeting profitability conditions, (59) and (60). This yields:

$$\frac{[1-(1/w_{LN})]}{[1-(1/\alpha)]} = \frac{a_{\mu N} D_{\mu N}}{a_{\mu F} D_{\mu F}} \quad \Rightarrow \quad \frac{[1-(1/w_{LN})]}{[1-(1/\alpha)]} = \frac{a_{\mu N}\delta_{\mu N}\gamma_{\mu F}}{a_{\mu F}\delta_{\mu F}\gamma_{\mu N}} \frac{\mu_N}{\mu_F}. \tag{61}$$

Lemma 3: *It follows from (61) that* $dw_{LN} / d(\mu_N/\mu_F) > 0$*: the North-South wage gap widens as the* μ_N/μ_F *ratio increases.*

With $a_{\mu N}$ and $a_{\mu F}$ increasing in the same proportion, the direct effects of increased Southern IPRs protection on (61) are neutralized. Given $dw_{LN}^* > 0$, it then follows from Lemma 3 that $d(\mu_N/\mu_F)^* > 0$. Intuitively, a higher w_{LN}* increases Northern production costs, enabling the Southern producers in *SN-type* industries to raise their limit prices. As a result, the profitability of *N-type* targeting imitation relative to *F-type* targeting imitation increases. Restoring the free-entry conditions requires an increase in $D_{\mu N}/D_{\mu F}$, which in turn implies a higher $(\mu_N/\mu_F)^*$ ratio via (56). With both μ_N* and μ_F* falling, this materializes if and only if the proportional decline in μ_F* is larger than that in μ_N*.

Third, I examine the change in c* by focusing on the free-entry condition for *F-type* targeting Southern entrepreneurs (60). A higher $a_{\mu F}$ raises the costs of *F-type* targeting imitation, putting upward pressure on the level of c that maintains the zero profit condition. On the other hand, the higher $(\mu_N/\mu_F)^*$

works against this effect by diminishing the stock of imitation difficulty faced by *F-type* targeting entrepreneurs [see (56)]. In addition, a possible change in ι also distorts the expected rewards from innovation. Simulations imply that the net impact is a decline in the profitability of *F-type* targeting imitation, and thus c^* must increase to restore equilibrium.

I am now in a position to demonstrate the impact on ι^* by investigating the profitability of innovation using (58). The lower imitation exposure of successful innovators μ_N^* and the fall in imitation-deterring expenditures associated with it raise the rewards from innovation.[37] In addition, the fall in innovation-deterring expenditure $(w_{HN}\gamma_\iota X_{\iota N})^*$ (which is implied by the simulations) and the rise in c^* further increase the rewards from innovation. The only negative effect, as in the imitation-only model, comes from the higher w_{LN}^*, which increases both production and innovation costs. Simulations reveal that the net impact is a fall in the profitability of innovation. Thus ι^* falls, and the forces identified in Corollary 1 on Northern R&D incentives remain intact.

The findings with regards to m, F and ι are in line with Glass and Saggi (2002). However, my model differs on two other results. First, I find that strengthening Southern IPR protection increases Northern relative wage w_{LN}, whereas Glass and Saggi (2000) find that w_{LN} does not respond to Southern IPR parameters. The stark difference is due to presence of imitation-deterring activities. In Glass and Saggi, the stock of imitation difficulty is exogenously given. This implies that $D_{\mu N}/D_{\mu F}$ in equation (61) is a constant, and w_{LN} is pinned down solely in terms of α, and $a_{\mu N}/ a_{\mu F}$. In my model, $D_{\mu N}/D_{\mu F}$ is an increasing function of μ_N/μ_F through (56). Thus, there is an *endogenous* component of imitation costs that links w_{LN} to μ_N/μ_F (Lemma 3) and thereby to *all* of the parameters of the model. The increase in Northern relative wage plays a crucial role in reducing innovation profitability and hence the rate of innovation. In Glass and Saggi (2002) this wage channel is muted, and the decline in innovation profitability is due to a decline in consumption expenditure c.

Second, I find that strengthening Southern IPR protection increases the fraction of Multinational industries n_F, where as Glass and Saggi (2002) predict a decline in n_F. The difference can be attributed to the more flexible product-cycle dynamics in my model. In Glass and Saggi, no Multinational industry is targeted for innovation. Hence, the outflow from Multinational industries occurs only via Southern imitation targeting Multinationals. In my model, Northern entrepreneurs target their innovation efforts at all of the industries in the continuum. Technically speaking, the steady-state equation that maintains n_F constant $\phi n_N = n_F(\mu_F + \iota)$ has the additional outflow term $n_F\iota$. Thus, the outflow from the Multinational

[37] Recall that the additional μ_N term in the adjusted discount rate captures the impact of imitation-deterring expenditures on υ_N.

pool also occurs due to successful innovation. With ι^* falling, the forces that reduce the outflow rate are stronger in my model in comparison to those in Glass and Saggi (2002).

5. EXTENSION B: ENDOGENOUS FRAGMENTATION

I now assume that Multinationals can fragment the production process between the North and the South. Let β stand for the proportion of production shifted to the South *within* each Multinational firm. Multinationals optimally choose the level of β to maximize their market value. The rest of the structure remains as in the previous section. With marginal product of labor normalized to one in both the North and the South, the Multinational's marginal cost equals

$$MC_F = (1-\beta)w_{LN} + \alpha\beta. \qquad (62)$$

Substituting for MC_F from (62) into (46b) using (36) gives an expression for the value of the Multinational firm as:

$$\upsilon_F(\beta) = \frac{\frac{\lambda - [(1-\beta)w_{LN} + \alpha\beta)]}{\lambda} c(L_N + L_S) - RPA_F}{\rho + \iota + \mu_F - n} \qquad (63)$$

Observe that the higher the level of β, the larger the mark-up rate and hence υ_F. Therefore firms would want to have a higher β, but as firms increase their β targets, technology transfer should become progressively more difficult. To capture this I redefine the unit labor requirement in technology transfer as $a_\phi = a_\phi(\beta)$ and assume $a_\phi'(\beta) > 0$ and $a_\phi''(\beta) > 0$. [38]

A Northern producer engaged in technology transfer now chooses β and F_j to maximize

$$[\upsilon_F(\beta) - \upsilon_N](F_j/D_\phi)dt - a_\phi(\beta)F_j(1-\sigma_F)dt.$$

The first order condition for the choice of β implies:

$$\frac{\partial \upsilon_F(\beta)}{\partial \beta} = \frac{\partial a_\phi(\beta)}{\partial \beta} D_\phi(1-\sigma_F) = 0 \qquad (64)$$

Substituting for $\partial\upsilon_F/\partial\beta$ using (63) into (64), and using (42) for D_ϕ yields:

$$\frac{(w_{LN} - \alpha)}{(\rho + \iota + \mu_F - n)} = a_\phi'(\beta)(1-\sigma_F), \qquad (65)$$

where the left hand side measures the marginal rewards due to an incremental increase in fragmentation, and the right hand side measures the marginal costs. The optimal level β^* is illustrated in Figure 5. An increase in w_{LN}, or a decrease in either ι or μ_F shifts the marginal rewards curve up. Taking the results from the FDI model for granted, which predicts a higher w_{LN}, and lower levels of ι and μ_F, one can

[38] This fragmentation scheme follows Glass and Saggi (2001), Glass (2004), and Sayek and Sener (2006). However, these papers treat β as exogenous.

conjecture that a tightening of the Southern IPR regime will raise the equilibrium level of β by raising the rewards from fragmentation.

To test for this conjecture, I rewrite the whole model taking into account the endogenous determination of β and its implications for labor markets. The simulation results, which are reported in Table 2b, imply that the findings from the FDI model remain intact, and as conjectured, β^* increases.[39] Let $\chi \equiv \beta n_F$ represent the extent of Multinational production in the South. A stronger Southern IPR regime raises χ via two channels: the increase in n_F (the extensive margin) and the increase in β (the intensive margin). Moreover, the amount of labor employed by Multinationals for technology transfer purposes $FT \equiv a_\phi \phi n_N D_\phi$ and for manufacturing purposes $FL \equiv \beta c(N_N + N_S)n_F/\lambda$ both attain higher levels. Thus, the model predicts a clear increase in all forms of Multinational presence in the South. It should be noted that the measure of manufacturing industries *located* in the South $MANS \equiv n_{SF} + n_{SN} + \beta n_F$ increases despite a decrease in the measure of indigenous Southern manufacturing $n_{SF} + n_{SN}$. These results remain robust under a wide range of parameters. Comparing the results from Table 2a and 2b suggest that the changes in multinationalization indicators are much larger when β is endogenous.

These findings are consistent with the recent empirical evidence provided by Branstetter et al. (2005a, b). Using firm level data, they find that US multinationals respond to tightening of IPR regimes by increasing the scale of their foreign activities and accelerating the rate of technology transfer. More specifically, following IPR reform, the foreign affiliates whose parents make heavy use of patents experience a 20 percent expansion in sales, a 5 percent increase in employment, a 30 percent increase in licensing payments, and a 40 percent increase in R&D spending [see Branstetter et al. (2005b, section 6) for further details].[40] Furthermore, in the reforming countries, the number of exportables at the 10 digit level increases in the order of 14 to 18 percent, and the aggregate industrial output increases in the order of 11 to 14 percent. These results are consistent with the increase in χ, FL, FT, and $MANS$ as implied by the simulations.

To the best of my knowledge, my paper offers the first North-South product cycle model that captures this *within* industry FDI response that is at the heart of the empirical work of Branstetter et al. (2005a, b). Common sense suggests that the first order effect of increased IPR protection would be to reduce the imitation exposure of Multinationals and thereby raise the rewards from within-firm technology transfer. This is captured by the increased rewards from fragmentation induced by a lower μ_F in (65). In addition, I identify two other general-equilibrium mechanisms: the higher Northern relative

[39] See Appendix F for the details of the endogenous fragmentation model and the software program used to run the simulations. The simulation exercise again follows the methodology described in footnote 29.

[40] In their companion paper, Branstetter et al (2005a) focus more tightly on technology transfer indicators proxied by royalty payments, affiliate R&D spending and resident vs. non-resident patenting.

wage w_{LN} and the lower creative destruction rate ι, both of which work to increase the profitability of fragmentation and foster intra-firm production shifting. In addition, the simulations highlight the role of endogenous fragmentation in magnifying the response of multinationals to IPR reforms, a point which is missed by the existing literature as it relies on rigid fragmentation schemes.

6. 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 (2006) in a North-South setting, which can be a useful template to study further issues in two-country endogenous growth models.

I argue that a strengthening of IPR protection in the South reduces the equilibrium rates of *both* Northern innovation and Southern imitation, and widens the North-South wage gap. This result has clear policy implications, cautioning policy makers about the possible negative consequences of raising Southern IPR protection for global technological progress and wage income convergence. With regards to multinational activity, the model generates more optimistic results consistent with recent empirical evidence. I find that a stronger IPR regime in the South increases not only the proportion of multinational industries but also the fraction of production shifted to the South within each multinational firm—an effect which stems from explicit modeling of endogenous fragmentation.

Several extensions of the model still remain to be explored. For instance, one can incorporate Southern innovation into the model and study the global effects of increasing IPR protection. Alternatively, one can differentiate between imitation and pirating activities in the South and investigate the global effects of specific IPR policies. One can also distinguish between intra-firm production and subcontracting decisions of multinationals and incorporate contractual frictions along the lines of Antras (2004). In addition, a thorough welfare analysis in the presence of spillovers associated with multinational firms can be a fruitful direction for future research.

Table 1: Changes in IPR Protection

Country	GDP per capita in 1990 (constant 2000 dollars)	IPR Index 1990	IPR Index 1995	IPR Index 2000	Change in IPR 1990-2000%
Ethiopia	95	0.00	0.00	1.00	..
Mozambique	151	0.00	0.00	0.00	..
Chad	195	2.71	2.71	3.05	0.125
Bangladesh	268	1.99	2.32	2.66	0.337
Madagascar	281	1.86	2.27	2.94	0.581
Togo	310	2.24	2.57	2.90	0.295
India	316	1.48	1.51	2.18	0.473
China	364	..	1.55	2.48	0.600
Kenya	379	2.57	2.90	3.05	0.187
Senegal	428	2.57	2.57	2.90	0.128
Pakistan	461	1.99	1.99	1.99	0.000
Indonesia	557	0.33	1.24	2.27	5.879
Zimbabwe	602	2.90	2.90	3.24	0.117
Sri Lanka	604	3.12	3.12	3.60	0.154
Guyana	605	1.42	1.42	1.90	0.338
Nicaragua	739	0.92	0.92	1.59	0.728
Egypt	1240	1.99	1.99	2.46	0.236
Ecuador	1299	1.54	2.71	3.71	1.409
Thailand	1427	1.85	2.24	2.24	0.211
Guatemala	1473	1.08	1.08	1.70	0.574
Tunisia	1503	1.90	1.90	2.24	0.179
Jordan	1624	1.86	2.19	2.99	0.608
Peru	1669	1.02	2.71	2.71	1.657
Bulgaria	1724	..	2.57	3.24	0.261
Colombia	1869	1.12	2.57	3.24	1.893
Romania	1924	..	2.71	2.71	0.000
Botswana	2487	1.90	1.90	2.24	0.179
Turkey	2497	1.80	1.80	2.86	0.589
Russia	2602	..	3.04	3.52	0.158
Grenada	3043	1.70	1.70	2.41	0.418
Poland	3053	..	2.90	3.24	0.117
S. Africa	3058	3.57	3.57	4.05	0.134
Chile	3072	2.41	3.07	3.41	0.415
Brazil	3119	1.85	3.05	3.05	0.649
Hungary	4169	..	3.37	3.71	0.101
Mexico	4973	1.63	2.86	2.86	0.755
Venezuela	5027	1.35	2.90	2.90	1.148
Czech Rep.	5250	..	3.19	3.52	0.103
Argentina	5643	2.26	3.19	3.33	0.473
Korea	6618	3.94	4.20	4.20	0.066
Average	2012	1.84	2.34	2.88	0.559

Source: IPR indices are from Park and Wagh (2002); GDP per capita figures are from World Bank (2005). Notes: For China, Bulgaria, Romania, Russia, Poland, Hungary and Czech Republic, due to missing data, the change in the IPR index is reported as the the difference between the 2000 and 1995 figures. Average IPR index change in the last row is the percent difference between 2000 and 1990 averages.Ginarte and Park index contains five categories: i) Patentability across seven product categories, ii) Membership in international patent agreements, iii) Restrictions or limitations on the use of patent rights, iv) Enforcement mechanisms, v) duration of protection. See Ginarte and Park (1997) for details.

Table 2a. Simulation Results: FDI, Imitation, Exogenous Fragmentation β=1

		A 10 % rise in aμN and aμF	
	Benchmark	New Levels	Changes
ι	0.0245	0.0226	-0.0768
μN	0.0238	0.0225	-0.0551
μF	0.0123	0.0106	-0.1436
φ	0.0236	0.0213	-0.0977
nN	0.3404	0.3402	-0.0004
nF	0.2184	0.2187	0.0013
nSN	0.3312	0.3389	0.0232
nSF	0.1100	0.1022	-0.0711
F	0.0080	0.0073	-0.0980
m	0.0108	0.0100	-0.0772
wLN	1.1013	1.1130	0.0106
c	1.0981	1.1045	0.0058
β	1.0000	1.0000	0.0000
χ=βnF	0.2184	0.2187	0.0013
FT	0.0127	0.0115	-0.0928
FM	0.5756	0.5797	0.0071
MANS	0.6596	0.6598	0.0002

Table 2b. Simulation Results: FDI, Imitation, Endogenous Fragmentation

		A 10 % rise in aμN and aμF	
	Benchmark	New Levels	Changes
ι	0.0286	0.0272	-0.0505
μN	0.0312	0.0301	-0.0356
μF	0.0376	0.0329	-0.1252
φ	0.0653	0.0588	-0.0998
nN	0.2290	0.2344	0.0237
nF	0.2256	0.2292	0.0160
nSN	0.2492	0.2591	0.0398
nSF	0.2962	0.2772	-0.0639
F	0.0149	0.0138	-0.0784
m	0.0156	0.0146	-0.0662
wLN	1.0735	1.0840	0.0098
c	1.0673	1.0742	0.0064
β	0.4814	0.5165	0.0729
χ=βnF	0.1086	0.1184	0.0901
FT	0.0006	0.0009	0.4134
FM	0.2783	0.3053	0.0970
MANS	0.6540	0.6547	0.0011

Note: All changes are in percentage terms (e.g., a 10% rise in AμN and AμF decreases ι by 7.68% in Table 2a)

Figure 1: Product Cycle Dynamics with Imitation

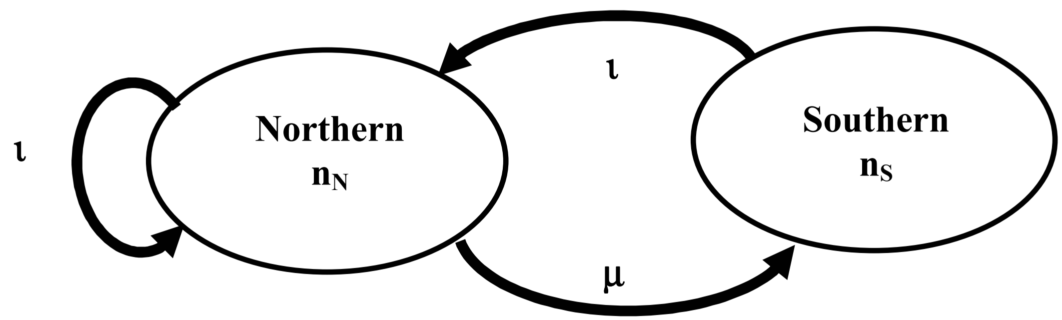


Figure 2a: The determination of $c(\iota,\mu)$ and $w_{LN}(\iota,\mu)$

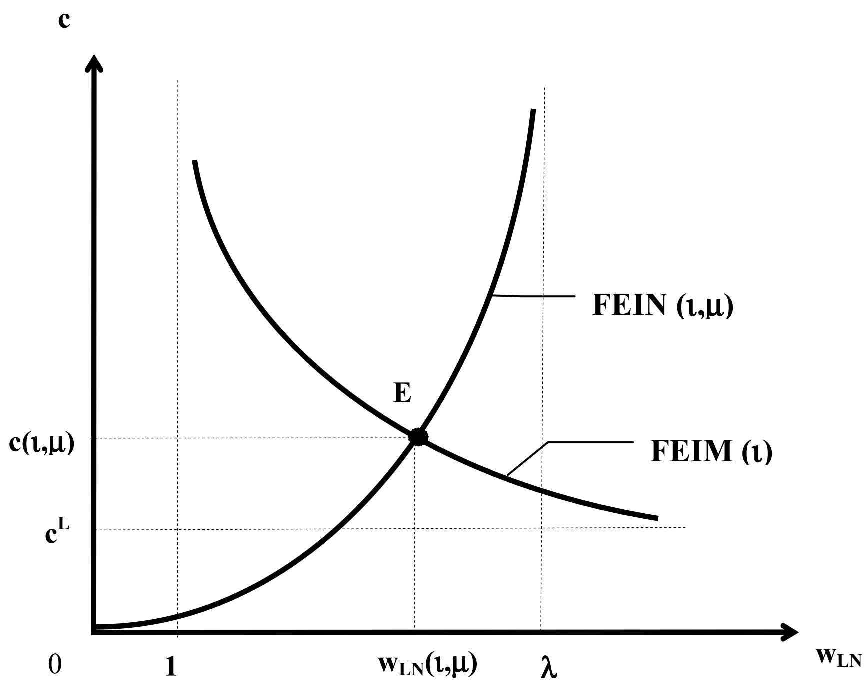


Figure 2b: The steady-state equilibrium

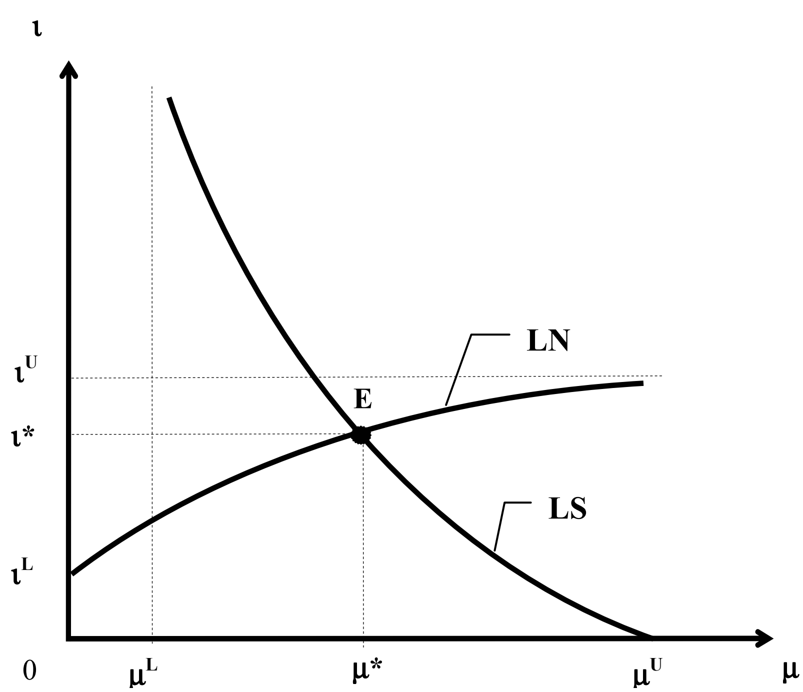


Figure 3a: Effects of Strengthening of Southern IPRs on $c(\iota,\mu)$ and $w_{LN}(\iota,\mu)$

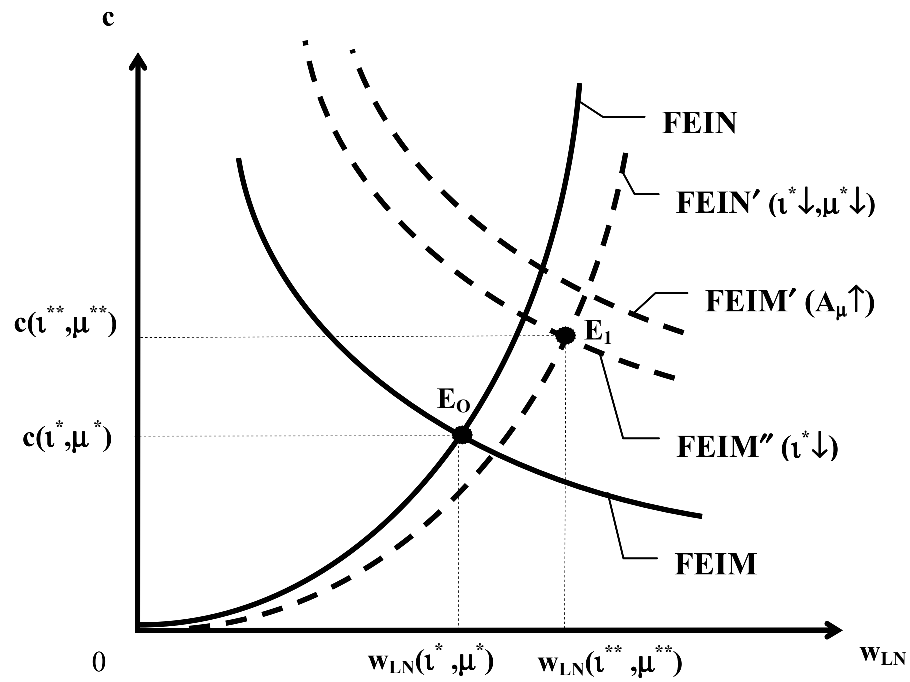


Figure 3b: Effects of Strengthening Southern IPRs on ι and μ

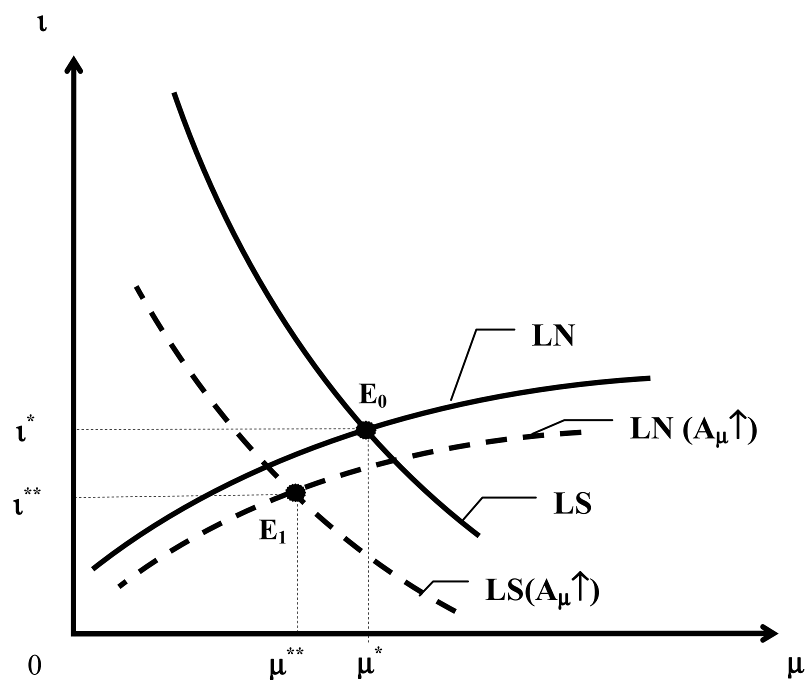


Figure 4: Product Cycle Dynamics with Imitation and FDI

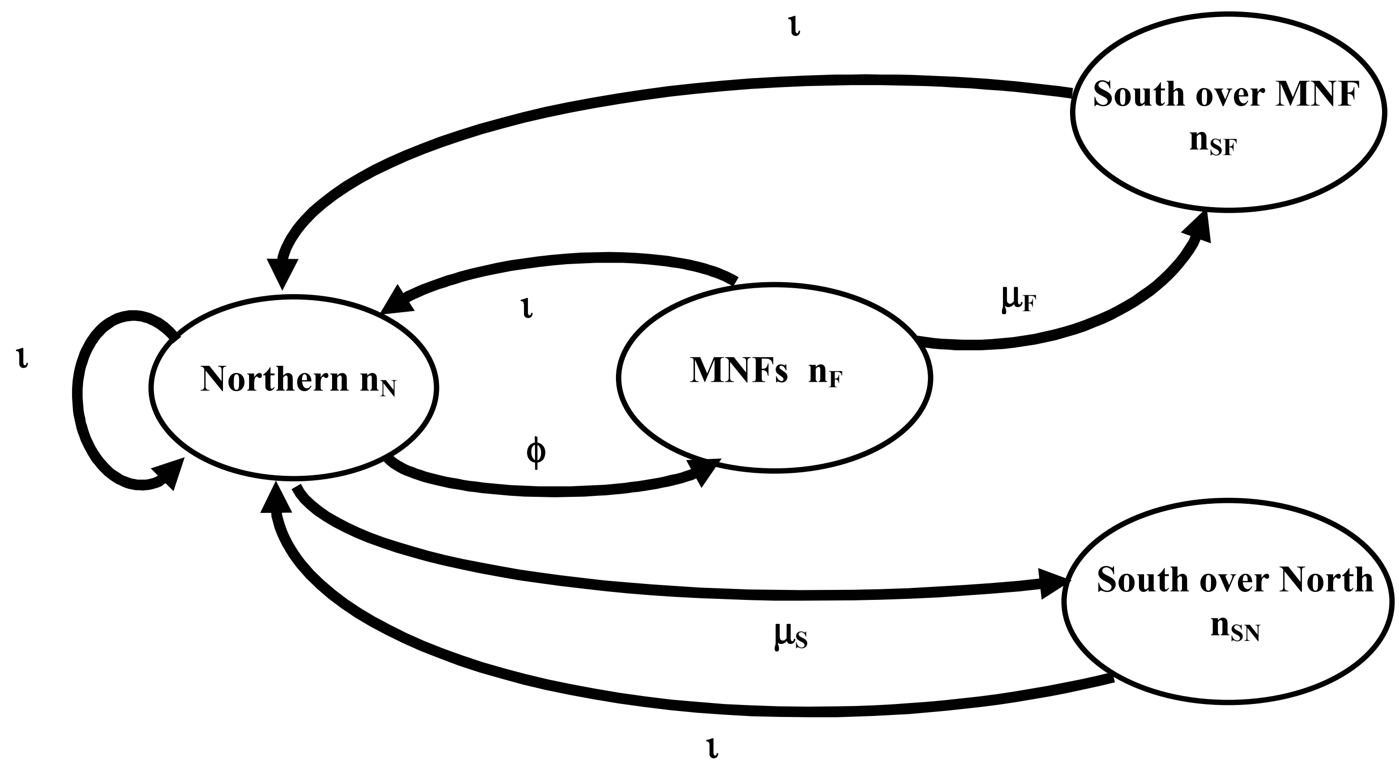
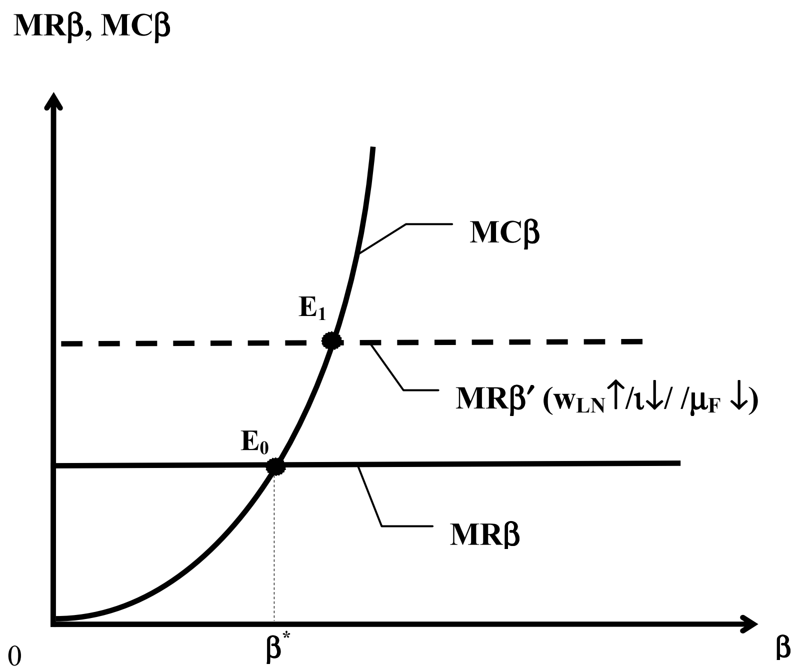


Figure 5: Endogenous Fragmentation



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