Foreign Direct Investment and Collective Intellectual Property Protection in Developing Countries

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October 2016

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 of a developing country influences foreign direct investment (FDI) inflows into that country, as well as FDI flows into adjacent developing countries. This finding suggests the presence of multilateral effects related to IPRs that existing models do not account for. I develop a general equilibrium international product cycle model to accommodate these effects, and find that the short-run benefits of unilateral IPRs reform spills over to neighboring countries, creating an individual incentive to maintain weak IPRs. However, reciprocal IPRs reform improves welfare among all reforming countries. I argue that this finding suggests a novel justification of the TRIPS agreement as a harmonization of IPRs among developing countries, which allows developing countries to achieve mutual benefit through collective reform.

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

JEL Classification: F23, O24, O34

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1 Introduction

In developed economies, intellectual property protection poses a familiar welfare trade-off. On one hand, protecting intellectual property incentivizes firms to undertake the costs and risk associated with R&D investment. 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 or nonexistent IPRs in order to allow for the use of foreign products and technology while avoiding 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 held 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 firms in 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 IPRs in developing countries resulting from endogenously determined foreign direct investment (FDI) inflows. In these models, firms in developed countries internalize the risk of product 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 monopoly 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 the 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 externalities associated with IPRs policy among developing countries. Using panel data on 32 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 within a developing region. This finding implies that the potential FDI inflows generated from unilateral IPRs reform spills over to other countries in the region, and suggests that individual developing countries can 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. Intuitively, the greater the distance between production and the imitating firm, the more difficult it is to attract labor familiar with the production process, or otherwise 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. 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 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. Following the literature, I calibrate the model to capture the aggregate

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

economic impact of the multilateral reform required by TRIPS agreement in developing countries. I use the calibrated model to compare these effects to a counterfactual scenario of equivalent unilateral reform in an individual developing country.

I find that the spillovers are sufficiently large so that unilateral IPRs reform *reduces* short-run 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 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 calibration of the model and presents the numerical results. Section 5 concludes.

2 Empirical Evidence

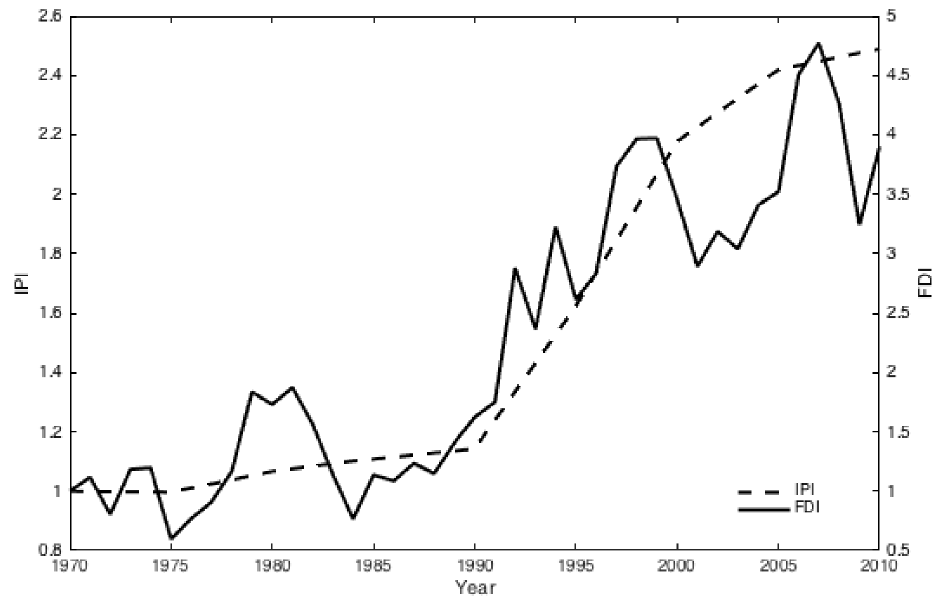
This section empirically analyzes the relationship between FDI inflows and IPRs policy in developing countries. First, I briefly review the effects of the large IPRs reforms required by the TRIPS agreement. Next, I investigate how FDI inflows into a country are influenced by both IPRs policy in that country itself, as well as IPRs policy in neighboring developing countries in the absence of an international IPRs agreement. To my knowledge, this paper is the first to empirically investigate how spillovers associated with IPRs protection affect FDI inflows into 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 32 developing countries, listed in Table A1 in appendix A, over a 40 year period from 1970-2010. To measure FDI inflows while controlling for the economic size of countries in the sample, I use net FDI inflow volume (new investment less disinvestment) as a percentage of GDP (FDI). As a measure of IPRs, this analysis uses the 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 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 32 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 coincidental increase in FDI inflows into the developing world.

Figure 1: Average IPRs and FDI inflows



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 115%, and average net FDI inflows as a percentage of GDP increased by 109%, from 1.557% to 3.261%.

Table 1: Summary Statistics: Before and After TRIPS

Year	Variable	Mean	Median	Std. Dev.	Coef. Variation	Min	Max
1990	IPI	1.484	1.337	0.568	0.382	0.588	2.782
	FDI	1.557	0.965	2.672	1.716	-1.012	14.331
2005	IPI	3.183	3.150	0.605	0.190	1.659	4.475
	FDI	3.261	2.734	3.166	0.971	-2.498	14.197

2.2 Empirical Analysis

While the relationship between FDI inflows and IPRs protection has been studied extensively in the context of TRIPS agreement, less attention has been given to analyzing the relationship *without* an international agreement in place. I argue that this distinction is important, as a major effect of the binding standards in TRIPS was a reduction in the variability of IPRs policy among developing countries. As Table 1 shows, the normalized measure of dispersion of IPI, the coefficient of variation, fell by 50.26% after adjustment to TRIPS, illustrating the movement towards harmonization of IPRs in developing countries. That is, while the TRIPS agreement required substantial institutional reform of most developing countries, it also ensured that this reform would be reciprocated by the other developing countries in the WTO.

In order to analyze how FDI inflows are influenced by IPRs policy in developing countries in the absence of a binding multilateral agreement, I exclude years after the implementation of TRIPS from the sample. Since developing countries were allowed a 5-year transition period to adhere to the standards in TRIPS, I exclude years after 1999. In addition, to empirically test how FDI inflows into a country respond to varying 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).[3]

Since both IPI_{it} & $\overline{\text{IPI}}_{-it}$ have increased over time on average, there is reason to believe they are substantially collinear. However, much of this collinearity stems from the years following the required adjustment to the TRIPS agreement. As the correlation tables in appendix A 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 (1970-2010) is considered, IPI_{it} & $\overline{\text{IPI}}_{-it}$ have a correlation of 0.786. In the post-TRIPS excluded sample (1970-1999), this correlation falls to 0.624.

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 country size, 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 log variance of the preceding 5 years of annual growth rate of real GDP to capture the recent economic volatility in each country (lnvol). This data is collected from The World Bank's

[3]Weighted averages based on neighboring country sizes and length of borders have been explored and have not changed the main qualitative results.

"World Development Indicators."[4]

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	782	1.807	0.920	3.163	-12.208	39.809
ln(GDPpc)	782	6.990	6.900	1.028	4.054	10.181
ln(pop)	782	16.438	16.346	1.635	13.475	20.949
GDPg	782	3.914	4.404	5.635	-50.248	35.224
ln(vol)	782	2.006	1.912	1.428	-2.875	6.729
IPI	782	1.684	1.611	0.699	0.588	4.361
$\overline{\text{IPI}}$	782	1.617	1.548	0.599	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:

$$FDI_{it} = \beta_0 + \beta_1 ln(GDPpc)_{it} + \beta_2 ln(pop)_{it} + \beta_3 GDPg_{it-1} + \beta_4 ln(vol)_{it} + \beta_5 IPI_{it} + \phi_i + \delta_t + \epsilon_{it} \quad (2.1)$$

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:

$$FDI_{it} = \gamma_0 + \gamma_1 ln(GDPpc)_{it} + \gamma_2 ln(pop)_{it} + \gamma_3 GDPg_{it-1} + \gamma_4 ln(vol)_{it} + \gamma_5 IPI_{it} + \gamma_6 \overline{IPI}_{-it} + \psi_i + \lambda_t + u_{it} \quad (2.2)$$

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. land-locked 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 (2.2) 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 regional group. That is, γ_5 represents the estimated marginal effect of unilateral IPRs policy reform on FDI inflows into country (i), holding neighboring policy constant. In contrast, $\gamma_5 + \gamma_6$ gives the estimated marginal effect when this IPRs policy reform is instituted by all countries in the regional group. I use the coefficient estimates of regression (2.2) 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.

[4]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.

2.3 Empirical Results

Table 3 presents results for the three specifications of regressions (2.1) & (2.2) discussed above. Focusing first on the control variables in regression (2.1), 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 developing countries are associated with lower FDI inflow as a percentage of GDP. 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)	-0.068	-0.341	-1.524**	-0.191	-0.423	-1.676**
	(0.386)	(0.494)	(0.729)	(0.416)	(0.532)	(0.766)
ln(pop)	-0.382*	-0.981	-10.410**	-0.401*	-1.546	-9.510**
	(0.221)	(1.322)	(4.940)	(0.224)	(1.343)	(4.656)
GDPg	0.065*	0.059*	0.053*	0.063**	0.054*	0.052**
	(0.034)	(0.034)	(0.026)	(0.032)	(0.031)	(0.025)
ln(vol)	-0.088	-0.077	-0.167	-0.074	-0.072	-0.169
	(0.112)	(0.117)	(0.127)	(0.115)	(0.121)	(0.124)
IPI	1.973***	2.395***	2.400***	1.262***	1.650***	2.140***
	(0.299)	(0.408)	(0.545)	(0.316)	(0.369)	(0.514)
$\overline{\text{IPI}}$	–	–	–	1.120**	1.272*	1.395*
				(0.574)	(0.633)	(0.697)
Fixed Effects	No	Yes	Yes	No	Yes	Yes
Year Controls	No	No	Yes	No	No	Yes
N	782	782	782	782	782	782
R^2	0.173	0.176	0.250	0.187	0.192	0.262

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 1.484, and average net FDI inflow was 1.557% of GDP. The results from the fixed effects regression with year controls included (column three) suggest that a

1% increase in IPI (0.0148 index value) is associated with a 2.28% increase in FDI (an additional inflow of 0.036% of GDP), holding all other variables constant.

Turning our attention to the three specifications of regression (2.2), we see that the coefficients on logged GDP per capita, logged population, lagged growth in real GDP, volatility in growth of GDP remain very similar to the estimates from regression (2.1) 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.[5]

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
$\frac{\gamma_5}{\gamma_5+\gamma_6}$	0.606	0.085	[0.439, 0.773]

The results suggest that unilateral IPRs reform is between 43.9% and 77.3% 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 these spillovers 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. When notationally convenient, I refer to a representative country $i \in S$ where it is understood to apply to all countries in the developing region.

[5]The p-values associated with the estimate of γ_6 in columns 4 and 5 are 0.054 and 0.055 repectively.

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:

$$U = \int_t^\infty e^{-\rho(\tau-t)} ln(D(\tau)) d\tau \tag{3.1}$$

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

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 (3.1) subject to the lifetime budget constraint:

$$\int_t^\infty e^{-r(\tau-t)} E(\tau) d\tau = \int_t^\infty e^{-r(\tau-t)} I(\tau) d\tau \tag{3.2}$$

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

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

$$x(k) = E \cdot \frac{p(k)^{-\epsilon}}{P^{1-\epsilon}}, \qquad \epsilon = \frac{1}{1-\alpha} > 1 \tag{3.3}$$

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:

$$P = \Big[\int_0^n p(k)^{1-\epsilon} dk\Big]^{\frac{1}{1-\epsilon}} \tag{3.4}$$

Furthermore, the intertemporal expenditure rule is given by $\frac{\dot{E}}{E} = r - \rho$. Following Grossman and Helpman (1991b), I will normalize $\frac{\dot{E}}{E} = 0$, 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 as $g \equiv \frac{\dot{n}}{n}$. The cost of innovating a new product variety is given by:

$$c_N = w_N \cdot \frac{a_N g^\beta}{n} \tag{3.5}$$

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 marginal cost w_N. 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. Reflecting the productivity disparity between Northern and Southern labor, $\eta > 1$ units of Southern labor are required to produce one unit of any differentiated product. Following Branstetter & Saggi (2011), I assume no additional fixed cost to establishing a MNC in either developing country. However, to capture the relative unfamiliarity of a MNC with a foreign labor force and production environment, a MNC must employ additional Southern labor for each unit produced. Let $\theta > 1$ be the additional labor requirement per unit for a MNC. In total, a MNC must employ $\theta\eta$ units of labor per unit of production, with corresponding marginal cost in Southern country i equal to $\theta\eta w_i$.

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:[6]

$$\mu_{ii} \equiv \frac{\dot{n}_{ii}}{n_{Mi}}, \qquad \mu_{iN} \equiv \frac{\dot{n}_{iN}}{n_N}, \qquad \mu_{ij} \equiv \frac{\dot{n}_{ij}}{n_{Mj}} \quad \forall\ j \in S_{-i} \tag{3.6}$$

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:

$$c_{ii} = w_i \cdot \frac{a_{ii}{\mu_{ii}}^{\beta}}{n_{Mi}}, \quad c_{iN} = w_i \cdot \frac{a_{iN}{\mu_{iN}}^{\beta}}{n_N}, \quad c_{ij} = w_i \cdot \frac{a_{ij}{\mu_{ij}}^{\beta}}{n_{Mj}} \quad \forall\ j \in S_{-i} \tag{3.7}$$

Analogous to (3.5), all imitative efforts suffer from diminishing returns at the industry level. Furthermore, 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:

$$a_{iN} = \gamma_N a_{ii}, \quad a_{ij} = \gamma_S a_{ii} \quad \forall\ j \in S_{-i} \tag{3.8}$$

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

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

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:

$$\psi_i \equiv \frac{\dot{n}_{Mi} + \sum_j^S \dot{n}_{ji}}{n_N}, \qquad \phi_i \equiv \frac{\dot{n}_{Mi}}{n_N} \tag{3.9}$$

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.[7] In appendix B, figure B1 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 (3.3), the profit maximizing price of a monopoly firm is a constant mark-up over marginal cost of $\frac{1}{\alpha}$:

$$p_N = \frac{w_N}{\alpha}, \qquad p_{Mi} = \frac{\theta \eta w_i}{\alpha} \tag{3.10}$$

After a product has been successfully imitated by a Southern firm, $\eta > 1$ units of Southern labor are required to produce one unit of that product, and 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

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

share.[8] Given that all imitating Southern firms in country i have an unconstrained monopoly price of $\frac{\eta w_i}{\alpha}$, the firm's profit maximizing price will be the highest price in the interval $[0, \frac{\eta w_i}{\alpha}]$ 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:

$$\theta w_i \leq \frac{w_i}{\alpha}, \quad \theta w_j \leq \frac{w_i}{\alpha}, \quad w_N \geq \frac{\eta w_i}{\alpha}, \quad \forall\ i, j \in S \tag{3.11}$$

Equivalently,

$$\theta\alpha \leq 1, \quad \theta\alpha \leq \frac{w_i}{w_j}, \quad \frac{\eta}{\alpha} \leq \frac{w_N}{w_i}$$

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.[9] Thus, the optimal prices of all Southern firms in country i are given by:

$$p_{ii} = \theta\eta w_i, \quad p_{ij} = \theta\eta w_j, \quad p_{iN} = \frac{\eta w_i}{\alpha}, \quad \forall\ j \in S_{-i} \tag{3.12}$$

Using the demand equation (3.3), the relative demand for any two products is given by $\frac{x(k)}{x(h)} = [\frac{p_k}{p_h}]^{-\epsilon}$. The pricing equations (3.10) & (3.12) determine the relative demand of varieties within all product categories, and are listed for reference in appendix B. Using marginal cost, and the pricing equations, flow, or instantaneous variable profits of all firm types, denoted by π, can be written as:

$$\pi_N = (p_N - w_N)x_N = \frac{(1-\alpha)w_N}{\alpha}x_N \tag{3.13}$$

$$\pi_{Mi} = (p_{Mi} - \theta\eta w_i)x_{Mi} = \frac{(1-\alpha)\theta\eta w_i}{\alpha}x_{Mi} \tag{3.14}$$

Similarly, for imitating Southern firms in country i:

$$\pi_{ii} = (p_{ii} - \eta w_i)x_{ii} = (\theta - 1)\eta w_i x_{ii} \tag{3.15}$$

$$\pi_{iN} = (p_{iN} - w_i)x_{iN} = \frac{(1-\alpha)\eta w_i x_{iN}}{\alpha} \tag{3.16}$$

$$\pi_{ij} = (p_{ij} - w_i)x_{ij} = (\theta w_j - w_i)\eta x_{ij}, \quad \forall\ j \in S_{-i} \tag{3.17}$$

[8] 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." The assumption is made for tractability, and the main results will still obtain in other formulations as long as the profit of a firm is reduced when their product is imitated.

[9] 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. These restrictions do not bind in the calibration described in section 4.1.

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:

$$V_{ii} = \frac{\pi_{ii}}{\rho + g}, \quad V_{iN} = \frac{\pi_{iN}}{\rho + g}, \quad V_{ij} = \frac{\pi_{ij}}{\rho + g}, \quad \forall\, j \in S_{-i} \tag{3.18}$$

where ρ is the continuous time discount factor as in (3.1), 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:

$$V_N = \frac{\pi_N}{\rho + g + \sum\limits_{i}^{S} \mu_{iN}}, \quad V_{Mi} = \frac{\pi_{Mi}}{\rho + g + \mu_{ii} + \sum\limits_{j}^{S_{-i}} \mu_{ji}} \tag{3.19}$$

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, $\sum\limits_{j}^{S_{-i}} \mu_{ji}$.

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:

$$g \equiv \frac{\dot{n}}{n} = \frac{\dot{n}_N}{n_N} = \frac{\dot{n}_{Mi}}{n_{Mi}} = \frac{\dot{n}_{ii}}{n_{ii}} = \frac{\dot{n}_{iN}}{n_{iN}} = \frac{\dot{n}_{ij}}{n_{ij}} \quad \forall\, i, j \in S \tag{3.20}$$

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:

$$n = n_N + \sum_{i}^{S} n_i, \quad \text{where} \quad n_i = n_{Mi} + n_{iN} + n_{ii} + \sum_{j}^{S_{-i}} n_{ij} \tag{3.21}$$

It is convenient to introduce notation for the proportion of all products produced by Northern firms, MNCs, and Southern imitating firms respectively. Let,

$$\Delta_N \equiv \frac{n_N}{n}, \quad \Delta_{MNC} \equiv \frac{\sum_i^S n_{Mi}}{n}, \quad \Delta_I \equiv \frac{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}{n} \tag{3.22}$$

so that $\Delta_N + \Delta_{MNC} + \Delta_I = 1$. Further define the proportion of all imitated products originiating from Northern firms, foreign MNCs, and domestic MNCs respectively by:

$$\delta_{IN} \equiv \frac{\sum_i^S n_{iN}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}, \quad \delta_{IFM} \equiv \frac{\sum_i^{S_{-j}} \sum_j^{S_{-i}} n_{ij}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}, \quad \delta_{IDM} \equiv \frac{\sum_i^S n_{ii}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}} \tag{3.23}$$

so that $\delta_{IN} + \delta_{IFM} + \delta_{IDM} = 1$. Given the balanced growth condition (3.20), the relative size of all product categories, and the proportions defined above, are constant in equilibrium. Expressions for the relative sizes of these product categories in terms of the endogenous rates of innovation, FDI, and imitation are derived in appendix B.

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

$$V_N = V_{Mi}, \quad \forall\ i \in S \tag{3.24}$$

Using (3.19), condition (3.24) delivers:

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

Substituting in for flow profits (3.13) and (3.14), we have:

$$\frac{w_N}{w_i} = \theta\eta \left[\frac{\rho + g + \mu_{ii} + \sum_j^{S_{-i}} \mu_{ji}}{\rho + g + \sum_i^S \mu_{iN}} \right]^{\frac{1}{\epsilon - 1}} \tag{3.25}$$

Since $\frac{w_i}{w_j} = \frac{w_N}{w_j}\frac{w_i}{w_N}$, from (3.25):

$$\frac{w_i}{w_j} = \left[\frac{\rho + g + \mu_{jj} + \sum_i^{S_{-j}} \mu_{ij}}{\rho + g + \mu_{ii} + \sum_j^{S_{-i}} \mu_{ji}} \right]^{\frac{1}{\epsilon - 1}}, \qquad \forall\ i, j \in S \tag{3.26}$$

Focusing on (3.25), we see that the Northern wage relative to the wage in country i is endogenously determined by the relative imitation threat facing MNCs in country i and Northern firms. Condition (3.24) 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 (3.24) 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.*[10] 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 (3.26), note that the relative wage of the Southern countries is controlled by the relative 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 $(g,\ \phi_i,\ \mu_{ii},\ \mu_{iN},\ \mu_{ij})$.[11]

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:

$$c_N = V_N, \quad c_{ii} = V_{ii}, \quad c_{iN} = V_{iN}, \quad c_{ij} = V_{ij}, \quad \forall\ i \in S,\ j \in S_{-i} \tag{3.27}$$

Using free entry, the requisite equilibrium conditions are derived by considering relative innovation and imitation costs:

$$\frac{c_N}{c_{ii}} = \frac{V_N}{V_{ii}}, \qquad \frac{c_{ii}}{c_{ji}} = \frac{V_{ii}}{V_{ji}}, \qquad \frac{c_{ii}}{c_{iN}} = \frac{V_{ii}}{V_{iN}} \tag{3.28}$$

[10] 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.

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

As shown in appendix B, substituting for innovation/imitation costs (3.5) & (3.7), PV of profits (3.18) & (3.19), and again for flow profits (3.13)-(3.17), we obtain from the first term of (3.28):

$$1 = \frac{\Omega(\rho+g)}{(\rho+g+\sum_i^S \mu_{iN})} \frac{n}{n_{Mi}} \frac{a_{ii}}{a_N} \frac{x_N}{x_{ii}} \left[\frac{\mu_{ii}}{g}\right]^{\beta}, \quad \text{where} \quad \Omega = \frac{1-\alpha}{\alpha\eta(\theta-1)} > 0 \tag{3.29}$$

Similarly, the second term of (3.28) becomes:

$$1 = \frac{a_{ii}}{a_{ji}} \frac{\left(\theta(\frac{w_i}{w_j})-1\right)}{(\theta-1)} \left[\frac{\mu_{ii}}{\mu_{ji}}\right]^{\beta}, \tag{3.30}$$

Upon substituting for relative product sizes and relative wages, equation (3.29) provides a total of S equilibrium conditions, and (3.30) provides $S(S-1)$ equilibrium conditions resulting from free entry. The final term of (3.28) provides a closed form expression 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:

$$\mu_{iN} = \left[\Gamma \frac{x_{iN}}{x_{ii}} \frac{n_N}{n_{Mi}}\right]^{\frac{1}{\beta}} \mu_{ii} \quad \text{where} \quad \Gamma = \frac{1-\alpha}{\gamma_N \alpha(\theta-1)} > 0 \tag{3.31}$$

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:

$$L_N = \frac{a_N g^{\beta}}{n} \dot{n} + n_N x_N \tag{3.32}$$

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

$$L_N = a_N g^{1+\beta} + \frac{n_N}{n} \frac{a_N \alpha g^{\beta}(\rho+g+\sum_i^S \mu_{iN})}{(1-\alpha)} \tag{3.33}$$

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:

$$L_i = \sum_j^S \frac{a_{ij}\mu_{ij}{}^{\beta}}{n_{Mj}} \dot{n}_{ij} + \frac{a_{iN}\mu_{iN}{}^{\beta}}{n_N} \dot{n}_{iN} + \theta\eta n_{Mi} x_{Mi} + \sum_j^S \eta n_{ij} x_{ij} + \eta n_{iN} x_{iN} \tag{3.34}$$

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

$$L_i = \sum_j^S a_{ij} g \mu_{ij}{}^{\beta} \frac{n_{ij}}{n_{Mj}} + a_{iN} g \mu_{iN}{}^{\beta} \frac{n_{iN}}{n_N} + \theta \frac{\alpha^{\epsilon} a_{ii}(\rho+g)}{\theta-1} \mu_{ii}{}^{\beta} + \sum_j^S \frac{n_{ij}}{n_{Mj}} \frac{a_{ij}(\rho+g)}{\left[\theta\left[\frac{w_j}{w_i}\right]-1\right]} \mu_{ij}{}^{\beta} + \frac{n_{iN}}{n_N} \frac{\alpha(\rho+g)a_{iN}\mu_{iN}{}^{\beta}}{(1-\alpha)} \tag{3.35}$$

Upon substituting for relative product sizes and relative wages, (3.33) and (3.35) provide equilibrium conditions resulting from labor market clearing in the North, and the S developing countries. Taken together, (3.29), (3.30), (3.31), (3.33), and (3.35) provide the requisite $1 + 3S + S(S-1)$ equilibrium conditions to solve the model.

3.5 Equilibrium FDI and Welfare

To allow for direct comparison with the measure of FDI inflows used in the empirical section, define equilibirum net FDI inflows as a fraction of GDP in developing country i by:

$$\kappa_i \equiv \frac{V_{Mi}\dot{n}_{Mi}}{V_{Mi}n_{Mi} + V_{iN}n_{iN} + \sum_j^S V_{ij}n_{ij}} \tag{3.36}$$

where the numerator of (3.36) gives the value of the instantaneous net FDI flow, and the denominator gives the equilibrium GDP of country i. As shown in appendix B, using the free entry conditions of (3.27), equation (3.36) can be rewritten as:

$$\kappa_i = \frac{g}{1 + \frac{w_i a_{ii}}{w_N a_N}\frac{n}{n_{Mi}}\left[\left(\frac{\mu_{ii}}{g}\right)^\beta \frac{n_{ii}}{n_{Mi}} + \gamma_S \sum_j^{S_{-i}} \left(\frac{\mu_{ij}}{g}\right)^\beta \frac{n_{ij}}{n_{Mj}} + \gamma_N \left(\frac{\mu_{iN}}{g}\right)^\beta \frac{n_{iN}}{n_n}\right]} \tag{3.37}$$

Since the innovation rate g, relative wages, and differentiated variety product shares are all constant in the balanced growth equilibrium defined in section 3.4, equilibrium κ is constant as well.

Finally, rewriting the price index given by (3.4), common across countries, we obtain:[12]

$$P^{1-\epsilon} = n_N p_N^{1-\epsilon} + \sum_i^S n_{Mi}p_{Mi}^{1-\epsilon} + \sum_i^S \sum_j^S n_{ij}p_{ij}^{1-\epsilon} + \sum_i^S n_{iN}p_{iN}^{1-\epsilon} \tag{3.38}$$

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

$$P = \left[\frac{n_N}{n}p_N^{1-\epsilon} + \sum_i^S \frac{n_{Mi}}{n}p_{Mi}^{1-\epsilon} + \sum_i^S \sum_j^S \frac{n_{ij}}{n}p_{ij}^{1-\epsilon} + \sum_i^S \frac{n_{iN}}{n}p_{iN}^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} n^{\frac{1}{1-\epsilon}}$$

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.

$$\frac{w_N}{P} = \left[\frac{n_N}{n}\left(\frac{1}{\alpha}\right)^{1-\epsilon} + \sum_i^S \frac{n_{Mi}}{n}\left(\frac{\theta\eta w_i}{\alpha w_N}\right)^{1-\epsilon} + \sum_i^S \sum_j^S \frac{n_{ij}}{n}\left(\frac{\theta\eta w_j}{w_N}\right)^{1-\epsilon} + \sum_i^S \frac{n_{iN}}{n}\left(\frac{\eta w_i}{\alpha w_N}\right)^{1-\epsilon}\right]^{\frac{1}{\epsilon-1}} n^{\frac{1}{\epsilon-1}} \tag{3.39}$$

$$\frac{w_i}{P} = \left[\frac{n_N}{n}\left(\frac{w_N}{\alpha w_i}\right)^{1-\epsilon} + \sum_j^S \frac{n_{Mj}}{n}\left(\frac{\theta\eta w_j}{\alpha w_i}\right)^{1-\epsilon} + \sum_k^S \sum_j^S \frac{n_{kj}}{n}\left(\frac{\theta\eta w_j}{w_i}\right)^{1-\epsilon} + \sum_j^S \frac{n_{jN}}{n}\left(\frac{\eta w_j}{\alpha w_i}\right)^{1-\epsilon}\right]^{\frac{1}{\epsilon-1}} n^{\frac{1}{\epsilon-1}} \tag{3.40}$$

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

Note that the bracketed terms of (3.39) and (3.40) are constant in equilibrium, while n grows at the rate of innovation, g. This implies that real wages, and therefore utility, in the North and South grow at the same constant rate of $\frac{1}{\epsilon-1}g$ in equilibrium. 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). In the numerical analysis that follows, I consider these components of welfare separately, and focus on the impact of IPRs reform on these short-run determinants of real income in the South. To emphasize that this measure is only a component of overall welfare, I will refer to the bracketed terms of (3.39) and (3.40) as the time zero real wage in the North and Southern countries respectively ($\frac{w_N}{P_0}$, $\frac{w_i}{P_0}$).

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 ($S = 2$).[13] Following existing literature, I calibrate the model to approximate the aggregate effects of the large IPRs reform required by the TRIPS agreement over the fifteen year period from 1990 to 2005. I use the calibrated model to explore a counterfactual in which country i reforms IPRs policy to the standards of the TRIPS agreement, while country j maintains weak IPRs policy at their pre-TRIPS level. To analyze the welfare implications of the multilateral effects of IPRs reform, I compare the equilibrium outcomes of the reciprocal reform required by TRIPS to the equivalent unilateral reform of the counterfactual.

4.1 Calibration

For model parameters that are standard in international product cycle models, I rely on estimates provided by existing literature. I set the CES utility parameter α to 0.667, in order to generate a monopoly mark-up over cost within the range estimated by Norrbin (1993) of 50%. This implies the elasticity of substitution between products, given by $\epsilon = \frac{1}{1-\alpha}$, is equal to 3.0. I fix the R&D diminishing returns parameter β to 0.7, which is within the range of estimates considered by Jakobsson and Segerstrom (2012). The continuous time discount factor ρ is set to 0.025, which implies a risk-free real interest rate of 2.5%. Finally, as in Jakobsson and Segerstrom (2012), the relative populations between countries is all that matters for the results. I normalize the Northern

[13] With $S = 2$, there are 9 unknown growth rates which characterize the balanced growth equilibrium. Figure B1 in appendix B illustrates the product cycle in the $S = 2$ case.

population to 1, and set the population of each Southern country to 1.45, reflecting the World Bank's estimate of the relative population in high income countries to middle income countries.

The remaining parameters, which dictate the relative labor requirements of innovation, imitation, and production, are calibrated to match the relevant features of the sample of 32 developing countries before and after the implementation of the TRIPS agreement. Specifically, I target the sample average of net FDI inflows as a percentage of GDP (κ) before and after TRIPS, as well as the average growth rate in real GDP. I use the purchasing power parity adjusted average GDP per capita in the sample, and estimates for high income countries provided by the World Bank to target a realistic North-South relative wage. In addition, I use estimates provided by Yang and Wang (2015) as realistic targets for shares of total varieties produced by Northern firms, MNCs, and imitating firms, $\Delta_N, \Delta_{MNC},$ and Δ_I as defined in (3.22), after the TRIPS agreement took effect.[14]

Finally, to ensure the separate identification of a_{ii}, γ_S and γ_N, I specify the composition of varieties within the imitated product category. That is, I will target estimates for shares of imitated products originating from Northern firms, foreign MNCs, and domestic MNCs respectively, $\delta_{IN}, \delta_{IFM},$ and δ_{IDM} as defined in (3.23). I follow Jakobsson and Segerstrom (2012) in imposing that the share of imitated products from Northern firms (δ_{IN}), is equal to 15% in the post-TRIPS equilibrium. This implies that the total share attributable to MNCs ($\delta_{IDM} + \delta_{IFM}$) is equal to 85%. Since an empirical estimate of of this composition is not available, I target a plausible, intermediate value of $\delta_{IFM} = 25\%$, so that $\delta_{IFM} \in (\delta_{IN}, \delta_{IDM})$. I examine the robustness of the results to different compositions of imitated products (δ_{IFM} & δ_{IN}) in appendix C.

In total, we have eight calibration targets, and exploiting the model's symmetry, six unknown parameters dictating the relative labor requirements of innovation, imitation, and production in the model, resulting in an overdetermined system. Note that a_{ii}, the model's measure of IPRs strength, need only be calibrated to its pre-TRIPS (1990) value. The post-TRIPS value is inferred from the observed sample average increase of the IPI index following the TRIPS agreement of 115%. The calibration targets, their sources, and the models performance in matching these targets are summarized in Table 5.

Table 5: Calibration Targets

Target	Target Value	Model Value	Error	Source
κ (1990)	1.557	1.531	1.70%	Sample avg.
κ (2005)	3.261	3.272	0.34%	Sample avg.
$\frac{w_N}{w_S}$ (2005)	4.320	4.345	0.58%	High inc. GDPpc / PPP adj. sample avg.
$\frac{w}{P}$ Growth (2005)	3.914	3.195	0.00%	Sample avg.
Δ_I (2005)	10.00%	10.84%	8.40%	Yang and Wang (2015)
Δ_{MNC} (2005)	20.00%	20.21%	1.05%	Yang and Wang (2015)
δ_{IN} (2005)	15.00%	14.93%	0.47%	Jakobsson and Segerstrom (2012)
δ_{IFM} (2005)	25.00%	25.00%	0.00%	Imposed

[14]Yang and Wang (2015) use U.S. Customs counterfeit seizure data to formulate a realistic estimate for the share of imitated products.

The majority of the error from the calibration stems from the model overshooting the total production of varieties in the South. The model's value of Δ_{MNC} and Δ_I are both larger than their associated targets, implying the share of production in the North, Δ_N is below target. That said, the combined effect of this error is that an additional 1.05% of all varieties are produced in the South. Overall, the model is able to replicate the targeted moments well, and I argue that the model's calibration error is unlikely to meaningfully impact the results. Table 6 reports the calibrated values of all parameters in the model.

Table 6: Calibration Results

Pre-set Parameters	Value	Description
L_N	1.0	Normalized Northern Pop.
L_i, L_j	1.45	Normalized Southern Pop.
ρ	0.025	Continuous time discount factor
α	0.667	CES utility parameter
β	0.70	Industry R&D dim. returns
Calibrated Parameters	**Value**	**Description**
a_N	26.555	Innovation labor req.
a_{ii} (1990)	31.073	Domestic MNC imitation labor req.
γ_S	1.847	Rel. foreign MNC imitation labor req.
γ_N	70.522	Rel. Northern firm imitation labor req.
θ	1.399	Additional MNC labor req.
η	2.701	Rel. Southern labor req.

4.2 Equilibrium Results

Table 7 displays the balanced growth 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 the observed 115%. Finally, column 3 explores the counterfactual 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. The nine underlying, endogenous growth rates that determine the balanced growth equilibrium are listed in the top panel of Table 7. The implications of these equilibrium growth rates in terms FDI rates, production allocation, and real wages follow in the bottom panel.

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%. The reduction in imitative activity reduces labor demand in the South, and Northern firms respond by increasing the rate of multinational activity (FDI) in both developing countries. As a result, equilibrium net FDI inflows as a percentage of GDP (κ) increase 113.7%, from 1.53% in the 1990 equilibrium, to 3.27% in 2005.

However, the IPRs reform is not without cost. To a degree, both countries sacrifice their ability

Table 7: Equilibrium Results

	Baseline (1990)	Reciprocal Reform (2005)	Unilateral Reform (counterfactual)
	$a_{ii} = 31.073$ $a_{jj} = 31.073$	$a_{ii} = 66.808$ $a_{jj} = 66.808$	$a_{ii} = 66.808$ $a_{jj} = 31.073$
g	0.0738	0.0784	0.0758
ϕ_i	0.0052	0.0115	0.0097
ϕ_j	0.0052	0.0115	0.0055
μ_{ii}	0.0340	0.0253	0.0273
μ_{ij}	0.0142	0.0105	0.0052
μ_{iN}	0.0035	0.0009	0.0012
μ_{jj}	0.0340	0.0253	0.0277
μ_{ji}	0.0142	0.0105	0.0239
μ_{jN}	0.0035	0.0009	0.0027
κ_i	1.531%	3.272%	2.993%
κ_j	1.531%	3.272%	1.659%
Δ_N	75.255%	68.949%	72.999%
Δ_{MNC}	10.656%	20.206%	14.606%
Δ_I	14.089%	10.844%	12.395%
$\frac{w}{P}$ Growth	3.686%	3.915%	3.786%
$\frac{w_i}{P_0}$	0.1716	0.1732	0.1673
$\frac{w_j}{P_0}$	0.1716	0.1732	0.1784

to imitate Northern firms directly, and the rates of imitation of Northern firms falls by 74.2% in each developing country. Despite this, the large increases in FDI more than offset the lost flow of products from imitating Northern firms. As a share of total products in the global economy, imitated products (Δ_I) falls from 14.09% to 10.84%, and the share of MNC products (Δ_{MNC}) increases from 10.66% to 20.21%. Overall, total share of production in the developing region increases by 25.48%, inducing the two primary welfare effects of reciprocal IPRs reform: first, it frees up Northern labor for innovation, resulting in an increase in the equilibrium growth rate of 6.21%, from 3.686% to 3.915%. Second, the increased production in Southern countries increases labor demand and puts upward pressure on Southern wages. All together, both developing countries benefit in the short-run through a 0.93% increase in their time zero real wage ($\frac{w}{P_0}$), as well as benefit from the long-run effects of a higher growth rate.[15]

In contrast, by comparing the pre-TRIPS agreement baseline to the counterfactual case of unilateral IPRs reform in country i (columns 1 and 3), we see that unilateral reform *reduces* short-run 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

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

rates from country i decrease. Since this reduces the labor used for imitative activity in country i, Northern firms respond to the surplus of labor by increasing FDI into country i. 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}. That is, the continued threat of imitation from neighboring country j partially offsets the additional incentives to conduct FDI in i generated from i's IPRs reform. The net result is that FDI rates in country i increase, but by a relatively diminished 95.5% over the 1990 baseline - 83.9% of the FDI increases from equivalent, reciprocated reform.

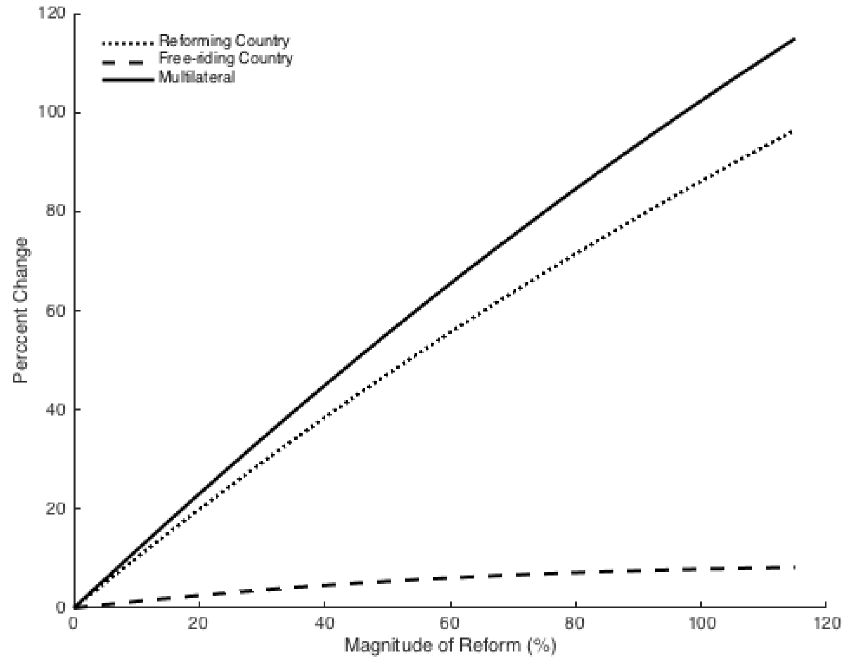
Moreover, the IPRs reform in country i also decreases the rate at which firms in country i imitate MNCs in country j, μ_{ij}. Combined with the reduction in μ_{jj} from firms in j shifting imitative efforts to target MNCs in country i, the total imitation rate targeting MNCs in j falls following i's reform. Thus, despite maintaining weak IPRs, country j still experiences an 8.36% 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 time-zero real wage in the reforming nation, i, *decreased* by 2.51%, while the real wage in country j *increased* by 3.96%. Although the total flow of production out of the North has increased, leading to a 2.71% increase in the rate of growth over the 1990 baseline, this is less than half of the increase in the growth rate resulting from reciprocal reform.

Evidently, despite calibrating the model to match only the aggregate effects of the reciprocal reform of TRIPS, the model generates FDI inflows in the counterfactual scenario that are consistent with the empirical evidence of section 2. Recall that the estimated range of relative effectiveness of FDI inflows from unilateral vs. reciprocal reform, displayed in Table 4, is [0.439, 0.773]. The model produces an estimate of 83.9%, 8.53% above the upper bound of the empirical estimate. However, as mentioned in section 3.4, as the number of developing countries in the region grows, the lower the expected relative effectiveness of unilateral reform. Given that the countries in the empirical sample had an average of 2.259 neighbors, a high relative effectiveness generated in a simplified setting with two ex ante identical developing countries is not surprising.

Finally, note that the crux of these results holds not only for the large reform required by TRIPS, but also for smaller, incremental reform. Figure 2 uses the calibrated model to plot the change in FDI inflows (κ) from different levels of IPRs reform, in both the reciprocal and unilateral case, from the 1990 baseline equilibrium. The large 115% reform corresponds to the TRIPS agreement case that is analyzed above. For any level of reform, the FDI inflows generated from unilateral reform is lower than the equivalent reciprocal reform (relative effectiveness below 1). In addition, the non-reforming country experiences increases in FDI inflow without restricting imitative efforts, illustrating their ability to free-ride.

In total, the results suggest that the documented spillovers related to IPRs reform in developing countries can be sufficiently large such that individual developing countries are not incentivized in

Figure 2: Change in FDI (κ) From IPRs Reform



the short-run to undertake unilateral IPRs reform. Indeed, the calibrated model suggests that, under plausible conditions, 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. While the short-run loses from unilateral reform are eventually compensated through a higher rate of innovation, these long-run benefits are shared by the free-riding country. Only through a binding reciprocal reform, such as the TRIPS agreement, can developing countries eliminate free-riding through collective policy action, and achieve mutual benefit from the reform in both the short and long-run. In this way, the model produces short-run welfare results that are analogous to the classic formulation of tariff policy as a prisoner's dilemma game. As commitment to the WTO controls individual incentives and allows for mutually beneficial tariff reduction, the TRIPS agreement may serve the same function in the context of IPRs in developing countries.

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 potentially 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 neighboring countries in the same region. This finding suggests that the dynamic benefits of unilateral IPRs reform cannot be fully captured by the reforming nation, and instead spill over to other countries in the region. Indeed, the results of the empirical analysis suggest that ignoring these effects may substantially overstate the benefits of unilateral IPRs reform.

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 unilaterally attract sufficient FDI inflows to offset the costs of IPRs reform in the short-run. 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 a novel 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.

Appendix A

Appendix A lists the developing countries included in the empirical sample, and displays the correlation among variables alluded to in the main text.

Table A1: Developing Countries in the Sample

Argentina	Ghana	Panama
Bolivia	Guatemala	Paraguay
Botswana	Guyana	Peru
Brazil	Honduras	Philippines
Cameroon	India	Rwanda
Chile	Kenya	Singapore
China	Malaysia	Sri Lanka
Colombia	Mexico	Uruguay
Costa Rica	Nicaragua	Venezuela
Ecuador	Nigeria	Zimbabwe
Gabon	Pakistan	–

Table A2: All Time Periods Correlation: (1970-2010)

	FDI	ln(GDPpc)	ln(pop)	GDPg	vol	IPI	$\overline{\text{IPI}}$
FDI	1.000						
ln(GDPpc)	0.381	1.000					
ln(pop)	-0.167	-0.204	1.000				
GDPg	0.180	0.019	0.120	1.000			
vol	-0.094	-0.008	-0.158	-0.172	1.000		
IPI	0.362	0.454	0.165	0.080	-0.152	1.000	
$\overline{\text{IPI}}$	0.346	0.389	0.075	0.039	-0.145	0.786	1.000

Table A3: Post-TRIPS Excluded Correlation: (1970-1999)

	FDI	ln(GDPpc)	ln(pop)	GDPg	vol	IPI	$\overline{\text{IPI}}$
FDI	1.000						
ln(GDPpc)	0.262	1.000					
ln(pop)	-0.158	-0.269	1.000				
GDPg	0.203	0.027	0.075	1.000			
vol	-0.105	-0.010	-0.125	-0.173	1.000		
IPI	0.306	0.234	0.077	0.117	-0.062	1.000	
$\overline{\text{IPI}}$	0.345	0.223	-0.006	0.079	-0.019	0.624	1.000

Appendix B

Along with an illustration of the product cycle in the calibrated $S = 2$ case, appendix B presents the mathematical derivations that are absent from the main text.

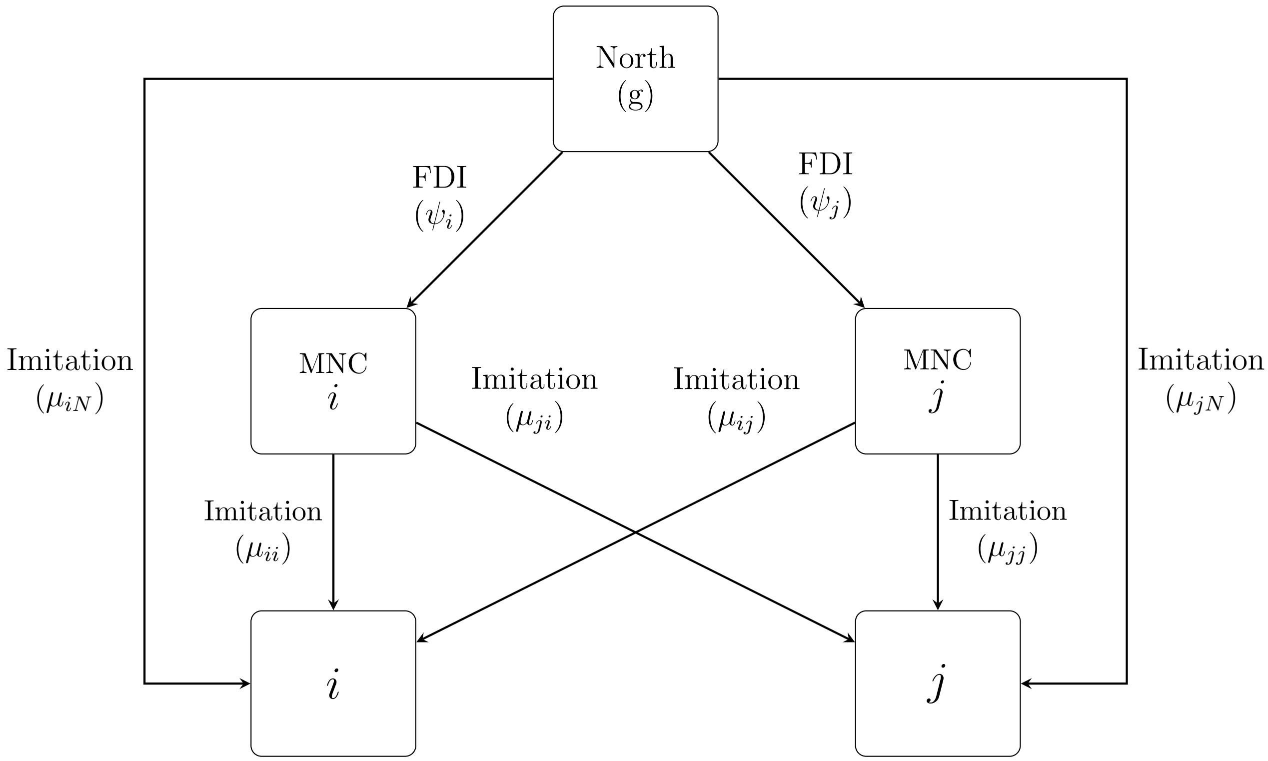


Figure B1: The above figure illustrates the product cycle for a developing region comprised of two countries, i and j, and the nine endogenous rates which determine the equilibrium of the model. Northern firms innovate new product varieties at rate g. There are four total channels through which production 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.

B1 Relative Product Demands

Given (3.3), relative demands are given by:

$$\frac{x(k)}{x(h)} = \left[\frac{p_k}{p_h}\right]^{-\epsilon} \tag{B.1}$$

From (3.10) & (3.12), we can derive the relative demand of varieties within all product categories.

Those in fixed proportion,

$$\frac{x_{ii}}{x_{Mi}} = \alpha^{-\epsilon}, \qquad \frac{x_{ij}}{x_{jj}} = 1, \qquad \frac{x_{ii}}{x_{iN}} = [\alpha\theta]^{-\epsilon}_{,} \quad \forall\ i, j \in S \tag{B.2}$$

and those that depend upon relative wages across countries,

$$\frac{x_{ij}}{x_{Mi}} = \left[\frac{\alpha w_j}{w_i}\right]^{-\epsilon}, \quad \frac{x_{ij}}{x_{ii}} = \left[\frac{w_j}{w_i}\right]^{-\epsilon}_{,} \quad \frac{x_{Mi}}{x_N} = \left[\frac{\theta\eta w_i}{w_N}\right]^{-\epsilon}, \quad \frac{x_N}{x_{ii}} = \left[\frac{w_N}{\alpha\eta\theta w_i}\right]^{-\epsilon}_{,} \tag{B.3}$$

Since relative wages are constant in the balanced growth equilibrium, all relative product demands are constant in equilibrium as well.

B2 Relative Product Shares

Using the balanced growth condition (3.20), and the definitions of the endogenous growth rates that determine the equilibrium of the model (3.6) & (3.9), equilibrium product shares are given by:

$$\frac{n_{Mi}}{n_N} = \frac{\dot{n}_{Mi}}{n_N}\frac{n_{Mi}}{\dot{n}_{Mi}} = \frac{\phi_i}{g} \tag{B.4}$$

Identical derivation produces:

$$\frac{n_{ii}}{n_{Mi}} = \frac{\mu_{ii}}{g}, \qquad \frac{n_{ij}}{n_{Mj}} = \frac{\mu_{ij}}{g}, \qquad \frac{n_{iN}}{n_N} = \frac{\mu_{iN}}{g} \tag{B.5}$$

Total variety shares across countries are given by:

$$\frac{n_i}{n_N} \quad = \quad \frac{n_{Mi} + n_{iN} + \sum_j^S n_{ij}}{n_N} \quad = \quad \frac{n_{Mi}}{n_N} + \frac{n_{iN}}{n_N} + \sum_j^S \frac{n_{ij}}{n_{Mj}} \cdot \frac{n_j}{n_N} \tag{B.6}$$

Using (B.4) & (B.5):

$$\frac{n_i}{n_N} \quad = \quad \frac{\phi_i + \mu_{iN}}{g} + \frac{\sum_j^S \mu_{ij}\phi_j}{g^2} \quad = \quad \frac{g\phi_i + g\mu_{iN} + \sum_j^S \phi_j\mu_{ij}}{g^2} \tag{B.7}$$

To derive expressions for the share of total products in the economy produced by Northern firms, multinationals, and imitating Southern firms respectively, recall from (3.22):

$$\Delta_N \equiv \frac{n_N}{n}, \quad \Delta_{MNC} \equiv \frac{\sum_i^S n_{Mi}}{n}, \quad \Delta_I \equiv \frac{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}{n} \tag{B.8}$$

Starting with Δ_N, consider:

$$\frac{1}{\Delta_N} = \frac{n_N}{n_N} + \frac{\sum_i^S n_{Mi}}{n_N} + \frac{\sum_i^S n_{iN}}{n_N} + \frac{\sum_i^S \sum_j^S n_{ij}}{n_N} \tag{B.9}$$

Using (B.4) & (B.5):

$$\frac{1}{\Delta_N} = 1 + \frac{\sum_i^S \phi_i}{g} + \frac{\sum_i^S \mu_{iN}}{g} + \frac{\sum_i^S \sum_j^S \phi_i \mu_{ij}}{g^2} \tag{B.10}$$

Rearranging yields:

$$\Delta_N = \frac{g^2}{g^2 + \sum_i^S g\phi_i + \sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_i \mu_{ij}} \tag{B.11}$$

Identical derivation produces:

$$\Delta_{MNC} = \frac{\sum_i^S g\phi_i}{g^2 + \sum_i^S g\phi_i + \sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_i \mu_{ij}} \tag{B.12}$$

$$\Delta_I = \frac{\sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_i \mu_{ij}}{g^2 + \sum_i^S g\phi_i + \sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_i \mu_{ij}} \tag{B.13}$$

Finally, to derive the proportion of all imitated products from Northern firms, foreign MNCs, and domestic MNCs respectively, recall from (3.23):

$$\delta_{IN} \equiv \frac{\sum_i^S n_{iN}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}, \quad \delta_{IFM} \equiv \frac{\sum_i^{S_{-j}} \sum_j^{S_{-i}} n_{ij}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}}, \quad \delta_{IDM} \equiv \frac{\sum_i^S n_{ii}}{\sum_i^S n_{iN} + \sum_i^S \sum_j^S n_{ij}} \tag{B.14}$$

Again using (B.4) & (B.5), and applying the same argument used to derive (B.11), we see:

$$\delta_{IN} = \frac{\sum_i^S g\mu_{iN}}{\sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_j \mu_{ij}}, \quad \delta_{IFM} = \frac{\sum_i^{S_{-j}} \sum_j^{S_{-i}} \phi_j \mu_{ij}}{\sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_j \mu_{ij}}, \quad \delta_{IDM} = \frac{\sum_i^S \phi_i \mu_{ii}}{\sum_i^S g\mu_{iN} + \sum_i^S \sum_j^S \phi_j \mu_{ij}} \tag{B.15}$$

B3 Derivation of Equilibrium Conditions

To derive the equilibrium conditions from free entry, begin by substituting for innovation/imitation costs (3.5) & (3.7) & PV of profits (3.18) & (3.19) into each term of (3.28). The first term becomes:

$$\frac{w_N a_N g^\beta n_{Mi}}{w_i a_{ii} \mu_{ii}^\beta n} = \frac{\pi_N}{\pi_{ii}} \frac{\rho + g}{\rho + g + \sum_i^S \mu_{iN}} \tag{B.16}$$

Substitute (3.13) & (3.15) for flow profits to find:

$$\frac{w_N a_N g^\beta n_{Mi}}{w_i a_{ii} \mu_{ii}^\beta n} = \frac{(1-\alpha) w_N x_N}{\alpha(\theta - 1)\eta w_i x_{ii}} \frac{\rho + g}{\rho + g + \sum_i^S \mu_{iN}} \tag{B.17}$$

Rearranging yields (3.29) in the text. Similarly expand the second term of (3.28) to obtain:

$$\frac{w_i a_{ii} \mu_{ii}^\beta}{w_j a_{ji} \mu_{ji}^\beta} = \frac{\pi_{ii}}{\pi_{ji}} \tag{B.18}$$

Substitute (3.15) & (3.17) to find:

$$\frac{w_i a_{ii} \mu_{ii}^\beta}{w_j a_{ji} \mu_{ji}^\beta} = \frac{(\theta - 1) w_i x_{ii}}{(\theta w_i - w_j) x_{ji}} \tag{B.19}$$

Rearranging yields (3.30). Finally, expand the last term of (3.28) to obtain:

$$\frac{a_{ii} \mu_{ii}^\beta}{a_{iN} \mu_{iN}^\beta} = \frac{\pi_{ii}}{\pi_{iN}} = \frac{(\theta - 1)\alpha x_{ii}}{(1-\alpha) x_{iN}} \tag{B.20}$$

Note that $\frac{a_{ii}}{a_{iN}} = \frac{1}{\gamma_N}$, and rearrange to obtain (3.31) as in the main text.

Labor market clearing conditions also use free entry to derive expressions for product demands. Starting from (3.32), consider the free entry into innovation condition:

$$\frac{w_N a_N g^\beta}{n} = \frac{(1-\alpha) w_N}{\alpha(\rho + g + \sum_i^S \mu_{iN})} x_N \Rightarrow x_N = \frac{a_N g^\beta \alpha (\rho + g + \sum_i^S \mu_{iN})}{n(1-\alpha)} \tag{B.21}$$

Recall that $g \equiv \frac{\dot{n}}{n}$, and substitute (B.21) into (3.32) to obtain (3.33).

To derive (3.35), note that $\frac{\dot{n}_{ij}}{n_{Mj}} = \frac{\dot{n}_{ij}}{n_{ij}} \frac{n_{ij}}{n_{Mj}} = g \frac{n_{ij}}{n_{Mj}}$ & $\frac{\dot{n}_{iN}}{n_N} = \frac{\dot{n}_{iN}}{n_{iN}} \frac{n_{iN}}{n_N} = g \frac{n_{iN}}{n_N}$. Use free entry to derive expressions for demands of imitated products:

$$\frac{w_i a_{ii} \mu_{ii}^\beta}{n_{Mi}} = \frac{(\theta - 1)\eta w_i}{\rho + g} x_{ii} \Rightarrow x_{ii} = \frac{(\rho + g) a_{ii} \mu_{ii}^\beta}{n_{Mi}(\theta - 1)\eta} \tag{B.22}$$

$$\frac{w_i a_{ij}\mu_{ij}^{\beta}}{n_{Mj}} = \frac{(\theta w_j - w_i)\eta}{\rho + g} x_{ij} \Rightarrow x_{ij} = \frac{(\rho+g)a_{ij}\mu_{ij}^{\beta}}{n_{Mj}(\theta\frac{w_j}{w_i} - 1)\eta} \tag{B.23}$$

$$\frac{w_i a_{iN}\mu_{iN}^{\beta}}{n_N} = \frac{(1-\alpha)\eta w_i}{\rho + g} x_{iN} \Rightarrow x_{iN} = \frac{(\rho+g)a_{iN}\alpha\mu_{iN}^{\beta}}{n_N(1-\alpha)\eta} \tag{B.24}$$

Finally, from (B.4), note that $x_{Mi} = \alpha^{\epsilon} x_{ii}$. Substitute (B.22)-(B.24) into (3.34) to obtain (3.35).

B4 Derivation of Equilibrium FDI Flows

Begin by considering:

$$\frac{1}{\kappa_i} = \frac{n_{Mi}}{\dot{n}_{Mi}} + \frac{V_{iN}n_{iN}}{V_{Mi}\dot{n}_{Mi}} + \frac{\sum_j^S V_{ij}n_{ij}}{V_{Mi}\dot{n}_{Mi}} \tag{B.25}$$

Note that $\frac{n_{Mi}}{\dot{n}_{Mi}} = \frac{1}{g}$, and impose free entry:

$$\frac{1}{\kappa_i} = \frac{1}{g} + \frac{c_{iN}n_{iN}}{c_N\dot{n}_{Mi}} + \frac{\sum_j^S c_{ij}n_{ij}}{c_N\dot{n}_{Mi}} \tag{B.26}$$

Expand using (3.5) & (3.7):

$$\frac{1}{\kappa_i} = \frac{1}{g} + \frac{w_i a_{ii}}{w_N a_N}\Big[\frac{n\ n_{ii}}{n_{Mi}\ \dot{n}_{Mi}}\big(\frac{\mu_{ii}}{g}\big)^{\beta} + \gamma_N\frac{n\ n_{iN}}{n_N\ \dot{n}_{Mi}}\big(\frac{\mu_{iN}}{g}\big)^{\beta} + \frac{\gamma_S\ n}{\dot{n}_{Mi}}\sum_j^{S_{-i}}\frac{n_{ij}}{n_{mj}}\big(\frac{\mu_{ij}}{g}\big)^{\beta}\Big] \tag{B.27}$$

Multiply by $\frac{n_{Mi}}{n_{Mi}}$, again noting $\frac{n_{Mi}}{\dot{n}_{Mi}} = \frac{1}{g}$:

$$\frac{1}{\kappa_i} = \frac{1}{g}\Big(1 + \frac{w_i a_{ii}}{w_N a_N}\frac{n}{n_{Mi}}\Big[\frac{n_{ii}}{n_{Mi}}\big(\frac{\mu_{ii}}{g}\big)^{\beta} + \gamma_N\frac{n_{iN}}{n_N}\big(\frac{\mu_{iN}}{g}\big)^{\beta} + \gamma_S\sum_j^{S_{-i}}\frac{n_{ij}}{n_{mj}}\big(\frac{\mu_{ij}}{g}\big)^{\beta}\Big]\Big) \tag{B.28}$$

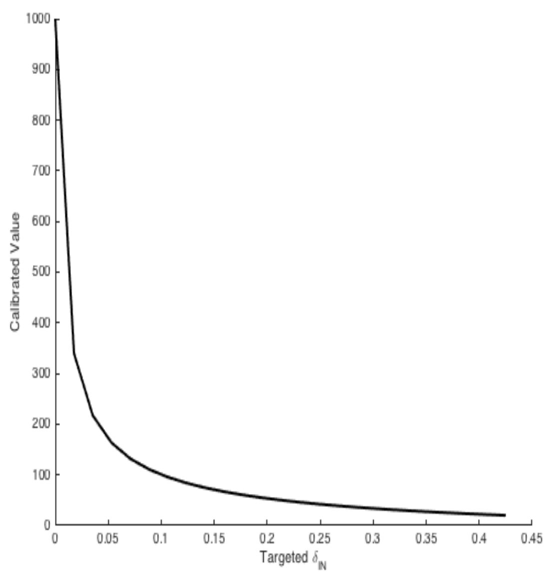
Rearrange to obtain (3.37) as in the text.

Appendix C

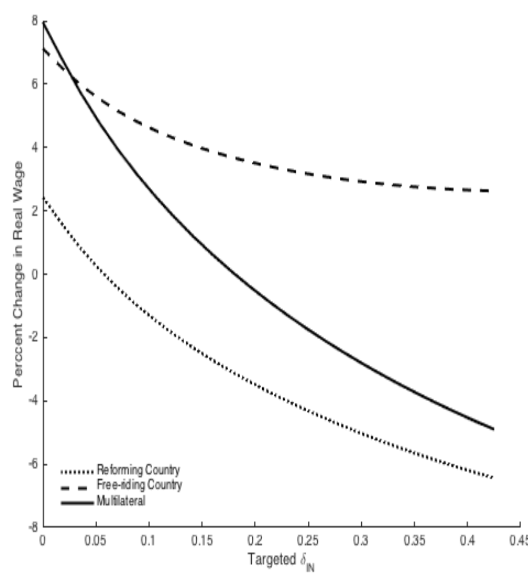
In appendix C I consider the robustness of the model's main results to the targeted composition of imitated products (δ_{IN}, δ_{IFM}, and δ_{IDM}). As Lai (1998) argued, the effects of IPRs reform in the South depends crucially on the channel of production transfer into the South. Specifically, he emphasized that if production transfer via direct imitation of Northern firms is sufficiently important relative to that via FDI, the costs of IPRs reform outweigh the benefits for developing countries. This result is present in my model as well. To see this, Figure C1 displays the implications of different calibration targets of δ_{IN} in the post-TRIPS equilibrium. That is, all other targeted moments remain as in the text, while δ_{IN} varies along the horizontal axis. $\delta_{IN} = 0.15$ corresponds to the case analyzed in the main text.

Figure C1: Implications of δ_{IN}

(a) Calibrated γ_N



(b) Change in $\frac{w}{P_0}$

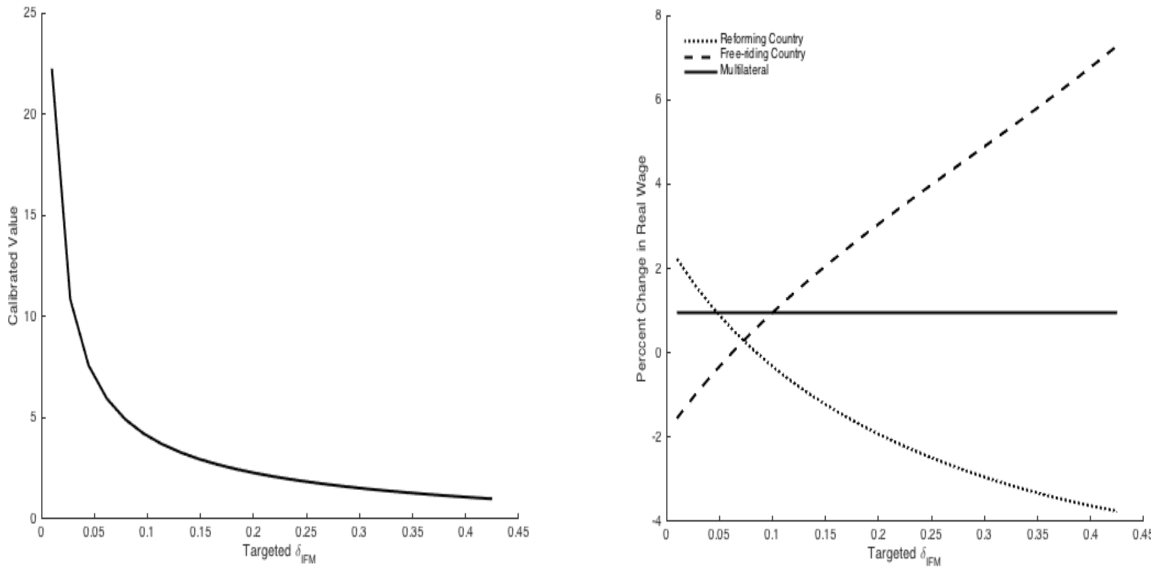


Since γ_N governs the relative difficulty of imitation of a Northern variety, the calibrated value of γ_N decreases monotonically with the targeted δ_{IN}. Panel (b) shows that, as in Lai (1998), the benefits of IPRs reform decrease as imitation of Northern products becomes a more important form of technology transfer. For sufficiently high δ_{IN}, neither reciprocal nor unilateral reform is advantageous for developing countries in the short-run.

My model introduces another form of production transfer; the shifting of production within developing countries via imitation of foreign MNCs. Analogous to C1, Figure C2 plots the implications of different calibration targets for δ_{IFM} in the post-TRIPS equilibrium, holding all other moments as in the main text. Note that this holds the overall importance of production transfer via imitation of Northern fixed, and implicitly adjusts δ_{IDM}, so that $\delta_{IN} + \delta_{IDM} + \delta_{IFM} = 1$. The intermediate value of $\delta_{IFM} = 0.25$ is analyzed in the main text.

Figure C2: Implications of δ_{IFM}

(a) Calibrated γ_S (b) Change in $\frac{w}{P_0}$



To accommodate the larger share of imitated products originating from foreign MNCs, γ_S decreases monotonically with δ_{IFM}. The highest value of δ_{IFM} considered corresponds to $\delta_{IFM} = \delta_{IDM} = 0.425$, and $\gamma_S = 1$. Due to the model's symmetry, the value of δ_{IFM} does not impact the welfare implications of multilateral reform. However, it has obvious implications for the impact of unilateral reform. When the flow of production via imitation of MNCs is sufficiently low, the ability of the non-reforming country to meaningfully free-ride is lost, and unilateral reform is beneficial. However, the benefit of unilateral reform decreases monotonically in δ_{IFM}, and for even modest values, unilateral reform becomes detrimental in the short-run. The change in $\frac{w}{P_0}$ becomes negative for the reforming country at approximately $\delta_{IFM} = 0.087$. The increase in $\frac{w}{P_0}$ for the free-riding country becomes larger than that of multilateral reform at approximately $\delta_{IFM} = 0.11$.

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