Foreign Direct Investment and Intellectual Property Protection in Developing Countries

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Abstract: This paper analyzes spillovers related to intellectual property rights (IPRs) in developing countries, and investigates how these spillovers influence the desirability of IPRs reform. I provide evidence that the IPRs policy of a developing country influences foreign direct investment (FDI) inflows into that country, as well as FDI flows into countries throughout the developing region. This finding suggests the presence of multilateral effects from IPRs reform that existing models cannot account for. I develop a general equilibrium international product cycle model that accommodates these effects, and find that the potential benefits of strengthened IPRs through unilateral reform spills over to all countries in the region, creating an incentive to maintain weak IPRs and free-ride on the IPRs of others. However, a reciprocal IPRs reform throughout the region, such as the TRIPS agreement required, prevents free-riding and improves welfare throughout the developing region. I argue that this analysis suggests a powerful justification of the TRIPS agreement as a harmonization of IPRs among developing countries, which successfully allows developing countries to achieve mutual benefit through collective reform, in a way that a unilateral reform can not.

Keywords: Intellectual Property Rights, Foreign Direct Investment, Developing Countries, TRIPS

JEL Classification: F23, O24, O34

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1 Introduction

In developed countries, intellectual property protection poses a familiar, and extensively analyzed, welfare trade-off. On one hand, protecting intellectual property incentivizes firms to undertake the substantial costs and risk associated with R&D investment and innovation. On the other, intellectual property rights (IPRs) grant monopoly power to the successful innovator, imposing substantial welfare costs on consumers. However, in developing countries with limited innovative capacity, the traditional incentives to protect intellectual property do not apply directly. Indeed, despite pressure from developed countries, developing countries have historically maintained weak IPRs in order to allow for imitation of foreign products, and avoid the monopoly pricing that strong IPRs entail. It was not until the trade related aspects of intellectual property rights (TRIPS) agreement, enacted by the GATT (WTO) in 1994, "require[d] Member countries to make patents available for any inventions, whether products or processes, in all fields of technology without discrimination,"[1] that many developing countries undertook substantial IPRs policy reform.

At the time, many economists argued that the TRIPS agreement benefited developed countries at the expense of the developing world. After all, developed countries hold the majority of existing intellectual property, and most already had comprehensive patent institutions in place prior to the TRIPS agreement (Park 2007). Chin and Grossman (1990) and Deardorff (1992) both concluded that strengthening IPRs in developing countries increases the market power of developed countries, and raises prices of technology intensive goods in the developing world. The TRIPS agreement received sharp criticism, optimized by Birdsall, Rodrik, and Subramanian (2005) declaring, "An international community that presides over TRIPS and similar agreements forfeits any claim to being development-friendly."

However, recent analyses utilizing general equilibrium international product cycle models, such as Branstetter & Saggi (2011) and Jakobsson & Segerstrom (2012), have emphasized the dynamic benefits of strengthened intellectual property protection in developing countries resulting from endogenously determined foreign direct investment (FDI) inflows. In these models, firms in developed countries internalize the risk of imitation when considering FDI in a developing country. By strengthening their IPRs, a developing country reduces this imitation risk, thereby stimulating FDI inflows and industrial development. In principle, these dynamic benefits can overcome the welfare losses resulting from reduced imitative activity, and higher prices. Moreover, empirical work, such as Lee and Mansfield (1996) and Branstetter, Fisman, Foley, & Saggi (2011), has indeed found that strengthened IPRs in developing countries are associated with increased FDI inflows, corroborating theoretical predictions.

However, while existing literature has provided theoretical and empirical rationale for a developing country to strengthen IPRs, it has not satisfactorily explained why an international IPRs agreement, such as TRIPS, is desirable. After all, developing countries have always been free to institute stronger IPRs. If it is indeed in their best interest to do so, an international IPRs agreement forcing this reform seems unnecessary. Some economists, such as McCalman (2001), have argued

[1] TRIPS agreement transcript. Article 27.1

that the TRIPS agreement, to a large extent, may have been designed to harmonize IPRs among developed and developing countries.[2] However, Grossman and Lai (2004) note "The arguments for harmonization are not always clear, but they seem to be based on a desire for global efficiency. Yet it is hardly obvious why efficiency should require identical policies in countries at different stages of economic development."

This paper seeks to fill this gap by emphasizing the presence of negative externalities associated with weak IPRs in developing countries. Using panel data on 46 developing countries, I show that FDI inflows into a developing country are associated not only with IPRs policy in that country, but are also influenced strongly by IPRs policy in neighboring countries throughout the developing region. In this way, the ability of a developing country to benefit from IPRs reform depends upon the IPRs policy of neighboring countries. Moreover, this regional dependency suggests that the additional FDI inflows generated from unilateral IPRs reform spills over to other countries in the region, creating an individual incentive for developing countries to maintain weak IPRs, and free-ride off of others' IPRs.

To analyze the implications of these spillovers, I develop a general equilibrium North-South product cycle model where innovation, FDI, and imitation are endogenous. Following Branstetter & Saggi (2011), innovation of a new differentiated product requires R&D investment, and is assumed to occur only in the developed North. Northern firms that have innovated successfully have the option to become a multinational corporation (MNC), and shift production to the South in order to utilize relatively cheap Southern labor. However, Southern firms can engage in costly imitation of an existing product, which allows the Southern firm to produce the product directly. I argue that the ability of a Southern firm to imitate a product depends on its proximity to the production process. The greater the distance between production and the imitating firm, the more difficult it is to attract labor familiar with the production process, and gain production knowledge. Northern firms, then, must weigh the increased operating profits of shifting production into the South against the increased risk of product imitation. IPRs policy in the South is assumed to affect the cost of product imitation. As Branstetter & Saggi (2011) concluded, strengthening IPRs reduces the rate of imitation, inducing increased MNC activity in the South.

To account for the multilateral effects of IPRs in developing countries, I extend existing product cycle models in two key ways. First, I consider the South not as a single, independent country, but as a developing *region* comprised of at least two countries. Importantly, Northern firms that have innovated successfully now endogenously decide both whether to become a MNC, and which Southern country to produce in. Second, I allow Southern firms to target Northern firms directly, MNCs in their home country, *and* MNCs in the other developing countries in the region for imitation. Reflecting the distance from the production process, while imitation of a MNC in a neighboring country is more costly than imitation of a domestic MNC, it is cheaper than direct imitation of a Northern firm.

Crucially, the threat of imitation facing a MNC is no longer determined solely by the IPRs

[2]McCalman ultimately concludes that such patent harmonization benefits most developed countries at the expense of developing countries

policy of a single developing country, but depends on the IPRs policy of all countries in the region. Hence, unlike existing models, my model can accommodate the negative externalities associated with weak IPRs in developing countries. I parametrize the model to capture both the observed increases in IPRs and FDI inflows in developing countries following the multilateral reform required by TRIPS agreement, as well as the relative ineffectiveness of unilateral reform implied by the empirical evidence I present in section 2. I use the parametrized model to examine the welfare implications of the multilateral IPRs reform of the TRIPS agreement, and contrast these findings with equivalent unilateral reform in an individual developing country.

I find that, under plausible conditions, the spillovers are sufficiently large so that unilateral IPRs reform *reduces* welfare in the reforming nation, while benefiting the free-riding neighboring countries. However, a *reciprocal* strengthening of IPRs policy among developing countries in the region, as TRIPS required, prevents free-riding and allows all developing countries to benefit from reform. These findings suggest that analyses ignoring these spillovers substantially overestimate the benefits of unilateral IPRs reform in developing countries. Moreover, I argue that they provide a powerful rebuttal to the criticisms levied against the TRIPS agreement; by harmonizing IPRs policy *among developing countries*, the TRIPS agreement successfully prevented free-riding, and allowed developing countries to benefit from IPRs reform through collective policy action.

The rest of the paper is organized as follows: Section 2 provides empirical evidence for the multilateral effects of IPRs reform. Section 3 develops the theoretical model. Section 4 discusses the parametrization of the model and presents the numerical results. Section 5 concludes.

2 Empirical Evidence

This section will empirically analyze the relationship between FDI inflows and IPRs policy in developing countries. First, I briefly review the effects of the large IPRs reforms required by the TRIPS agreement. Next, I investigate how FDI inflows into a country are influenced by both IPRs policy in that country itself, as well as IPRs policy in the broader developing region in the absence of an international IPRs agreement. To my knowledge, this paper is the first to empirically investigate the regional dependency of FDI inflows generated by spillovers associated with IPRs protection in developing countries.

2.1 FDI and the TRIPS Agreement

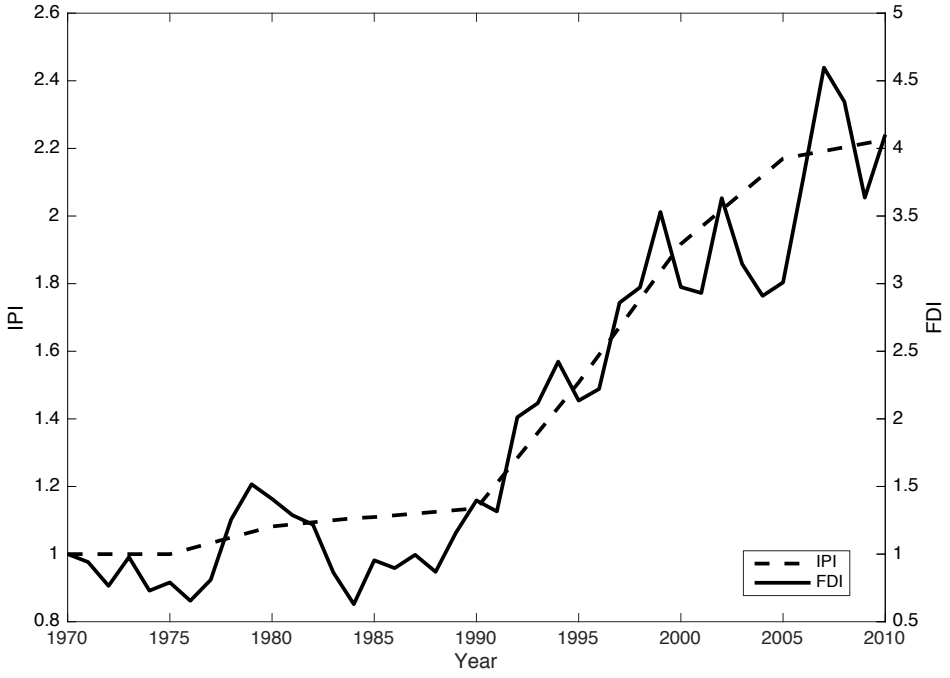
To analyze the relationship between FDI and IPRs in developing countries, this section uses a panel data set of 46 developing countries, listed in Table 6 in the appendix, over a 40 year period from 1970-2010. To measure FDI inflows, I use net FDI inflow volume (new investment less disinvestment) as a percentage of GDP (FDI). This variable captures FDI inflows, while controlling for differences in the economic size of the countries in the sample. Moreover, it matches the simulated FDI flows generated by the model developed in the following section.

To measure IPRs, this analysis uses a country specific intellectual property index (IPI) created

and maintained by Ginarte and Park (1997). The index considers five broad categories of patent protection: duration of patent protection, breadth of coverage, provisions for loss of patent protection, enforcement mechanisms, and membership in international patent agreements. Based on these five categories, intellectual property protection in each country is scored from zero to five. IPI values are updated quinquennially (every five years) beginning in 1970. I linearly interpolate IPI values between updates to maintain the annual structure of the panel.

Figure 1 plots the average FDI inflows and average IPI of the 46 developing countries from 1970-2010. These averages have been normalized to their 1970 value. Figure 1 illustrates both the substantial strengthening of IPRs in developing countries resulting from the TRIPS agreement, and the corresponding increase in FDI inflows into the developing world,

Figure 1: Average IPRs and FDI inflows



While the TRIPS agreement was instituted in 1994, developing countries were allowed a 5-year transition period to adhere to the required IPRs standards. Moreover, counties designated as "least developed countries" were granted extended transition periods.[3] Following Jakobsson & Segerstrom (2012), I consider a 1990 pre-TRIPS baseline, and a 2005 benchmark after developing countries have adjusted to the IPRs standards of the TRIPS agreement. Table 1 displays the summary statistics of IPI and FDI in the pre and post-TRIPS benchmarks of the countries used in the sample.

After adjustment to the TRIPS agreement, the average IPI in the sample increased by 90%, and average net FDI inflows increased by 115.7%. In addition, the normalized measure of dispersion of IPI, the coefficient of variation, fell by 46% illustrating the movement towards harmonization of IPRs in developing countries.

[3] 13 of the 46 countries in the sample are considered least developed countries.

Table 1: Summary Statistics: (1990, 2005)

Year	Variable	Mean	Median	Std. Dev.	Coef. Variation	Min	Max
1990	IPI	1.554	1.666	0.486	0.313	0.588	2.782
	FDI	1.390	0.806	2.366	1.701	-1.012	14.331
2005	IPI	2.953	2.892	0.642	0.214	1.659	4.475
	FDI	2.998	1.997	3.279	1.095	-2.498	14.197

2.2 Regression Analysis

In addition to IPI and net FDI inflow, I follow the literature on the determinants of FDI flows into developing countries, and include common explanatory variables in order to isolate the relationship between FDI and IPI. I include four primary control variables: First, in order to account for disparities in economics development across countries in the sample, I include the natural logarithm of real GDP per capita in 2005 U.S. dollars (lnGDPpc). To account for differing labor force sizes, I include the log of each country's population, in millions, (lnpop). I include a one year lag of the annual growth rate of real GDP (GDPg) to proxy the attractiveness of recent investment in the host country. I use a one-year lag to avoid endogeneity with contemporaneous FDI flows. Finally, I include the logged variance of the preceding 5 years of annual growth rate of real GDP to capture the recent economic volatility in each country (lnvol).[4,5]

In order to empirically test how FDI inflows into a country are influenced by the IPRs policy of other developing countries, for each country (i) in the sample, I will determine a "regional group" of neighboring countries. I define country (i)'s regional group as all countries that share a border with (i). Given this definition, for each country (i) in year (t), $\overline{\text{IPI}}_{-i,t}$ will denote the average value of IPI in country (i)'s contiguous neighbors, excluding country (i).

However, there is reason to believe that IPI_{it} & $\overline{\text{IPI}}_{-it}$ are significantly collinear, since they both, on average, have increased over time. The collinearity is particularly severe in the years following adjustment to the TRIPS agreement as many developing countries strengthened their IPRs sharply to meet the IPRs standards in TRIPS. While this is not a case of perfect multicollinearity, leading to a loss of identification, even with significant partial collinearity among regressors, inference may be unreliable. Furthermore, since our primary interest is estimating how FDI flows respond to differing levels of IPRs protection among developing countries *without* an international agreement in place, I present empirical estimates excluding years after 1999, when many of the countries in the sample were required to adhere to the standards in TRIPS. As the correlation tables in the appendix show, while IPI_{it} & $\overline{\text{IPI}}_{-it}$ are significantly correlated, there does appear to be a substantial amount of variation to exploit in the restricted sample. When the entire sample is considered, IPI_{it} & $\overline{\text{IPI}}_{-it}$

[4]Data collected from The World Bank's "World Development Indicators."

[5]Measures of international trade volume have been included in previous regressions, and have not changed the primary results. I have removed them due to endogeneity concerns. However, as I include measures of economic size and country fixed effects, which control for geographical location, I argue the major determinants of international trade volume are accounted for.

have a correlation of 0.775. In the post-TRIPS excluded sample, this correlation falls to 0.621.

Table 2 displays summary statistics for the variables used in this empirical analysis, pooled across the 1970-1999 sample.

Table 2: Summary Statistics: (1970-1999)

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
FDI	1153	1.536	0.763	2.858	-12.208	39.809
ln(GDPpc)	1153	6.572	6.486	1.085	4.054	10.181
ln(pop)	1153	16.260	16.078	1.461	13.475	20.949
GDPg	1153	3.496	3.965	5.648	-50.248	35.224
ln(vol)	1153	2.125	2.199	1.450	-2.974	6.729
IPI	1153	1.682	1.700	0.601	0.588	4.361
$\overline{\text{IPI}}$	1153	1.674	1.677	0.514	0.669	3.721

As a benchmark, I first evaluate the hypothesis that strengthened IPRs in country i are associated with increased FDI inflows into country i using the following regression specification:

$$FDI_{it} = \beta_0 + \beta_1 ln(GDPpc)_{it} + \beta_2 ln(pop)_{it} + \beta_3 GDPg_{it-1} + \beta_4 ln(vol)_{it} + \beta_5 IPI_{it} + \phi_i + \delta_t + \epsilon_{it} \quad (1)$$

The hypothesis that FDI inflows into country (i) correspond to, not only IPRs strength in country (i), but also IPRs strength in neighboring countries will be evaluated using:

$$FDI_{it} = \gamma_0 + \gamma_1 ln(GDPpc)_{it} + \gamma_2 ln(pop)_{it} + \gamma_3 GDPg_{it-1} + \gamma_4 ln(vol)_{it} + \gamma_5 IPI_{it} + \gamma_6 \overline{IPI}_{-it} + \psi_i + \lambda_t + u_{it} \quad (2)$$

I estimate three versions of the above regression specifications: First, I estimate pooled OLS. Next, I include country fixed effects to control for relevant, time-invariant characteristics (e.g. landlocked country). Finally, I include year dummy variables into the fixed effects regression to control for spurious correlation resulting from common time trends among variables. Throughout the analysis, heteroskedasticity robust standard errors, clustered at the country level, are used.

Notice that regression (2) allows for the separate estimation of the change in FDI inflows associated with a unilateral IPRs policy reform, and the equivalent multilateral reform by all countries in the developing region. That is, γ_5 represents the estimated marginal effect of unilateral IPRs policy reform on FDI inflows into country (i), holding neighboring policy constant, while $\gamma_5 + \gamma_6$ gives the estimated marginal effect when this IPRs policy reform is reciprocated by all countries in the region. I use the coefficient estimates of regression (2) to obtain bounds on the relative effectiveness, in terms of net FDI inflow, of unilateral versus reciprocated reform. That is, I estimate the statistic $\gamma_5/(\gamma_5 + \gamma_6)$ and use bootstrapped standard errors to derive a 95% confidence interval.

2.3 Empirical Results

Table 3 presents results for the three specifications of regressions (1) & (2) discussed above. Focusing first on the control variables in regression (1), we see that the coefficients on lagged growth in real GDP are all positive and statistically significant across all three specifications. While not

significant, the coefficients on volatility in annual GDP growth are negative, as expected. All else equal, this suggests that economic stability and growth are associated with increased FDI inflows. Without year controls, the coefficients on the log of real GDP per capita and logged population are not statistically significant. However, with the inclusion of year controls, both coefficient estimates become negative and significant, suggesting richer and more populous countries are associated with lower FDI inflow. Since, on average, both population and GDP per capita have been increasing over time along with FDI inflows, estimation without accounting for time trend is likely biased.

Table 3: Empirical Results

	Post-TRIPS Excluded (1970-1999)			Post-TRIPS Excluded (1970-1999)		
ln(GDPpc)	0.112	-0.463	-1.387**	0.084	-0.484	-1.462**
	(0.283)	(0.406)	(0.626)	(0.292)	(0.421)	(0.629)
ln(pop)	-0.230	-0.546	-9.318**	-0.321	-1.340	-8.504**
	(0.191)	(0.860)	(4.390)	(0.197)	(0.906)	(4.048)
GDPg	0.054**	0.050**	0.046**	0.053**	0.045**	0.045**
	(0.022)	(0.023)	(0.018)	(0.021)	(0.020)	(0.018)
ln(vol)	-0.076	-0.058	-0.115	-0.059	-0.055	-0.113
	(0.076)	(0.081)	(0.091)	(0.075)	(0.081)	(0.086)
IPI	1.782***	2.303***	1.988***	0.864***	1.288***	1.510***
	(0.236)	(0.346)	(0.426)	(0.270)	(0.284)	(0.368)
$\overline{\text{IPI}}$	–	–	–	1.354***	1.697**	1.487**
				(0.508)	(0.639)	(0.662)
Fixed Effects	No	Yes	Yes	No	Yes	Yes
Year Controls	No	No	Yes	No	No	Yes
N	1153	1153	1153	1153	1153	1153
R^2	0.142	0.149	0.206	0.161	0.174	0.219

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coefficients on the index of IPRs (β_5) are positive, statistically significant, and quantitatively substantial across all three specifications. At the pre-TRIPS baseline in 1990, the average IPI value among countries in the sample was 1.554, and average net FDI inflow was 1.391% of GDP. The results from the fixed effects regression with year controls included (column three) suggest that the observed 90% increase in IPI (1.399 index value) to the 2005 post-TRIPS average, is associated with a 191% increase in FDI (an additional inflow of 2.66% of GDP), holding all other variables constant.[6]

Turning our attention to the three specifications of regression (2), we see that the coefficients on logged GDP per capita, logged population, lagged growth in real GDP, volatility in growth of GDP

[6]While this estimates a larger increase in FDI inflow volume than the observed 115.7%, both GDP per capita and population in the developing countries grew over the 15 year period, putting downward pressure on FDI inflows.

remain very similar to the estimates from regression (1) in both magnitude and significance. Although the coefficient on IPI remains positive and significant, the estimates have fallen substantially in magnitude across all three specifications. That decrease, however, is more than compensated for by the coefficient on $\overline{\text{IPI}}$ (γ_6), which is positive and significant in all three specifications.

Table 4 presents the estimate of the relative effectiveness of unilateral versus reciprocated reform, $\gamma_5/(\gamma_5 + \gamma_6)$, using the third regression specification (with country fixed effects and year controls) and bootstrapped standard errors with 1000 replications.

Table 4: Relative Effectiveness of Unilateral vs. Reciprocated IPRs Reform

	Estimate	Standard Error	95% Confidence Interval
$\frac{\gamma_5}{\gamma_5 + \gamma_6}$	0.504	0.092	[0.323, 0.685]

The results suggest that unilateral IPRs reform is between 32.3% and 68.5% as effective at attracting FDI inflows compared to an equivalent, reciprocated reform. This finding provides evidence that the ability of a developing country to benefit from IPRs reform depends upon the IPRs policy of neighboring countries. Moreover, it implies that developing countries can free-ride on the IPRs policy of others, appropriating a substantial portion of the additional FDI inflows, without undertaking reform themselves.

In light of the strong correlation between IPI & $\overline{\text{IPI}}$, empirical analyses that ignore this regional dependency invite omitted variable bias, and likely overstate the effectiveness of unilateral IPRs policy reform substantially. Furthermore, existing international product cycle models considering one developing country cannot account for the multilateral effects of IPRs reform. In the following sections, I extend existing models to accommodate these multilateral effects, and highlight their welfare implications.

3 The Model

The international product cycle model developed in this paper builds upon Lai (1998), Branstetter & Saggi (2011), and Jakobsson & Segerstrom (2012). The model considers a continuous, infinite time horizon. There is one developed or Northern country (N), and $S \geq 2$ developing or Southern countries, constituting a developing region. For simplicity, all developing countries are ex ante identical.

3.1 Preferences

There are L_N homogeneous agents is the North, and L_i in the Southern countries ($i = 1, ..., S$),

each with identical instantaneous utility functions given by a standard CES aggregator:

$$U = \int_t^{\infty} e^{-\rho(\tau - t)} ln(D(\tau)) d\tau \tag{1}$$

$$D = \Big[\int_0^n x(k)^{\alpha} dk \Big]_{,}^{1/\alpha} \qquad 0 < \alpha < 1$$

Where $x(k)$ is consumption of variety k, and n is the total number of varieties available in the economy. Complete credit markets are assumed. Agents maximize (1) subject to the lifetime budget constraint:

$$\int_t^{\infty} e^{-r(\tau - t)} E(\tau) d\tau = \int_t^{\infty} e^{-r(\tau - t)} I(\tau) d\tau \tag{2}$$

Where $I(\tau)$ denotes instantaneous income, and $E(\tau)$ denotes instantaneous expenditure.

As is standard, optimization yields demand for each differentiated variety of:

$$x(k) = E \cdot \frac{p(k)^{-\epsilon}}{P^{1-\epsilon}}, \qquad \epsilon = \frac{1}{1-\alpha} > 1 \tag{3}$$

Here, time subscripts are dropped for convenience, and ϵ denotes the elasticity of substitution between any two differentiated products. P denotes the price index, which is defined as:

$$P = \Big[\int_0^n p(k)^{1-\epsilon} dk \Big]^{\frac{1}{1-\epsilon}} \tag{4}$$

Furthermore, the intertemporal expenditure rule is given by:

$$\frac{\dot{E}}{E} = r - \rho \tag{5}$$

Following Grossman and Helpman (1991b), I will normalize $E(t) = 1$ for all t, implying $r(t) = \rho$ in equilibrium.

3.2 Firms & The Product Cycle

Labor is the only factor of production, immobile across countries, and supplied inelastically. At any point in time, a Northern firm may enter the market by innovating a new differentiated variety, with certainty, by employing the requisite amount of labor in R&D at the Northern wage rate, w_N. Define the endogenous rate of innovation in the North by:

$$g = \frac{\dot{n}}{n} \tag{6}$$

The labor requirement for innovation is given by:

$$\frac{a_N g^\beta}{n} \tag{7}$$

Where, $a_N > 0$ is an exogenously given productivity parameter, and n denotes the number of products available in the global economy. As in Lai (1998), the labor requirement of innovation is decreasing in n. Since n is equivalent to the number of successful innovations in the North, this assumption captures the positive spillovers generated from past innovations, and the "stock" of production knowledge in the North. As in Jakobsson & Segerstrom (2012), the g^β term with $\beta > 0$, imposes diminishing returns to simultaneous R&D investment at the industry level, and is intended to capture duplicative R&D investment.

After innovation, I assume one unit of Northern labor can produce one unit of any differentiated variety. Therefore, Northern firms exhibit increasing returns to scale with innovation cost c_N and total cost C_N given by:

$$c_N = w_N \frac{a_N g^\beta}{n}, \qquad C_N(x) = w_N \frac{a_N g^\beta}{n} + w_N x \tag{8}$$

Upon successful innovation, a Northern firm *may choose* to set up a multinational corporation (MNC) in any Southern country $i \in S$. A MNC is owned by agents in the North, but uses Southern labor for production at the corresponding wage w_i. Following Branstetter & Saggi (2011), I assume no additional fixed cost to establishing a MNC in either developing country. However, a MNC must employ $\theta > 1$ units of Southern labor to produce one unit of any differentiated product. This assumption is designed to capture the relative unfamiliarity of a MNC with a foreign labor force, and foreign production environment. Therefore, the marginal cost of production of a MNC in a Southern country i is equal to θw_i.

Southern firms cannot innovate new product varieties directly. Instead, Southern firms may imitate an existing product variety that is produced by a Northern firm, or a MNC in *any* Southern country by employing the requisite amount of labor in imitative R&D. Define the endogenous rates of imitation from firms in each country i by:[7]

$$\mu_{ii} = \frac{\dot{n}_{ii}}{n_{Mi}}, \qquad \mu_{iN} = \frac{\dot{n}_{iN}}{n_N}, \qquad \mu_{ij} = \frac{\dot{n}_{ij}}{n_{Mj}} \quad \forall\ j \in S_{-i} \tag{9}$$

Where n_N and n_{Mi} denote the number of varieties produced by Northern firms, and MNCs in country i respectively. The fixed R&D costs associated with each of the possible channels of imitation for firms in country i are given by:

$$c_{ii} = w_i \cdot \frac{a_{ii}{\mu_{ii}}^\beta}{n_{Mi}}, \quad c_{iN} = w_i \cdot \frac{a_{iN}{\mu_{iN}}^\beta}{n_N}, \quad c_{ij} = w_i \cdot \frac{a_{ij}{\mu_{ij}}^\beta}{n_{Mj}} \quad \forall\ j \in S_{-i} \tag{10}$$

Analogous to (7), all imitative efforts suffer from diminishing returns at the industry level. Fur-

[7] For imitated products, read the subscripts as (location of production, location of target).

thermore, all imitation costs are decreasing in the number of products available to *target*. Intuitively, the fewer products available for imitation, the more duplicative imitative efforts become, and successful imitation of a product becomes more costly. I model the relative difficulty of the channels of imitation available to a Southern firm as a function of the proximity to the production process:

$$a_{iN} = \gamma_N a_{ii}, \quad a_{ij} = \gamma_S a_{ii} \quad \forall\ j \in S_{-i} \tag{11}$$

$$\text{Where} \qquad \gamma_N > \gamma_S > 1$$

For simplicity, I consider only two distinct distances: the distance between developing countries within the developing region, captured by γ_S, and the distance between the developing region and the North, captured by γ_N. Crucially, the base labor requirement is highest for imitation of a Northern firm, next highest for imitation of a neighboring MNC, and lowest for imitation of a domestic MNC. The IPRs policy of the Southern countries enters the model through the parameters dictating the cost of imitating a product of a domestic MNC, a_{ii}. A strengthening of IPRs in country i makes all imitation more costly by increasing a_{ii}, and therefore, a_{iN} and all a_{ij}'s proportionately. That is, when a developing country strengthens IPRs, all channels of imitation become more costly, but remain possible.

In total, production of differentiated varieties can shift from the North into a developing country through imitation of a Northern firm, or through non-imitative technology transfer via MNCs. The rate at which Northern firms voluntarily shift production to MNCs in the South will be interpreted as the rate of FDI. Define the gross and net FDI rates in each developing country i respectively by:

$$\psi_i = \frac{\dot{n}_{Mi} + \sum_{j=1}^{S} \dot{n}_{ji}}{n_N}, \qquad \phi_i = \frac{\dot{n}_{Mi}}{n_N}, \quad \forall\ i \in S \tag{12}$$

Since the production of all varieties imitated from MNCs was originally transferred to a Southern country voluntarily, the gross FDI rate, ψ, must incorporate the flow of production transfer from MNCs whose products are imitated by Southern firms. However, since this includes the flow of products out of a country through imitation from firms in neighboring developing countries, I focus primarily on the rate of net FDI, ϕ.[8] In the appendix, Figure 3 presents an illustration of the product cycle for the case of a developing region (S) comprised of two countries, i and j.

3.3 Prices and Present Value of Firms

Before a variety has been imitated, the Northern firm, or associated MNC, has monopoly power over that good. Given the form of demand (3), the profit maximizing price of a monopoly firm is a

[8]The gross and net FDI rates are related according to $\psi_i = \phi_i(1 + \sum_{j=1}^{S} \frac{\mu_{ji}}{g})$.

constant mark-up over marginal cost of $\frac{1}{\alpha}$:

$$p_N = \frac{w_N}{\alpha}, \qquad p_{Mi} = \frac{\theta w_i}{\alpha} \tag{13}$$

After a product has been successfully imitated by a Southern firm, I assume that one unit of Southern labor can produce one unit of that product, and that the Southern firm enters into competition with the original producer of the product. Since I do not consider quality differences among producers, the firm offering the lowest price for a particular product will capture that product's entire market share.[9] Given that all imitating Southern firms in country i have an unconstrained monopoly price of $\frac{w_i}{\alpha}$, the firm's profit maximizing price will be the highest price in the interval $[0, \frac{w_i}{\alpha}]$ that is less than or equal to the marginal cost of its competitor. For simplicity, I assume the original producer ceases production rather than producing at zero variable profit with price equal to marginal cost.

In what follows I restrict attention to the case of:

$$\theta w_i \leq \frac{w_i}{\alpha}, \quad \theta w_j \leq \frac{w_i}{\alpha}, \quad w_N \geq \frac{w_i}{\alpha}, \quad \forall\ i, j \in S \tag{14}$$

Equivalently,

$$\theta\alpha \leq 1, \quad \theta\alpha \leq \frac{w_i}{w_j}, \quad \frac{1}{\alpha} \leq \frac{w_N}{w_i}, \quad \forall\ i, j \in S$$

The above restrictions ensure that the marginal cost of a MNC producing in any Southern country is lower than the unconstrained monopoly price of a Southern firm. In contrast, the marginal cost of a Northern firm (w_N) is larger than the unconstrained monopoly price of a Southern firm.[10] Thus, the optimal prices of all Southern firms in country i are given by:

$$p_{ii} = \theta w_i, \quad p_{ij} = \theta w_j, \quad p_{iN} = \frac{w_i}{\alpha}, \quad \forall\ j \in S_{-i} \tag{15}$$

Using the demand equation (3), relative demand for any two products is given by:

$$\frac{x(k)}{x(h)} = \left[\frac{p_k}{p_h}\right]^{-\epsilon} \tag{16}$$

Using the pricing equations (13) & (15), we can derive the relative demand of varieties within all product categories: Those in fixed proportion,

$$\frac{x_{ii}}{x_{Mi}} = \alpha^{-\epsilon}, \qquad \frac{x_{ij}}{x_{jj}} = 1, \qquad \frac{x_{ii}}{x_{iN}} = [\theta\alpha]^{-\epsilon}_{,} \quad \forall\ i, j \in S \tag{17}$$

and those that depend upon relative wages across countries,

[9] This assumes a Southern country can export an imitated product back to the North despite patent protection in the North, reflecting the substantial market for "knock-offs".

[10] For ex ante identical Southern countries, the relative wage restriction among developing countries is met easily. For realistic values of α, the final restriction is also natural when comparing wage rates between developed and developing economies. For the parameterization used for the numerical results, these restrictions do not bind.

$$\frac{x_{ij}}{x_{Mi}} = \left[\frac{\alpha w_j}{w_i}\right]^{-\epsilon}, \qquad \frac{x_{ij}}{x_{ii}} = \left[\frac{w_j}{w_i}\right]^{-\epsilon}, \quad \forall\ i,j \in S \tag{18}$$

$$\frac{x_{Mi}}{x_N} = \left[\frac{\theta w_i}{w_N}\right]^{-\epsilon}, \qquad \frac{x_N}{x_{ii}} = \left[\frac{w_N}{\theta\alpha w_i}\right]^{-\epsilon}, \quad \forall\ i \in S \tag{19}$$

Using marginal cost, and the pricing equations, flow, or instantaneous variable profits of all firm types, denoted by π, can be written as:

$$\pi_N = (p_N - w_N)x_N = \frac{(1-\alpha)w_N}{\alpha}x_N \tag{20}$$

$$\pi_{Mi} = (p_{Mi} - \theta w_i)x_{Mi} = \frac{(1-\alpha)\theta w_i}{\alpha}x_{Mi} \tag{21}$$

Similarly, for imitating Southern firms in country i:

$$\pi_{ii} = (p_{ii} - w_i)x_{ii} = (\theta - 1)w_i x_{ii} \tag{22}$$

$$\pi_{iN} = (p_{iN} - wi)x_{iN} = \frac{(1-\alpha)w_i x_{iN}}{\alpha} \tag{23}$$

$$\pi_{ij} = (p_{ij} - w_i)x_{ij} = (\theta w_j - w_i)x_{ij}, \quad \forall\ j \in S_{-i} \tag{24}$$

Since all Southern firms that have successfully imitated a product do not face the threat of imitation, their present discounted value (PV) is given by:

$$V_{ii} = \frac{\pi_{ii}}{\rho + g}, \quad V_{iN} = \frac{\pi_{iN}}{\rho + g}, \quad V_{ij} = \frac{\pi_{ij}}{\rho + g}, \quad \forall\ j \in S_{-i} \tag{25}$$

Where ρ is the continuous time discount factor as in (1), and g is the rate of product innovation. Intuitively, the PV of all firms decreases in the rate of innovation since each new differentiated product reduces the market share of existing firms.

Since Northern firms and MNCs in each Southern country i face the risk of imitation, and imitation eliminates all future profits of a firm, their expected PV is given by:

$$V_N = \frac{\pi_N}{\rho + g + \sum_{i=1}^{S} \mu_{iN}}, \quad V_{Mi} = \frac{\pi_{Mi}}{\rho + g + \mu_{ii} + \sum_{j=1}^{S_{-i}} \mu_{ji}} \tag{26}$$

Where the total imitation rate facing a firm, given by the sum of country specific imitation rates targeting that firm type, enters in the denominator of the firm's expected PV. For a MNC producing in country i, it is convenient to decompose the total imitation rate into imitation from firms in country i itself, μ_{ii}, and the sum of imitation rates from all other developing countries in the

region, $\sum_{j=1}^{S_{-i}} \mu_{ji}$.

3.4 Equilibrium Conditions

Following Branstetter & Saggi (2011), I study a balanced growth equilibrium in which all product categories grow at the same, constant rate g:

$$g = \frac{\dot{n}}{n} = \frac{\dot{n}_N}{n_N} = \frac{\dot{n}_{Mi}}{n_{Mi}} = \frac{\dot{n}_{ii}}{n_{ii}} = \frac{\dot{n}_{iN}}{n_{iN}} = \frac{\dot{n}_{ij}}{n_{ij}} \quad \forall\ i, j \in S \tag{27}$$

The total number of products in the global economy n can be divided into distinct product categories: goods produced in the North (n_N), those produced by MNCs in the Southern countries (n_{Mi}), products imitated from Northern firms (n_{iN}), products imitated from a MNC producing in the same country as the imitating firm (n_{ii}), and finally products imitated from a MNC producing in a neighboring Southern country (n_{ij}). In terms of production location,

$$n = n_N + \sum_{i=1}^{S} n_i \tag{28}$$

$$\text{Where} \qquad n_i = n_{Mi} + n_{iN} + n_{ii} + \sum_{j=1}^{S_{-i}} n_{ij}$$

Using this balanced growth condition, and the definitions of the endogenous rates of innovation, FDI, and imitation (6), (9), & (10), we can display the relative size of all product categories, which will be constant in equilibrium:

$$\frac{n_{Mi}}{n_N} = \frac{\phi_i}{g}, \qquad \frac{n_{ii}}{n_{Mi}} = \frac{\mu_{ii}}{g}, \qquad \frac{n_{ij}}{n_{Mj}} = \frac{\mu_{ij}}{g}, \qquad \frac{n_{iN}}{n_N} = \frac{\mu_{iN}}{g} \quad \forall\ i, j \in S \tag{29}$$

and the relative share of total production across countries:

$$\frac{n_i}{n_N} = \frac{g\phi_i + g\mu_{iN} + \phi_i\mu_{ii} + \sum_{j=1}^{S_{-i}} \phi_j\mu_{ij}}{g^2}, \qquad \frac{n_j}{n_i} = \frac{g\phi_j + \phi_j\mu_{jj} + \sum_{i=1}^{S_{-j}} \phi_j\mu_{ij}}{g\phi_i + \phi_i\mu_{ii} + \sum_{j=1}^{S_{-i}} \phi_j\mu_{ij}} \tag{30}$$

Since a Northern firm may choose to become a MNC in any Southern country with no additional fixed cost, in equilibrium, we must have:

$$V_N = V_{Mi} \quad \forall\ i \in S \tag{31}$$

Using (26), condition (31) delivers:

$$\frac{\pi_{Mi}}{\pi_N} = \frac{\rho + g + \mu_{ii} + \sum_{j=1}^{S_{-i}} \mu_{ji}}{\rho + g + \sum_{i=1}^{S} \mu_{iN}}, \qquad \frac{\pi_{Mj}}{\pi_{Mi}} = \frac{\rho + g + \mu_{jj} + \sum_{i=1}^{S_{-j}} \mu_{ij}}{\rho + g + \mu_{ii} + \sum_{j=1}^{S_{-i}} \mu_{ji}}, \qquad \forall\ i, j \in S$$

Substituting in for flow profits (20) and (21), we have:

$$\frac{\pi_{Mi}}{\pi_N} = \left[\frac{\theta w_i}{w_N}\right]^{1-\epsilon} \quad \Rightarrow \quad \frac{w_N}{w_i} = \theta \left[\frac{\rho + g + \mu_{ii} + \sum_{j=1}^{S_{-i}} \mu_{ji}}{\rho + g + \sum_{i=1}^{S} \mu_{iN}}\right]^{\frac{1}{\epsilon-1}} \tag{32}$$

Since $\frac{w_i}{w_j} = \frac{w_N}{w_j}\frac{w_i}{w_N}$, from (32):

$$\frac{w_i}{w_j} = \left[\frac{\rho + g + \mu_{jj} + \sum_{i=1}^{S_{-j}} \mu_{ij}}{\rho + g + \mu_{ii} + \sum_{j=1}^{S_{-i}} \mu_{ji}}\right]^{\frac{1}{\epsilon-1}}, \qquad \forall\ i, j \in S \tag{33}$$

Focusing on (32), we see that the Northern wage relative to the wage in country i is determined by the relative imitation threat facing MNCs in country i and Northern firms. Condition (31) requires that, in order for a Northern firm to shift production into country i, it must be sufficiently compensated for the additional imitation risk it takes on. This compensation takes the form of a lower wage rate, and thus marginal cost, for MNCs in country i. When the total imitation rate of MNCs in i is too high, FDI rates into country i will fall, lowering labor demand in country i and reducing w_i until condition (31) obtains. In other words, attracting FDI inflows is critical to maintaining a healthy relative wage in Southern countries.

Crucially, the IPRs policy in country i, through a_{ii} and therefore μ_{ii}, can only dictate a fraction of the total imitation facing MNCs in country i. This insight highlights the main argument of this paper; even if an individual Southern country's government wishes to use IPRs policy to attract FDI, *the policy's effectiveness depends on the IPRs policy of the neighboring Southern countries.*[11] Furthermore, by strengthening IPRs, county i *reduces* the imitation threat in all neighboring countries through all μ_{ij}'s. In other words, some of the potential benefits of country i's IPRs reform, namely FDI inflows, spills over to other developing countries in the region. Thus, the FDI inflows into a particular Southern country depend on both the IPRs policy of that country, *and* the IPRs policy of the neighboring Southern countries.

Finally, via (33), note that the relative wage of the Southern countries is controlled by the rela-

[11] All else equal, this dependency becomes more severe as the number of developing countries in the region (S) grows, since the proportion of the total imitation rate facing MNCs that is controlled by IPRs policy in that country declines.

tive attractiveness, and hence, relative levels, of FDI in the two countries. Since the countries are ex ante identical, if both countries institute the same IPRs policy, their imitation rates equalize, and their relative wage collapses to one.

3.4.2 Free entry and Labor Market Clearing

In order to solve the model, we need to derive the equilibrium conditions that pin down the endogenous rates of innovation, FDI, and imitation that determine the balanced growth equilibrium (g, ϕ_i, μ_{ii}, μ_{iN}, μ_{ij}).[12]

Free entry into innovation and all channels of imitation is assumed. That is, in equilibrium, the fixed cost of innovation and imitation must exactly offset the PV of profits:

$$c_N = V_N, \quad c_{ii} = V_{ii}, \quad c_{iN} = V_{iN}, \quad c_{ij} = V_{ij}, \quad \forall\ i,j \in S \tag{34}$$

Rearranging (8) and (11), we obtain expressions for wages in terms of innovation and imitation costs:

$$\frac{w_N}{w_i} = \frac{n}{n_{Mi}}\frac{c_N}{c_{ii}}\frac{a_{ii}}{a_N}\Big[\frac{\mu_{ii}}{g}\Big]^{\beta}_{,} \qquad \forall\ i \in S \tag{35}$$

$$\frac{w_i}{w_j} = \frac{c_{ii}}{c_{ji}}\frac{a_{ji}}{a_{ii}}\Big[\frac{\mu_{ji}}{\mu_{ii}}\Big]^{\beta}_{,} \qquad \forall\ i,j \in S \tag{36}$$

$$1 = \frac{n_{Mi}}{n_N}\frac{c_{ii}}{c_{iN}}\frac{a_{iN}}{a_{ii}}\Big[\frac{\mu_{iN}}{\mu_{ii}}\Big]^{\beta}_{,} \qquad \forall\ i \in S \tag{37}$$

Using free entry to substitute expressions for PV of profits (25) & (26), again for flow profits (20)-(24) and relative demands (17)-(19) we obtain from (35):

$$1 = \frac{(1-\alpha)\theta^{\epsilon}\alpha^{\epsilon-1}(\rho+g)}{(\theta-1)(\rho+g+\mu_{iN}+\sum_{j=1}^{S_{-i}}\mu_{jN})}\frac{n}{n_{Mi}}\frac{a_{ii}}{a_N}\Big[\frac{w_N}{w_i}\Big]^{-\epsilon}\Big[\frac{\mu_{ii}}{g}\Big]^{\beta}_{,} \quad \forall\ i \in S \tag{38}$$

Similarly, (36) becomes:

$$1 = \frac{a_{ii}}{a_{ji}}\frac{\big(\theta(\frac{w_i}{w_j})-1\big)}{(\theta-1)}\Big[\frac{\mu_{ii}}{\mu_{ji}}\Big]^{\beta}_{,} \quad \forall\ i,j \in S \tag{39}$$

Upon substituting for relative product sizes and relative wages, equation (38) provides a total of S equilibrium conditions, and (39) provides $S(S-1)$ equilibrium conditions resulting from free entry. Equation (37) provides analytical solutions for rates of imitation targeting Northern firms in terms of the rate of innovation, FDI, and imitation of domestic MNCs, resulting in the following S equilibrium conditions:

$$\mu_{iN} = \Big[\frac{(1-\alpha)(\alpha\theta)^{\epsilon}}{\gamma_N\alpha(\theta-1)}\frac{g}{\phi_i}\Big]^{\frac{1}{\beta}}\mu_{ii} \qquad \forall\ i \in S \tag{40}$$

[12]For $S \geq 2$ Southern countries, there are $1+3S+S(S-1)$ unknown, endogenous growth rates.

The final $S+1$ equilibrium conditions come from labor market clearing (LMC) conditions in the North (N), and the S developing countries. Since labor in the North is used for innovation and production, the Northern LMC condition is given by:

$$L_N = \frac{a_N g^\beta}{n}\dot{n} + n_N x_N \tag{41}$$

Using the free entry into innovation condition, we obtain an expression for x_N:

$$\frac{w_N a_N g^\beta}{n} = \frac{(1-\alpha)w_N}{\alpha(\rho + g + \sum_{i=1}^{S}\mu_{iN})}x_N \Rightarrow x_N = \frac{a_N g^\beta \alpha(\rho + g + \sum_{i=1}^{S}\mu_{iN})}{n(1-\alpha)}$$

Plugging into (41), we have:

$$L_N = a_N g^{1+\beta} + \frac{n_N}{n}\frac{a_N \alpha g^\beta(\rho + g + \sum_{i=1}^{S}\mu_{iN})}{(1-\alpha)} \tag{42}$$

Labor in Southern countries is used for imitation, production of varieties owned by MNCs, and production of successfully imitated varieties. The LMCs for each country i is given by:

$$L_i = \sum_{j=1}^{S}\frac{a_{ij}{\mu_{ij}}^\beta}{n_{Mj}}\dot{n}_{ij} + \frac{a_{iN}{\mu_{iN}}^\beta}{n_N}\dot{n}_{iN} + \theta n_{Mi}x_{Mi} + \sum_{j=1}^{S} n_{ij}x_{ij} + n_{iN}x_{iN} \tag{43}$$

Once again using free entry conditions to derive expressions for product demands, we obtain:

$$L_i = \sum_{j=1}^{S} a_{ij} g {\mu_{ij}}^\beta \frac{n_{ij}}{n_{Mj}} + a_{iN} g {\mu_{iN}}^\beta \frac{n_{iN}}{n_N} + \theta\frac{\alpha^\epsilon a_{ii}(\rho+g)}{\theta-1}{\mu_{ii}}^\beta + \sum_{j=1}^{S}\frac{n_{ij}}{n_{Mj}}\frac{a_{ij}(\rho+g)}{\left[\theta\left[\frac{w_j}{w_i}\right]-1\right]}{\mu_{ij}}^\beta + \frac{n_{iN}}{n_N}\frac{\alpha(\rho+g)a_{iN}{\mu_{iN}}^\beta}{(1-\alpha)} \tag{44}$$

Upon substituting for relative product sizes and relative wages, (42) and (44) provide equilibrium conditions resulting from labor market clearing in the North, and the S developing countries. Taken together, (38), (39),(40), (42), and (44) provide the requisite $1+3S+S(S-1)$ equilibrium conditions to solve the model.

3.5 Equilibrium Price Index and Welfare

Rewriting the price index given by (4), common across countries, we obtain:[13]

$$P^{1-\epsilon} = n_N p_N^{1-\epsilon} + \sum_{i=1}^{S} n_{Mi} p_{Mi}^{1-\epsilon} + \sum_{i=1}^{S}\sum_{j=1}^{S} n_{ij} p_{ij}^{1-\epsilon} + \sum_{i=1}^{S} n_{iN} p_{iN}^{1-\epsilon} \tag{45}$$

[13] With the addition of iceberg trade costs, we have country specific price indices. Trade costs have been omitted for simplicity.

Multiplying through by $\frac{n}{n}$ yields:

$$P = \Big[\frac{n_N}{n}p_N^{1-\epsilon} + \sum_{i=1}^{S}\frac{n_{Mi}}{n}p_{Mi}^{1-\epsilon} + \sum_{i=1}^{S}\sum_{j=1}^{S}\frac{n_{ij}}{n}p_{ij}^{1-\epsilon} + \sum_{i=1}^{S}\frac{n_{iN}}{n}p_{iN}^{1-\epsilon}\Big]^{\frac{1}{1-\epsilon}} n^{\frac{1}{1-\epsilon}}$$

By substituting in for all prices, and dividing by wages, we obtain an expression for the real wage, or purchasing power, of the North and each Southern country, which will be used as measure of welfare.

$$\frac{w_N}{P} = \Big[\frac{n_N}{n}\Big(\frac{1}{\alpha}\Big)^{1-\epsilon} + \sum_{i=1}^{S}\frac{n_{Mi}}{n}\Big(\frac{\theta w_i}{\alpha w_N}\Big)^{1-\epsilon} + \sum_{i=1}^{S}\sum_{j=1}^{S}\frac{n_{ij}}{n}\Big(\frac{\theta w_j}{w_N}\Big)^{1-\epsilon} + \sum_{i=1}^{S}\frac{n_{iN}}{n}\Big(\frac{w_i}{\alpha w_N}\Big)^{1-\epsilon}\Big]^{\frac{1}{\epsilon-1}} n^{\frac{1}{\epsilon-1}} \tag{46}$$

$$\frac{w_i}{P} = \Big[\frac{n_N}{n}\Big(\frac{w_N}{\alpha w_i}\Big)^{1-\epsilon} + \sum_{j=1}^{S}\frac{n_{Mj}}{n}\Big(\frac{\theta w_j}{\alpha w_i}\Big)^{1-\epsilon} + \sum_{k=1}^{S}\sum_{j=1}^{S}\frac{n_{kj}}{n}\Big(\frac{\theta w_j}{w_i}\Big)^{1-\epsilon} + \sum_{j=1}^{S}\frac{n_{jN}}{n}\Big(\frac{w_j}{\alpha w_i}\Big)^{1-\epsilon}\Big]^{\frac{1}{\epsilon-1}} n^{\frac{1}{\epsilon-1}} \tag{47}$$

Note that the bracketed term is constant in equilibrium, while n grows at the rate of innovation, g. In this way, we can decompose our welfare analysis into the short and long run. In the short run, production allocation and the price mix determine each country's purchasing power. However, in the long run, the rate of innovation is the dominant determinant of welfare.

Importantly, in terms of long run welfare, the incentives in the developing countries are aligned. Each Southern country has an incentive to encourage Northern firms to shift production out of the North, freeing up labor for innovation, and increasing g. To improve short run welfare, the developing countries compete to bring production to their country (both through FDI and imitation). However, as mentioned above, the ability of a Southern country to attract FDI through IPRs policy depends crucially on the IPRs policy of its neighbors. As the numerical results below illustrate, a unilateral increase in IPRs by a Southern country cannot efficiently accomplish both welfare goals.

4 Numerical Results

The following provides a numerical solution to the model for the case of two developing countries (i & j), together constituting the developing region ($S = 2$).[14] The model is parametrized to match both the observed strengthening of IPRs and increases in FDI inflows in developing countries following the multilateral reform required by the TRIPS agreement, as well as capture the relative ineffectiveness of unilateral reform estimated in Section 2. I use the parametrized model to highlight the welfare implications of the multilateral effects of IPRs reform in developing countries.

[14] With $S = 2$, there are 9 unknown growth rates which characterize the balanced growth equilibrium. Figure 3 in the appendix illustrates the product cycle in the $S = 2$ case.

4.1 Parametrization

The following parameters are used to solve the model numerically, and produce net FDI inflows consistent with the empirical evidence: $\rho = 0.03$, $\alpha = 0.5$, $\theta = 1.25$, $\beta = 1$, $L_N = 1$, $L_i = L_j = 2$, $\gamma_S = 2$, $\gamma_N = 15$, $a_N = 35$, $a_{ii} = 20$ in 1990, and 38 in 2005.

The continuous time discount factor, ρ, is set to 0.03 to reflect a risk-free real return of 3%. The parameter dictating the degree of product differentiation, α, is set to 0.5 to yield a monopoly markup over marginal cost of 100%. The value of $\theta = 1.25$ implies a MNC requires 25% more Southern labor hours compared to equivalent production in the North. The diminishing returns parameter, β, is set to 1, which matches the value used in Jakobsson & Segerstrom (2012).

The remaining parameters dictate the populations, and labor requirements for innovation and imitation in the three countries. As in Jakobsson & Segerstrom (2012), the relative populations between countries is all that matters for the results. I normalize the population in the Northern country to 1, and set the population in the each Southern country to 2. The distance parameters, γ_S and γ_N, are set to 2 and 15 respectively. This implies that, compared to imitation of a product produced by a MNC in a Southern firm's own country, imitation of a neighboring MNC requires twice the base labor input, and imitation of a Northern firm requires 15 times the base labor input.[15] Finally, the innovation productivity parameter $a_N = 35$, while the base labor required for imitation, our measure of IPRs strength, is set to 20 in 1990 and increases by the observed average of 90% after the implementation of the TRIPS agreement to 38 in 2005.

4.2 Equilibrium Results

On the following page, Table 5 displays the equilibrium of the model under three scenarios: Column 1 presents the equilibrium for the pre-TRIPS agreement 1990 baseline. Column 2 presents the post-TRIPS 2005 equilibrium, in which both developing countries have strengthened their IPRs by 90%. Finally, column 3 explores the equilibrium in which country i undertakes unilateral IPRs reform to the standard of the TRIPS agreement, while country j maintains IPRs at their pre-TRIPS level.

First comparing columns 1 to 2, we see that the reciprocal IPRs reform required by the TRIPS agreement has benefited both developing countries. With imitation now more costly, the IPRs reform lowers all rates of imitation from the developing countries, and the total imitation rate targeting MNCs in each country ($\mu_{ii} + \mu_{ji}$ and $\mu_{jj} + \mu_{ij}$ respectively) falls by 25.7%. In response to lower imitation rates, Northern firms increase the rate of multinational activity (FDI) in both developing countries. As a result, the equilibrium ϕ's both increase by the 115.7%, matching the observed increases in net FDI inflows following the TRIPS agreement.

However, the IPRs reform is not without cost. To a degree, both countries sacrifice their ability to imitate Northern firms directly, and the rates of imitation of Northern firms falls by 63.4% in

[15] Recall that, given the assumption stated in (14), the returns to imitation of a Northern firm is larger than imitation of a variety produced by a MNC.

Table 5: Numerical Results

	Baseline	Reciprocal Reform	Unilateral Reform
	$a_{ii} = 20$ $a_{jj} = 20$	$a_{ii} = 38$ $a_{jj} = 38$	$a_{ii} = 38$ $a_{jj} = 20$
g	0.1374	0.1465	0.1417
ϕ_i	0.0585	0.1262	0.1010
ϕ_j	0.0585	0.1262	0.0671
μ_{ii}	0.0870	0.0646	0.0690
μ_{ij}	0.0435	0.0323	0.0260
μ_{iN}	0.0213	0.0078	0.0101
μ_{jj}	0.0870	0.0646	0.0789
μ_{ji}	0.0435	0.0323	0.0498
μ_{jN}	0.0213	0.0078	0.0174
$\frac{w_i}{w_j}$	1.0000	1.0000	0.9520
Real w_i	0.4796	0.4875	0.4743
Real w_j	0.4796	0.4875	0.4982

each developing country. Despite this, the large increases in FDI more than offset the lost flow of products from imitating Northern firms. Overall, total share of production in the developing region increases by 12.8%, inducing the two primary welfare effects of reciprocal IPRs reform: first, it frees up Northern labor for innovation, resulting in an increase of the equilibrium innovation rate of 6.62%. Second, the increased labor demand in the Southern countries puts upward pressure on Southern wages. All together, both developing countries enjoy a 1.65% increase in their real wage, as well as benefit from the long run effects of a higher innovation rate.[16]

In contrast, by comparing the pre-TRIPS agreement baseline to the case of unilateral IPRs reform in country i (columns 1 and 3), we see that unilateral reform *reduces* welfare in the reforming nation, while benefiting its free-riding neighbor. Strengthened IPRs in country i makes all imitative efforts of firms in country i more costly, and as a result, all imitation rates from country i decrease. Since this includes the imitation rate of firms in country i targeting MNCs in country i, μ_{ii}, the

[16]These findings are similar to existing models considering IPRs reform with only one developing country.

rate of net FDI flows into country i, ϕ_i increases. However, since IPRs in country j remain weak, firms in country j respond to the increase in multinational activity in country i by increasing the rate at which they imitate MNCs in i, μ_{ji}. The net result is that total imitation rate facing MNCs in country i ($\mu_{ii} + \mu_{ji}$), falls by a relatively modest 9.0% compared to the 1990 baseline. While this net decrease in imitation still allows net FDI rates in country i to increase, it does so by only 72.6% over the 1990 baseline - 62.8% of the FDI increases from equivalent, reciprocated reform. That is, the parametrized model generates a relative ineffectiveness of unilateral reform that is consistent with the empirical evidence of Section 2.[17]

Moreover, the IPRs reform in country i also decreases the rate at which firms in country i imitate MNCs in country j, μ_{ij}. Combined with the reduction in μ_{jj} from firms in j shifting imitative efforts to target MNCs in country i, the total imitation rate of MNCs in j ($\mu_{jj} + \mu_{ij}$) falls by 19.6%. Thus, despite maintaining weak IPRs, country j still experiences an 14.7% increase in net FDI inflow rates. Crucially, country j experiences the benefits of increased FDI *without sacrificing imitative ability.* That is, country j maintains the relatively high flow of production into j through imitation, while still appropriating some of the increased FDI resulting from IPRs reform in country i. The combined effect is that, compared to the 1990 baseline, the real wage in i *decreased* by 1.11%, while the real wage in country j increased by 3.88%. While the total flow of production out of the North has increased, leading to a 3.12% increase in the rate of innovation over the 1990 baseline, this is less than half of the increase in the innovation rate resulting from reciprocal reform.

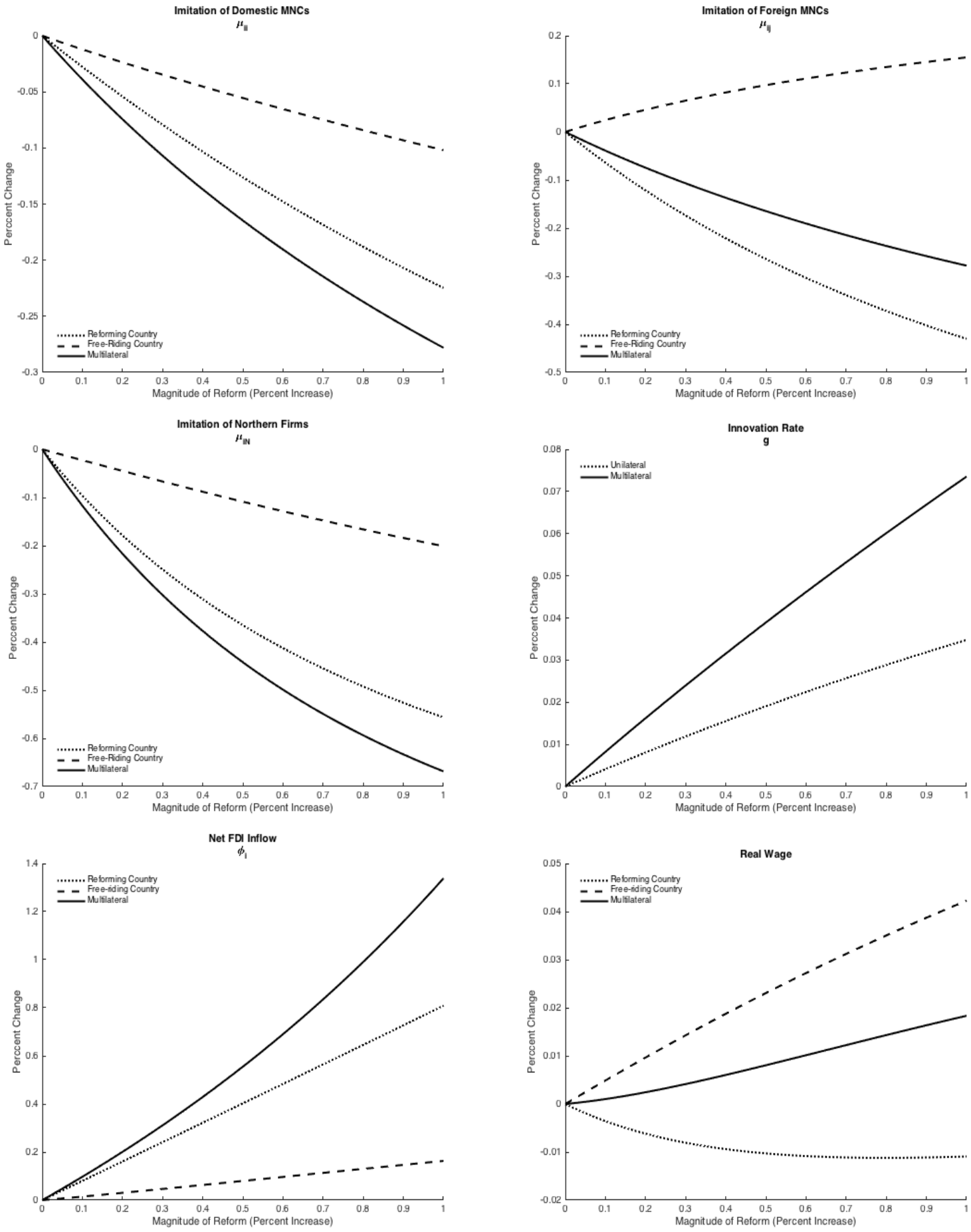
In total, the results suggest that the documented spillovers related to IPRs reform in developing countries are sufficiently large such that individual developing countries are not incentivized to undertake unilateral IPRs reform. Indeed, the best outcome for a developing country is obtained through maintaining weaker IPRs than neighboring countries, and free-riding off the benefits of others' IPRs protection. However, through a binding reciprocal reform, such as the TRIPS agreement, developing countries can eliminate free-riding through collective policy action, and achieve mutual benefit from the reform.

Furthermore, this main result holds not only for the large, discrete IPRs reforms required by the TRIPS agreement, but also for smaller, incremental reform. On the following page, Figure 2 graphs the percent change from the 1990 baseline in all endogenous growth rates and real wages resulting from different levels of reform. The large reform from the TRIPS agreement, analyzed above, corresponds to a 90% increase in the graphs below.[18] For all levels of reform, unilateral reform attracts net FDI inflow less effectively than the equivalent reciprocated reform, and the free-riding country experiences increases in net FDI inflow. Correspondingly, while both countries experience increases in their real wage from multilateral reform, neither developing is incentivize to undertake unilateral reform.

[17] As mentioned in section 3.4, as the number of developing countries in the region grows, the smaller the proportion of the total imitation rate each country controls, and the lower the expected relative effectiveness of unilateral reform.

[18] Since the developing countries are ex ante identical, the effects of multilateral reform apply to both countries.

Figure 2: Effects of Incremental IPRs Reform



5 Conclusion

Although intellectual property protection in developing countries remains controversial, recent theoretical and empirical work has emphasized that the benefits of increased FDI and technology transfer into developing countries resulting from strengthened IPRs may more than offset the cost of lost imitative ability. Lai (1998), Branstetter & Saggi (2011), and Jakobsson & Segerstrom (2012) analyze North-South international product cycle models and show that, under plausible conditions, developing countries benefit from strengthening their IPRs. Empirical studies such as Lee and Manfield (1996) and Branstetter, Fisman, Foley, & Saggi (2011) have shown that strengthened IPRs are associated with increased FDI inflows in developing countries, providing supporting evidence for these theoretical results.

However, despite some authors arguing that these findings provide a justification for the TRIPS agreement, the role for an international IPRs agreement in this framework is unclear. The models only consider one developing country with the ability to set IPRs policy, and effectively attract FDI inflows. The TRIPS agreement enters these models only as a forced strengthening of IPRs in the South, but provides no efficiency gains over the Southern country's ability to set IPRs policy autonomously. In other words, a unilateral policy reform in the South is indistinguishable from a reciprocal agreement like TRIPS in these models.

The empirical analysis presented in this paper shows that existing models ignore the substantial multilateral effects of IPRs reform in developing countries. I provide evidence that FDI inflows into a developing country are associated with not only intellectual property protection in that country, but also with the protection of other countries in the region. This finding suggests that the dynamic benefits of unilateral IPRs reform cannot be fully appropriated by the reforming nation, and instead spill over to other countries in the region. Indeed, the results of the empirical analysis suggest that an IPRs strengthening among a developing country's contiguous neighbors can be associated with larger increases in FDI inflows than an equivalent policy reform in the developing country itself.

The model presented in this paper extends existing international product cycle models in order to explicitly accommodate these multilateral effects. I consider multiple developing countries, and allow firms in each country to imitate multinational corporations throughout the developing region. In this way, the IPRs policy of a particular Southern country can only partially impact the imitation risk facing multinational corporations in that country. As a result, the FDI inflows into a particular developing country depend upon the collective intellectual property protection in the region, and each developing country is unable to effectively attract substantial FDI inflows through unilateral IPRs reform. This understanding may, in part, explain why developing countries resisted strong intellectual property protection prior to international agreements. In standardizing intellectual property protection *among developing countries*, TRIPS assured each developing country that their IPRs reform would be met by equivalent reform in neighboring countries. This reciprocal policy reform allows for the benefits of increased FDI inflows to be shared among developing countries.

I argue that this insight suggests an interpretation of the TRIPS agreement, not as a forced standardization of intellectual property protection in developed and developing countries, but as a harmonization of IPRs among developing countries. After all, developed and developing countries differ vastly in their innovative capacity, and thus, in their incentives to protect intellectual property. However, among developing countries with limited innovation potential, these incentives are much

more aligned. As this paper demonstrates, the TRIPS agreement may have allowed developing countries to prevent free-riding behavior, and efficiently balance the benefit of increased FDI inflows with the cost of lost imitative ability through a collective policy action, in a way that an unilateral policy reform could not.

Appendix

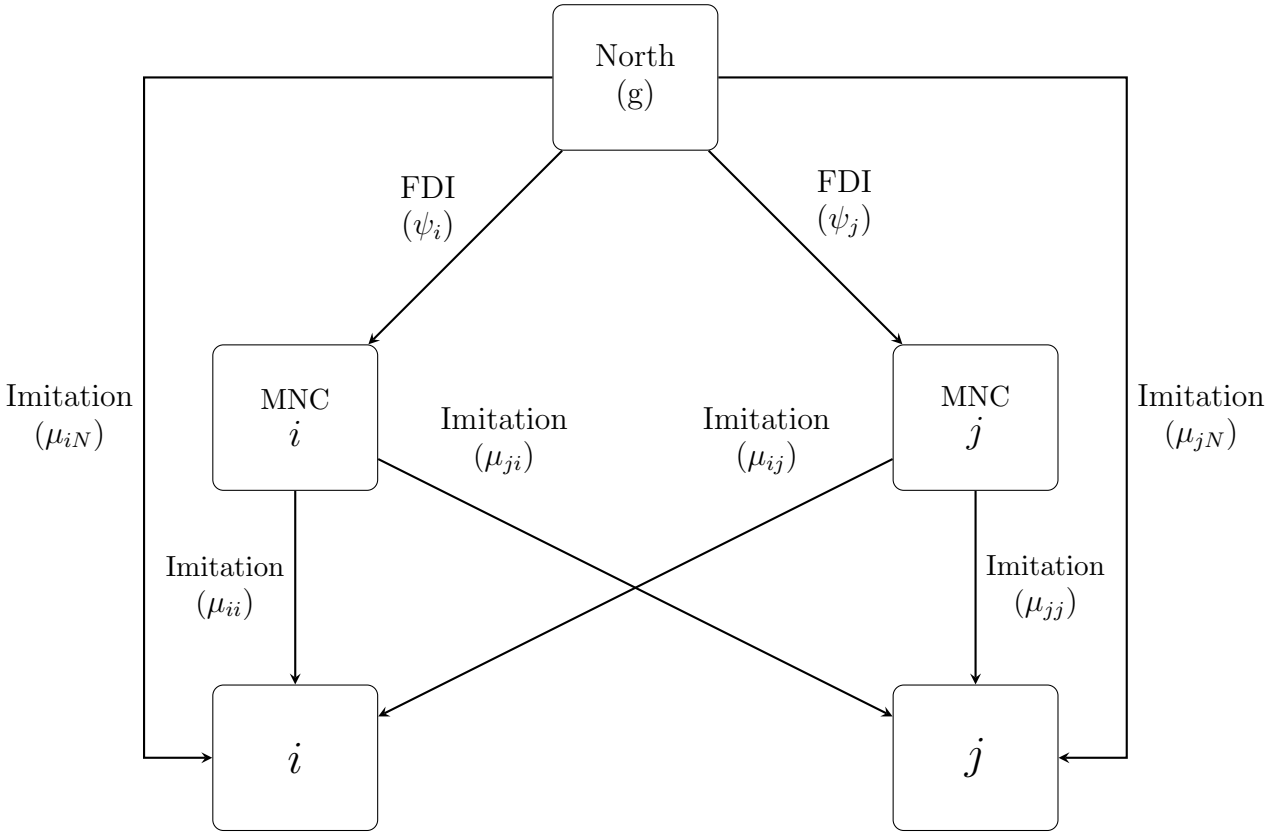


Figure 3: The above figure illustrates the product cycle for a developing region comprised of two countries, i and j, and the nine endogenous rates which determine the equilibrium of the model. Northern firms innovate new product varieties at rate g. There are four total channels through which production of varieties may shift to a Southern country: Southern firms may imitate a Northern firm's product directly, at rates μ_{iN} and μ_{jN}, or Northern firms may choose to become a MNC in either country through FDI, at gross FDI rates ψ_i and ψ_j. When a product is produced by a MNC in either Southern country, its product can be imitated by firms in that country *and* in the neighboring Southern country. That is, MNCs in country i are imitated by firms in i at rate μ_{ii}, and by firms in j at rate μ_{ji}, while MNCs in country j are imitated by firms in j at rate μ_{jj}, and by firms in i at rate μ_{ij}. In addition, the length of the arrows signifying imitation rates roughly correspond to the distance of the imitating firm from the production process, and therefore, illustrate the relative base labor requirement of the channels of imitation.

Developing Countries in the Sample

Table 6: Developing Countries in the Sample

Argentina	Ecuador	Nigeria
Bangladesh	Gabon	Pakistan
Benin	Ghana	Panama
Bolivia	Guatemala	Paraguay
Botswana	Guyana	Peru
Brazil	Honduras	Philippines
Burkina Faso	India	Rwanda
Burundi	Ivory Coast	Singapore
Cameroon	Kenya	Sri Lanka
Central African Republic	Madagascar	Togo
Chad	Malawi	Uruguay
Chile	Malaysia	Venezuela
China	Mexico	Zambia
Colombia	Nepal	Zimbabwe
Congo, Rep.	Nicaragua	–
Costa Rica	Niger	–

Variable Correlations

Table 7: All Time Periods Correlation: (1970-2010)

	FDI	ln(GDPpc)	ln(pop)	GDPg	vol	IPI	$\overline{\text{IPI}}$
FDI	1.000						
ln(GDPpc)	0.317	1.000					
ln(pop)	-0.129	-0.058	1.000				
GDPg	0.163	0.072	0.120	1.000			
vol	-0.055	-0.070	-0.227	-0.149	1.000		
IPI	0.333	0.436	0.162	0.096	-0.173	1.000	
$\overline{\text{IPI}}$	0.337	0.320	0.072	0.052	-0.183	0.775	1.000

Table 8: Post-TRIPS Excluded Correlation: (1970-1999)

	FDI	ln(GDPpc)	ln(pop)	GDPg	vol	IPI	$\overline{\text{IPI}}$
FDI	1.000						
ln(GDPpc)	0.286	1.000					
ln(pop)	-0.135	-0.114	1.000				
GDPg	0.190	0.087	0.082	1.000			
vol	-0.086	-0.080	-0.201	-0.153	1.000		
IPI	0.284	0.195	0.050	0.106	-0.062	1.000	
$\overline{\text{IPI}}$	0.311	0.066	-0.015	0.047	-0.030	0.621	1.000

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