Abstract

The issue of Intellectual Property Rights (IPRs) in the North-South context has been the subject of some controversy. The question that has been raised is whether a stronger IPR regime is beneficial or harmful for the South. While a stronger IPR enforcement can increase innovation in the North, it reduces the rate of adoption of new technology by the South. This paper attempts to address this issue with the help of a North-South general equilibrium model of endogenous growth. The model is solved numerically for reasonable parameter values. The main result of the paper is that the South always loses (and the North always gains) from a stronger IPR regime. This suggests that in the absence of adequate compensation schemes there will be a genuine conflict of interest between the North and the South over this issue.

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1 Introduction

The enforcement of intellectual property rights (IPRs) was an important issue in the Uruguay Round of GATT negotiations. While some agreement was reached regarding their enforcement, IPRs still continue to be a controversial issue in LDCs. While proponents emphasize the positive effects on innovation, opponents focus on the negative effects on the development process of LDCs and on consumer welfare. The interesting question is under what conditions will IPR enforcement increase (or decrease) welfare for the South given that there is this trade-off.

The analysis of IPR enforcement in a North-South context has been done mostly in a partial equilibrium framework (e.g. Chin and Grossman (1990), Deardorff (1992), Diwan and Rodrik (1991) and Zigic (1998)). The obvious problem with using a partial equilibrium framework is that we cannot make any claims about the economy as a whole. General equilibrium results can differ substantially from partial equilibrium results. The model presented in Helpman (1993), which is a general equilibrium model and is discussed below, is a stark example of this. Also, one cannot say anything about macroeconomic variables like per capita income, growth or the terms of trade, which are of interest to policy makers, with the help of partial equilibrium models. There are two competing effects of a stronger IPR regime, as far as the South is concerned. On one hand, a stronger IPR regime is beneficial because it increases the innovation rate. On the other hand, a stronger IPR regime reduces the rate of adoption of new technology in the South. This may have the effect of forcing less developed countries to produce goods that command a low relative price in world markets, thereby reducing their terms of trade and welfare (this mechanism occurs in the model presented in this paper). The question is whether the South gains or loses from a stronger IPR regime, given that there are these two effects. This is the issue we try to address in this paper.

The only paper that deals with the issue of IPR enforcement in the North-South context in a general...
equilibrium framework is Helpman (1993). His model also has the advantage of having endogenous growth and trade. A model with endogenous growth and trade is the right framework to look at the effects of IPR enforcement in the North-South context since it is endogeneity of the innovation process that makes IPRs important and it is trade which makes it an issue between the North and the South. It is unlikely that Northern firms would care about IPR enforcement in the South if they did not export to or compete with imports from the South. Helpman tries to answer the question whether IPR enforcement is good for the South or not in the presence of this trade-off between the terms of trade effect and the growth effect. Unfortunately, in his model IPR enforcement reduces innovation in the steady state. This a consequence of the general equilibrium nature of his model and is a result that is not obtained in any partial equilibrium model. Since IPR enforcement decreases innovation in the Helpman model, there is no trade-off to be considered for the South. IPR enforcement is always bad for the South since it reduces innovation and also reduces its terms of trade. It may or may not be good for the North. Therefore, the issue is not dealt with satisfactorily in Helpman's model.

The reason that IPR enforcement decreases innovation in Helpman's model is the following. In his model innovation takes the form of increased varieties and the profit rate depends on the output per variety. With a fixed amount of labor in the North as the number of varieties in the North increases as a result of IPR enforcement, the output per variety falls. This reduces the profit rate and therefore the inducement to invest and growth. In other words, since there is a limited amount of labor resources in the North, when a greater fraction of varieties is produced in the North, resources are diverted away from innovation towards the production of these varieties.

In order to get back to the more intuitive result that IPR enforcement increases innovation we need another sector from which the innovative sector can draw resources when a greater number of varieties is being produced in the North. Such an assumption seems reasonable. It is difficult to believe that the
innovation sector gets stunted due to a lack of resources in a large economy such as the US. There will be other sectors from which to obtain resources. In the model described below we introduce a third sector (besides the varieties and the R & D sectors) in the Helpman model. This allows us to have an increase in the growth rate as a result of an increase in IPR enforcement. We then analyze the effects of IPR enforcement on the welfare of the North and the South. We derive numerical solutions using reasonable parameter values to evaluate the effects of IPRs since deriving analytical conditions is difficult because of the highly non linear nature of the system. We find that the South always loses and the North always gains from stricter IPR enforcement for the "feasible" range of imitation rates.

This paper is organized as follows. Section 2 describes the model. Section 3 describes the effect of IPR enforcement on growth and welfare. Section 4 describes the numerical results. Section 5 concludes.

2 The Model

Assume there are two regions - North and South. North is developed and is capable of innovation while the South is underdeveloped and cannot innovate. Firms in the South can only imitate technology that is invented in the North. We will assume that intellectual property rights are protected in the North. That is, Northern rms are protected from other Northern rms but not from Southern rms. This seems like a reasonable assumption since this is the state of affairs in the world today. A Northern government has the means the enforce its laws over its own rms but not over rms from other countries. It can, of course, ban the imports of Southern rms but that involves trade policy which can be problematic. There is no IPR protection in the South. We will assume that at each instant the South imitates a constant fraction of the varieties produced in the North.

There are three sectors - two consumption goods sectors X and Y and one R & D sector. Each
consumption goods sector consists of a number of varieties. The R & D sector creates new varieties for the X sector only. We will assume that there is no innovation in the Y sector. We will assume that the producer in the North of each variety in both the X and Y sector enjoys market power \(^1\). We will also assume that all Northern producers of X varieties face identical demand and cost conditions. The same is true for all producers of Y varieties.

There is only one factor of production - labor. It is used both for the production of goods as well as R&D. We will assume that the supply of labor in both the North and the South is exogenous and fixed and each household in both the North and the South supplies 1 unit of labor inelastically.

We will assume that the South specializes in the production of the X good. That is, the South can imitate varieties only in the X sector. They cannot produce the varieties in the non innovative Y sector. Therefore, while a fraction of existing varieties in the X sector are produced in the South, all the varieties in the Y sector are produced in the North \(^2\).

There can be two interpretations of the Y sector. The z varieties in the Y sector can either be consumption goods that are directly consumed or they can be thought of as different kinds of inputs that can be costlessly assembled to make the composite commodity Y. LDCs require a number of essential inputs from developed nations that they cannot produce themselves either because they are too difficult to imitate or

\(^1\) The producer of each X variety needs to enjoy market power since the profits provide the incentive for innovation. Since there is no innovation in the Y sector, there is no reason for the presence of market power in this sector. This assumption has been made to simplify the model.

\(^2\) The assumption that the South specializes in the production of the X good is also a simplifying assumption. A model in which both the North and the South produce some amount of the Y good would make the analysis more difficult. However, it is critical for the results of this paper to hold that the North produce some amount of the Y good. That is, it is important that the North does not specialize in the production of the X good. If the North specializes in X then more varieties in the X sector can be produced in the North only by reducing significantly the output per variety. This will reduce the profit rate per variety.
because they are too costly to manufacture because of their capital intensity. The primary metals industry would be a good example of this category of goods. On the other hand, the X varieties can be thought of as goods that are easy to imitate e.g. pharmaceuticals, computer software, audio cassettes etc. The demand for stricter IPR protection has come mainly from these sectors. The Y sector should have two characteristics. Varieties in this sector should not be symmetric to the varieties in the X sector, i.e., sales per variety in the Y sector can be different from sales in the X sector in equilibrium. One way to think about the Y sector is to assume that it is an industry that is distinct from the X industry even at a low level of disaggregation. Also, there should be no innovation in the Y sector. It will be important to keep these characteristics in mind when we choose our parameter values for our numerical simulations.

We will assume that production in the South takes place under perfect competition and all Southern producers face identical demand and cost conditions. we will also assume that wages are lower in the South. Therefore, when Southern firms learn to imitate a particular variety, they take over the world production of that variety.

We will assume that there are no international capital flows although there is trade in goods.

We will assume that both the North and the South derive utility from increased varieties of both the X as well as the Y commodity. There is no uncertainty in this model. Households have rational expectations. The utility function for the infinitely lived representative household in both the North and the South takes the following form

$$U = \int_0^1 e^{i \frac{1}{2} [\frac{3}{4} \log C_{xt} + (1 - \frac{1}{4}) \log C_{yt}]} dt$$

where $\frac{1}{2}$ is the subjective discount rate and

$$C_{xt} = \int_0^1 \frac{\partial C_{xt}}{\partial t}$$

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where $n_t$ is the number of varieties in the X sector at time $t$ and $c_{xt}$ is the amount of each variety consumed.

\[
C_{yt} = Z \int_0^z c_{yt} \text{d}t
\]

where $z$ is the number of varieties in the Y sector and $c_{yt}$ is the amount consumed of each variety in that sector. we will assume that $z$ is fixed.

One implication of this utility function is that a constant fraction $\frac{3}{4}$ of the consumption budget is spent on the X commodity as a whole (i.e. including all varieties) and a fraction $1 - \frac{3}{4}$ is spent on the Y good. Another implication is that the price elasticity of demand, which we will denote by $2$ for each variety in both the X and the Y sector is a constant and is as follows

\[
2 = \frac{1}{1 - \frac{3}{4}}
\]

Since there are certain asymmetries between the North and the South, we will discuss them separately.

The North

Let us consider the North first. we will assume that the representative household in the North inelastically supplies 1 unit of labor and maximizes the following utility function

\[
U = \int_0^1 e^{\frac{1}{4}t[\frac{3}{4}\log c_{xt} + (1 - \frac{3}{4})\log c_{yt}]} \text{d}t
\]

subject to the budget constraint that for all $t$ (We have suppressed the time subscripts to maintain clarity)

\[
k = w_N + r k_{i} n_N c_{xNN} + n_S p_S c_{xNS} + z p_Y c_{yNN}
\]

and a terminal condition

\[
\lim_{t \to 1} k_t e^{r v} = 0
\]
where \( k \) is the nominal value of assets which each representative household holds, \( r \) is the nominal interest rate, \( w_N \) is the wage rate in the North, \( n_N \) and \( n_S \) are the number of X varieties produced in the North and the South, respectively, \( p_N \) and \( p_S \) are the prices of Northern X varieties, respectively and \( p_Y \) is the price of the Y variety produced in the North. The variables \( c_{xNN}, c_{xNS} \) and \( c_{yNN} \) denote consumption in the North of Northern X varieties, Southern X varieties and the Y varieties, respectively. we have made use of the fact that all Northern producers of the X varieties face identical demand and cost conditions so that the price and consumption is the same for all Northern X varieties, and Y varieties. The budget constraint states that savings, which takes the form of accumulation of \( k \), will equal the difference between total income (wage income + interest income) and total consumption expenditure.

The dynamic optimization problem of the representative consumer of the North leads to the following first order condition

\[
\frac{E_N}{E_N} = r \frac{1}{\frac{1}{2}}
\]  

(1)

where \( \frac{1}{2} \) is the subjective discount rate or the rate at which the consumer discounts future utility and \( E_N \) is the total nominal consumption expenditure in the North.

Given the utility function we have the following expression for demand in the North for a particular variety \( i \) (produced either by a Northern or a Southern producer) in the X sector at each instant.

\[
c_{xNi} = \frac{p_i^{1/2}}{n_N p_N^{1/2} + n_S p_S^{1/2}} \frac{3/2}{E_N}
\]  

(2)

where \( ^2 \) is the price elasticity of demand, \( p_i \) is the price of the \( i \)th variety and \( c_{xNi} \) is the demand for the \( i \)th X variety in the North.

The demand in the North for each variety in the non innovative Y sector is as follows

\[
c_{yNi} = \frac{(1/4) E_N}{zp_Y}
\]  

(3)
where, \( p_Y \) is the price of each variety in the Y sector and is identical for all the varieties in this sector since all the varieties are produced in the North and \( c_{yNi} \) is the demand for the ith Y variety in the North.

We will assume that in the X sector, each innovator is granted an infinitely lived patent in the North. That is, no other Northern rm can produce the same variety. The innovator enjoys this patent as long as it is not imitated by a Southern rm. The producer of a variety in the X sector in the North can charge a monopoly price for his/her product if it is not imitated. Once it is imitated, then the product is produced in the South with price equal to the marginal cost in the South, since anyone in the South can produce the product.

We will assume that in the non innovative sector Y also, the producer of each variety enjoys monopoly power. This market power may be due to various barriers to entry arising due to technology or government regulation. Since these varieties cannot be imitated by the South each Y variety is always produced under monopoly conditions. The assumption that these varieties are produced under monopoly conditions makes the analysis easier.

We will assume that 1 unit of labor is needed to produce 1 unit of any X or Y variety. These assumptions lead to the following price relations. In the X sector, the price of each variety produced in the North is

\[
p_N = \frac{w_N}{\mathbb{R}}
\]

where \( w_N \) is the Northern wage, where \( 1=\mathbb{R} \) is the mark up and is equal to \( 1=(1; 1=?) \).

The price of each y variety is

\[
p_y = \frac{w_N}{\mathbb{R}}
\]

Equations (4) and (5) imply that the price of each Northern X variety is the same as that of each Y variety.

Let us now consider the R&D sector. we will assume that \( a=n \) units of labor are needed to produce 1 unit of innovation i.e. 1 new variety. This implies that productivity in innovation increases as the
cumulative stock of knowledge in the economy rises. This stock of knowledge is assumed to equal the number of varieties \( n \). There is, therefore, an externality arising from the production of new varieties. This also implies that if the number of new varieties created at each instant is \( n \) then the labor required to produce these new varieties will be

\[
ag = \frac{an}{n} = ag
\]

where \( g \) is the growth rate in the number of varieties. That is the labor required to produce the new varieties will be the growth rate times the measure of productivity in the R & D sector.

We will assume that R & D is produced under perfect competition. Therefore, the value of an innovation, denoted by \( v_N \), has to equal the cost of innovation. Therefore,

\[
v_N = \frac{aw_N}{n} = \frac{aw}{n}
\]

(6)

Let us now consider the factor market. The labor market equilibrium condition in the North is as follows

\[
ag + n_N x_N + zy = L_N
\]

(7)

where \( L_N \) is the population in the North, \( x_N \) is the amount of each X variety produced in the North and \( y \) is the amount of each Y variety produced and \( ag \) is the labor used up in the R & D sector.

The only asset that people hold in this model is the right to an innovation which yields a stream of profits until it is imitated by a Southern firm. Since all X varieties (both new and old) produced in the North earn the same amount of profits, they all have the same value \( v_N \). Therefore, in equilibrium, the \( k \) or the nominal value of assets held by the representative household is as follows

\[
k = \frac{n_N v_N}{L_N}
\]

(8)

That is, the total value of assets held by all agents in the North has to equal the number of varieties produced in the North times the value of each variety.
Equilibrium in the capital market requires\(^3\)

\[
\frac{1}{v_N} + \frac{v_N}{\nu} = r + m
\]  

(9)

The equation above states that the interest rate earned by the representative household has to equal the profit rate plus capital appreciation minus the imitation rate.

Let us define a new variable \(V\) such that \(V = \nu_{vN}\) and \(\gamma\) such that \(\gamma = zy\). The latter variable denotes the total amount of the \(Y\) goods produced. Since 1 unit of labor is required to produce 1 unit of the \(Y\) variety it also denotes the total labor used up in the production of the \(Y\) varieties. We will provide an interpretation for \(V\) later in this section.

Using equations (6), (4) and the definition of \(V\), we get

\[
\alpha \beta V = \frac{1}{p_N}
\]  

(10)

Nominal consumption expenditure in the North \(E_N\) has to equal income minus savings. Income will equal the total value of goods produced in the economy (both consumption goods as well as investment). This will equal \(p_N n_N x_N + p_N y = zy + v_N (\nu n_N + \nu_N)\). Savings will equal the amount spent on creating new varieties i.e. \(v_N (\nu n_N + \nu_N)\). Therefore, nominal consumption expenditure will equal

\[
E_N = p_N n_N x_N + p_N zy
\]  

(11)

Following Grossman and Helpman (1991), we will choose nominal consumption spending in the North \(E_N\) to be the numeraire. This is a bit unconventional but turns out to be quite convenient. This choice of numeraire, along with equation (11), the definition of \(\gamma\) and the fact that the price of each Northern \(X\) variety is the same as the price of each \(Y\) variety, lead to the following equation.

\[
n_N x_N + \gamma = \frac{1}{p_N}
\]  

(12)

\(^3\)See Mazumdar (1996) for details.
Since \( p_N \) is the price of the Northern X varieties and the consumption expenditure equals 1, the right hand side of equation (12) is real consumption expenditure in terms of Northern X varieties. The left hand side of the equation is the total amount of Northern X varieties and Y varieties produced. The equation states that \( \text{"real"} \) consumption in terms of the X good must equal real production of the X good and the Y good in the North i.e. the consumption goods in the North.

Using equations (10) and (12), we get

\[
n_N x_N + y = a \hat{\alpha} V
\]

(13)

The interpretation of \( V \) implied by equation (13) will be useful for subsequent analysis. The equation states that \( V \) times a constant is the total amount of labor used up for the production of consumption goods X and Y. As \( V \) increases, the labor used up in the consumption goods sectors increases proportionally. Since there is a fixed amount of labor in the North, an increase in \( V \) will mean less labor available for the R&D sector which will imply less growth. This relation is expressed in the following equation which has been derived from the labor market equilibrium condition in the North (equation 7) and equation (13).

\[
g = \frac{L_N}{a} \hat{\alpha} V
\]

(14)

\( \hat{\alpha} V \) has the interpretation of real consumption expenditure from equation (12). Therefore a high \( V \) implies that real consumption expenditure in the North is high.

Since \( E_N \) is the numeraire, \( E_N \) equals 0. This fact and equation (1) imply

\[
r = \frac{1}{2}
\]

(15)

That is, the interest rate always equals the subjective discount rate, regardless of whether the economy is in a steady state or not.\footnote{In this model the consumption can grow over time although the interest rate equals the discount rate always. This is}
The profits of a Northern firm in the X industry, denoted by $\pi_N$, are as follows

$$\pi_N = (1 - \beta) P_N X_N = (1 - \beta) \bar{w}_N X_N$$  \hfill (16)$$

Equations (16) and (6) imply that the profit rate of a Northern firm in the X industry will be as follows

$$\frac{\pi_N}{\pi_N} = (1 - \beta) n x_N$$  \hfill (17)$$

Equation (17) specifies a crucial relation in this model. It states that the profit rate depends on the number of varieties in existence and the output per variety. If the North decides to produce a greater share of the existing varieties then while the total number of varieties $n$ will not change, $x_N$ will. If the total amount of labor employed in the X sector is a constant then as the number of varieties produced by the North rises, the output per variety $x_N$ falls leading to a fall in the profit rate. That is, if the North produces a larger share of existing varieties (due to increased IPR enforcement, say) then the profit rate per variety falls. This plays a crucial role in this model and is responsible for Helpman’s result that increased IPR enforcement reduces growth, as we will see later.

If we substitute the expression for $x_N$ from equation (13) in the expression for the profit rate in equation (17) then we get

$$\frac{\pi_N}{\pi_N} = (1 - \beta) n x_N$$  \hfill (18)$$

The equation states that an increase in $n_N$ relative to $n$ or the share of the North in the all existing varieties will decrease the profit rate. An increase in $V$ will increase the profit rate because a larger amount of labor because the price level relative to nominal expenditure can change. If we think of the household’s inter-temporal problem in discrete time then the household will shift consumption to the future until $(1 + r) u'(c) = (1 + \beta)(1 + r) u'(c+1)$. That is, in equilibrium the marginal utility from a dollar spent today, which is the amount of goods bought $1 + \beta$ times the marginal utility should equal the marginal utility of a dollar spent tomorrow adjusted for the interest rate and the discount rate. If $r = \frac{1}{2}$ always then consumption today equals consumption tomorrow only if price today equals price tomorrow. Consumption can grow even with $r = \frac{1}{2}$ if the price declines from this period to the next.
will be devoted to the production of consumption goods. An increase in $y$-keeping $V$ constant will decrease the profit rate because as more labor gets diverted towards the production of $Y$ varieties, there will be less left for the production of $X$ varieties which will reduce their output and therefore the profit rate.

The South

The utility function of the South is the same as the North. However, since there are no assets to accumulate in the South, the representative households do not face an inter-temporal problem like their Northern counterparts. The Southern household maximizes its utility at each instant in time like in a static problem. Given the utility function we have the following expression for demand in the South for a particular variety $i$ (produced either by a Northern or a Southern producer) in the $X$ sector.

$$c_{xSi} = \frac{p_i^{1-\theta_n} n_{N} p_{N}^{1-\theta_n} z_{E}^{1-\theta_s}}{n_{N} p_{N}^{1-\theta_n} + n_{S} p_{S}^{1-\theta_s}}$$  \hspace{1cm} (19)$$

$c_{xSi}$ is the demand for the $i$th $X$ variety in the South. The demand in the South for each variety in the non innovative $Y$ sector is as follows

$$c_{ySi} = \frac{(1-\theta_s) z_{E}^{1-\theta_s}}{z_{p_y}}$$  \hspace{1cm} (20)$$

$c_{ySi}$ is the demand for the $i$th $Y$ variety in the South.

We will assume that in the South too, 1 unit of labor is needed to produce 1 unit of any $X$ variety that the South has imitated. we will also assume that the varieties in the South are produced under perfect competition. These assumptions lead to the following relation

$$p_S = w_S$$  \hspace{1cm} (21)
where \( p_S \) and \( w_S \) are the price of each Southern X variety and the wage in the South, respectively. We will assume that \( w_S \) is always lower than \( w_N \).

The South is not able to innovate. However, it can imitate Northern varieties. We will assume that it imitates a constant fraction \( m \) of the Northern varieties \( n_N \) that have not yet been imitated. We will assume that the imitation rate depends on the degree of enforcement of intellectual property rights. A stricter enforcement of IPRs will reduce the imitation rate \( m^5 \). We will model a stricter enforcement of IPRs as an exogenous decrease in \( m \). My assumptions about the imitation rate implies

\[
\begin{align*}
n_S &= mn_N & (22) \\
\end{align*}
\]

The labor market equilibrium condition for the South is

\[
\begin{align*}
n_S x_S &= L_S & (23) \\
\end{align*}
\]

where \( L_S \) is the population of the South and \( x_S \) is the amount of each Southern variety produced.

The nominal expenditure in the South has to equal nominal income since there are no savings in the South and there are no international capital movements. Therefore, we have

\[
\begin{align*}
E_S &= p_S L_S = w_S L_S & (24) \\
\end{align*}
\]

The International Equilibrium

Using equations (2) and (19), we get

\[
\begin{align*}
c_{x_Nj} + c_{x_Sj} &= x_j = \frac{p^i_j}{n_N p_N + n_S p_S} - \frac{3}{4} (E_N + E_S) & (25) \\
\end{align*}
\]

\(^5\) The imitation rate may be a function of other factors. In this paper I will consider the effect of IPR on \( m \) only.
where $j = \text{N;S}$. We have made use of the fact that in equilibrium the total consumption of a $X$ variety from each region has to equal the supply of that variety. We have also used the fact that the producers of all $X$ varieties in the North are identical and so are all producers in the South (the producers in the North are, of course, different from those in the South).

Using equations (3) and (20), we get

$$c_yN + c_yS = y = \frac{(1 - \theta)(E_N + E_S)}{zp_y}$$

(26)

Here again we have made use of the fact that total consumption of $Y$ has to equal total supply and the fact that the producers of all $Y$ varieties are identical. Using equation (25) we can get the ratio of the prices between the Northern $X$ varieties and the Southern $X$ varieties as follows

$$\frac{p_N}{p_S} = \frac{x_N}{x_S}^{\frac{1}{i - \frac{1}{2}}}$$

(27)

Although this ratio is between the price of the Northern $X$ varieties and the Southern $X$ varieties, it should be interpreted as the terms of trade between the North and the South since the price of the $Y$ varieties is the same as the price of the $X$ varieties produced in the North. Therefore, the terms of trade between the North and the South is a function of the output of each Northern and Southern variety that is supplied. The amount of each Southern variety that gets produced depends on the inelastic labor supply in the South and the number of varieties the South produces, as one can see from equation (23). The amount of each Northern variety that gets produced depends on the supply of labor in the North, the labor used up in the $Y$ and the R&D sector and the number of varieties that the North produces, as one can see from equation (7).

Let us define a new variable $\delta$ such that

$$\delta \cdot \frac{n_N}{n}$$
That is \( \theta \) is the share of Northern varieties. Using (23), (27), (7) and the definition of \( \theta \) we get

\[
\frac{p_N}{p_S} = \frac{L_S}{L_N} \cdot \frac{\theta}{\theta_N \cdot \theta_S}
\]  

(28)

We can see from the above equation that the higher is \( \theta \) or the share of varieties that the North produces, the higher will be the terms of trade of the North and lower will be the terms of trade of the South. This relation between the terms of trade and \( \theta \) will play a crucial role in this model. An increase in \( \theta \) or an increase in the number of varieties produced in the North (and a decrease in the number of Southern varieties) means that Northern labor gets distributed over a larger number of varieties which implies that a smaller amount of each variety is produced. The opposite is true for the South where a smaller number of varieties means that the output of each variety increases since the labor supply is inelastic. This means that Northern varieties become scarce relative to Southern varieties which increases the relative price of the Northern varieties.

The expression for the terms of trade in equation (28) includes the term \( L_N \cdot \theta \) in the denominator. One can see from the labor market equilibrium condition of the North (equation 7) that \( L_N \cdot \theta \) is the total amount of labor employed in the production of the consumption goods and therefore is equal to \( a \cdot \theta \) (from equation 13). The expression \( L_N \cdot \theta \) is the total amount of labor employed in producing the \( X \) varieties in the North. Using equation (13), (28) and the definition of \( \theta \) we get

\[
\frac{p_N}{p_S} = \frac{L_S}{a \cdot \theta_N \cdot \theta_S} \cdot \frac{\theta}{\theta_N \cdot \theta_S}
\]  

(29)

Using the fact that \( p_Y \) equals \( p_N \) and that \( E_N \) equals 1 and equations (12), (13), (24), (29) and the definition of \( \eta \), we can rewrite (26) or the equilibrium condition in the market for \( Y \) varieties as follows

\[
\eta = (1 \cdot \theta) \cdot \frac{\theta}{a \cdot \theta_S} + (1 \cdot \theta) \cdot \frac{\theta}{L_S} \cdot \frac{1}{a \cdot \theta_N \cdot \theta_S}
\]  

(30)

The first term on the right hand side of the above equation is the consumption of \( Y \) varieties in the North and is equal to the consumption share of the \( Y \) good times the real consumption expenditure in the
North \( a \bar{V} \) (equation 13). The second term on the right hand side is the consumption of the \( Y \) variety in the South and depends on the labor supply of the South and the terms of trade of the South.

Equation (30) defines \( y \) as a function of \( V \) and \( \circ \) as can be seen from Figure 1. \( y \) is measured along the horizontal axis while the l.h.s. and the r.h.s. of equation (30) are measured along the vertical axis. The plot of the l.h.s. of the equation is just the 45 degree line through the origin. The r.h.s. is a negatively sloped line, since it decreases with \( y \), and takes \( V \) and \( \circ \) as given. A solution for \( y \) exists and is unique for given \( V \) and \( \circ \). \( y \) is increasing in \( V \) and decreasing in \( \circ \).

Equation (30) will play a crucial role in this model. The term within large straight brackets raised to the power \( 1 = \frac{1}{2} \) on the right hand side of the equation is the terms of trade of the South. When IPRs are enforced and \( m \) goes down, the share of the South in the number of varieties in sector \( X \), \( \frac{1}{j} \), decreases. This reduces the terms of trade of the South since the South now produces fewer varieties which means that it produces more of each variety, driving down their price. A reduction in the terms of trade of the South reduces the consumption of the \( Y \) varieties in the South. Everything else remaining the same a reduction in the terms of trade of the South will reduce \( y \) or the output of the \( Y \) sector, as can be seen from equation (30). This releases labor in the North, and this labor can then be absorbed in the \( X \) sector and in the R & D sector. In the absence of this mechanism, as we will see later, \( g \) will not rise, replicating Helpman’s result. Substituting the expression for the profit rate from equation (18) into equation (9), which gives an expression for the interest rate \( r \), and using the fact that \( r \) has to equal \( \frac{1}{2} a \) and that \( V = \bar{V} \) has to equal \( \frac{1}{n} (n \bar{N} = \bar{V}_N \text{ (from the definition of } V) \text{ and the definition of } \circ \text{ we get,} \]

\[
\frac{\bar{V}}{\bar{V}} = i (g + \frac{1}{2} + m) + \left( \frac{1}{\circ} (V \bar{y} \bar{n}) \right) \]

(31)

Using the definition of \( \circ \) and the fact that the South imitates a constant fraction \( m \) of the Northern varieties we get an expression for the evolution of the share of Northern varieties over time,
The growth rate $g$ is a function of $V$ since the latter denotes the total amount of labor devoted to consumption goods and therefore the labor in the R & D sector. This relation is described by equation (14). $y$ is a function of $V$ and $\circ$ (given by equation (30)). Therefore, equations (31) and (32) (along with equations (14) and (30)) constitute a system of two differential equations in two unknowns $V$ and $\circ$.

In the steady state both $V$ and $\circ$ will be constants. Therefore we have (using equations (31) and (32)),

$$\frac{1}{\circ} \frac{d}{dV} \left( \frac{y}{\circ} \right) = g + \frac{1}{2} + m$$

(33)

and,

$$\circ = \frac{g}{m + g}$$

(34)

Equation (33) above is a no arbitrage condition. The right hand side of the equation represents the effective cost of capital or cost incurred in investment. It includes the discount rate since investment today implies postponing consumption and consumption in the future yields less utility than consumption in the present. It includes the imitation rate since a portion of the value of the capital stock is lost when Southern firms succeed in imitating the Northern varieties. This can be thought of as a depreciation rate. Here the depreciation does not come from any physical depletion but arises due to the loss in value when no more profits can be earned from a variety that has been imitated by the South. The cost of capital also includes the growth rate $g$ because as the number of varieties increases the same amount of labor has to be distributed over a large number of varieties. This means less of each variety will be produced which will reduce profits since they depend on the amount of each variety produced. The left hand side of equation (33) represents the profit rate. It depends on $a\circ V$ i.e. the total amount of labor resources engaged in the consumption goods sector, $y$ or the labor employed in the $Y$ sector and $\circ$ the share of North in the total labor.
number of X varieties produced. The equation states that in the steady state the effective cost of capital should equal the return from investment i.e. the profit rate.

In order to see the intuition behind equation (34) one can rewrite it as follows.

\[
g = \frac{m^o}{1 - \frac{\circ}{i}} = \frac{mn_N}{n_S}
\]

Here we have made use of the fact that \( \circ \) equals \( n_N = n \) and \( 1 - \frac{\circ}{i} \) equals \( n_S = n \). In equation (35), \( mn_N \) is the number of varieties imitated by the South in a particular period while \( n_S \) is the total number of varieties that the South produces. Therefore, the equation states that in the steady state the growth rate in the total number of varieties should equal the growth rate in the number of varieties produced by the South. That is, the varieties produced by the North and the South should grow at the same rate. If the number of varieties produced by the South grows at a faster rate than \( g \) then the fraction of varieties produced by the South increases and vice versa.

The phase diagram of the dynamic system defined by equations (31) and (32) is shown in figure 2. It is easy to show that the \( \circ = 0 \) locus is negatively sloped. The \( V = 0 \) locus has a positive slope if the following condition is satisfied (proof in Appendix).

\[
1_i \left[ (1 - \frac{\circ}{i}(1 - \frac{\circ}{i} \frac{1}{\circ}L_S \frac{1_i \circ}{\circ_{g + m + \frac{1}{2}}}) > \circ
\right]
\]

This condition is obviously not satisfied for \( \circ \) close to 1. However, we do not need to consider the entire 0 to 1 range for \( \circ \) since for given \( m \), the value of this variable is determined by \( g \) in the steady state (see equation 34) and the growth rate can never exceed \( L_N = a \) (see equation 14). Therefore, the maximum value of \( \circ \) in the steady state will be \( L_N = \left( L_N + am \right) \). This implies that the \( V = 0 \) locus will be positively sloped over the feasible range of \( \circ \) if the following holds

\[
1_i \left[ (1 - \frac{\circ}{i}(1 - \frac{\circ}{i} \frac{1}{\circ}L_S \frac{1_i \circ}{\circ_{g + m + \frac{1}{2}}}) > \frac{L_N}{L_N + am}
\right]
\]
The relevant $g$ in the condition above is the one implied by the $V = 0$ locus at $\theta = L_N = (L_N + a)m^6$. This is obtained by solving equations (33), (14) and (30) for $g$ at this value of $\theta$. This condition is satisfied in our numerical solutions for all values of $m$ greater than or equal to 2% (it is not satisfied when the rate is 1%). Therefore, the range of imitation rates we consider is 2% and above.

3 The Effects of IPR Enforcement

Let us now look at the effects of an increase in IPR enforcement. We will model this as a decrease in $m$. We will evaluate the effects of a decrease in $m$ on the steady state growth rate, Northern welfare and Southern welfare. We will ignore all transitional dynamics. This approach has been adopted for this highly non-linear system mainly for the sake of computational simplicity.

3.1 Growth

The effect of IPR enforcement on $g$ is ambiguous in this model. The intuition behind the result described above is the following. A decrease in the imitation rate will do two things. While it will decrease the effective cost of innovation, as reflected by the r.h.s of equation (33), it will also decrease the profit rate by increasing $\theta$, the share of Northern products, which we can see from the l.h.s. of the equation (33). If the latter effect is larger then the r.h.s. of equation (33) has to decrease at the new imitation rate $m$. This can be brought about by a decrease in $g$ i.e. the growth rate. This is the mechanism which operates in Helpman’s framework. If, on the other hand, the former effect is larger, i.e. the effect on the cost of innovation is larger than that on the profit rate then $g$ will increase. This is a possibility in the model.

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If the condition is satisfied along the $V = 0$ locus for $\theta = L_N = (L_N + a)m$ then it will be satisfied for all values of $\theta$ that are less than this value. This is because along the $V = 0$ locus as $\theta$ decreases, $V$ falls. This raises the value of $g$ since it is negatively related to $V$. This raises the l.h.s. of the inequality while a decrease in $\theta$ decreases the r.h.s. of the inequality.
presented in this paper, unlike the one in Helpman's paper.

3.2 Welfare

Since we will compare the effects of a change in the IPR regime across steady states, the question we will be asking about welfare is the following. What would the welfare of an infinitely lived household be under different IPR regimes if the economy were to instantaneously jump to the implied steady states? We will point out what the various components of welfare are. This will help us interpret the results in the numerical section.

Let us look at the welfare in the South first. Using the expressions for the quantity consumed in the South of each X and Y variety given by equations (19) and (20), respectively, the expression for the nominal expenditure in the South, \( E_S \), given by equation (24) and substituting them into the instantaneous utility function and taking the discounted sum of utilities over an infinite horizon we get an expression for Southern utility.

\[
U_S = K_S + \frac{(1 - \frac{\theta}{2})}{2} \log \frac{P_S}{P_N} + \frac{\theta}{2} \left( \frac{\theta}{\theta - 1} \right) \log \left( \frac{\mu}{\frac{P_S}{P_N}} \right) + (1 - \theta) \frac{1}{\theta - 1} \]  

(37)

where \( K_S \) is a collection of constants (we have assumed that the initial \( n \) is a constant).

The utility of the Southern consumer therefore depends on the terms of trade of the South, the number of varieties available and \( \theta \). The second term in the expression for Southern utility is the utility that is derived from the consumption of the Y good. It depends on the share of consumption on the Y good as well as the terms of trade since the South buys the Y good from the North. The third term represents the utility derived from the number of varieties available. It depends on the consumption share of the X good as well as innovation in the number of varieties. The fourth term represents the utility from the consumption of the X varieties. If the varieties are being produced in the North then the South has to buy
them at Northern prices so that its consumption of these varieties would depend on its terms of trade. This is represented by the first term within straight brackets. It is the product of the share of Northern products and an expression involving the terms of trade. If the varieties are produced in the South then of course the terms of trade does not matter for consumption in the South. The utility derived from consumption of Southern varieties in the South is represented by the term \((1 - \theta)\) within straight brackets.

A decrease in the imitation rate \(m\) will decrease the terms of trade of the South and will also decrease the share of Southern varieties. One can see that this will reduce the second and the fourth terms unambiguously. The consumption of the Y good will fall as a result of the decrease in the terms of trade. The consumption of the X varieties will also fall in the South because the share of Northern varieties increases and also because the terms of trade falls. An increase in the share of Northern varieties will reduce the consumption of these varieties in the South even without a terms of trade decrease. This is because the cost of production in the North is higher than in the South which makes varieties more expensive if they are produced in the North. If \(g\) decreases as a result of a decrease in imitation rates then the South is unambiguously worse off as result of IPR enforcement, as in Helpman's framework. If \(g\) rises then effect of IPR enforcement on Southern welfare is more ambiguous and this is the case we are interested in.

Using the expressions for the quantity consumed in the North of each X and Y variety given by equations (2) and (3), respectively, making use of the fact that the nominal expenditure in the North has been normalized to 1 and substituting them into the utility function we get an expression for Northern utility.

\[
U_N = K_N + \frac{1}{12}\log V + \frac{3}{2} \frac{g}{1^{1/2}} + \frac{3}{4} \frac{\log \theta}{\theta} + (1 - \theta) \frac{\mu_{N,S}}{\frac{\mu_{N,S}}{\theta}} (38)
\]

where \(K_N\) is a collection of constants.

In the expression for Northern utility the second term represents the utility from consumption. \(V\) as mentioned before, is a measure of real consumption expenditure. The higher is \(V\), the higher is consumption
in the North and the higher is the utility to the Northern consumer. We know from equation (14) that a higher $g$ will imply a lower $V$: The intuition behind this result is that a higher $g$ implies a larger amount of savings will be required to finance the increased R&D efforts and therefore real consumption will be lower. The third term in the expression for Northern utility is the utility derived from more varieties which is the same as in the case of Southern utility. The last term again represents the utility derived from the consumption of $X$ varieties. If the varieties are being produced in the South then the consumption of these varieties will depend on the terms of trade of the North. This is represented by the second term within straight brackets which is the product of the share of Southern varieties and an expression involving the terms of trade of the North. If the North produces the varieties, then the terms of trade does not matter. This is represented by the first term within straight brackets.

A decrease in $m$ will increase $\theta$ and raise the terms of trade of the North. The effects of these two changes can be seen in the last term of the expression for Northern utility. An increase in $\theta$ will reduce welfare (just as it does in the South) since a smaller fraction of goods will be produced in the cheaper location of production, i.e., the South. However, an increase in $p_N = p_S$ or the North's terms of trade will increase Northern welfare since the North will be able to acquire Southern products at a cheaper price (relative to its income). This is what leads to the conflict of interest between the North and the South. If the decrease in $m$ increases $g$, then the North will gain from increased innovation (the third term) but lose from lower consumption (the second term).

4 Numerical Results

In this section we analyze the effects of a stricter enforcement of IPRs (or a decrease in $m$) on growth and welfare in both the North and the South by solving the model numerically. We analyze how the different
parameters of the model influence the effects of IPR enforcement on the growth rate and welfare in the North and the South. We find numerical solutions to steady state of the system defined by equations (33) and (34) and then look at the effect of changing the imitation rate, \( m \), on the equilibrium values of the important variables in the model viz. the growth rate \( g \), the utility in the South and the utility in the North.

In order to come up with these numerical solutions one would like to use realistic values for the parameters for which estimates are available. The parameters of this model are the discount rate \( \frac{1}{2} \) the utility parameter \( \beta \) which determines the price elasticity of demand \( \eta \), the consumption share of the X goods \( \theta \) the productivity parameter in the R & D sector \( a \), the population of the North \( L_N \), the population of the South \( L_S \) and the imitation rate \( m \).

Estimates are available for the subjective discount rate and price elasticity of demand. The estimate of the subjective discount rate \( \frac{1}{2} \) that is used in the macroeconomics literature is around 4 % to 5 % \(^7\). We use a \( \frac{1}{2} \) equal to 0.05, which is a typical estimate used in the real business cycle literature (see e.g. Cooley and Prescott, 1995), in our numerical solutions. We use a price elasticity of demand equal to 2 which is derived from Robert Hall's estimate of mark ups for two-digit industries (Hall 1990). About half the industries in Hall's sample have mark ups which imply an elasticity around 2. This implies an \( \beta \) equal to 0.5. The share of innovative industries in consumption, \( \theta \), depends on our definition of non innovative industries. Industries whose R&D expenditures are less than 1% of their net sales are classified as non innovative industries. Food and kindred products (including tobacco), petroleum refining and extraction and primary metals fall into this category. We use their share in U.S. manufacturing value added as a

\(^7\) The estimates are obtained from a steady state condition in representative agent models which requires that the rate of return to investment adjusted for the depreciation rate and the growth rate should equal the subjective discount rate.
proxy for their share in consumption expenditure since we do not have data on the latter. The share of the non innovative sectors in US manufacturing value added was close to 20% in 1990. Therefore, we use a value of 0.8 for . As far as , , and are concerned, scaling up all three by the same proportion leaves the steady state solution unchanged. Therefore, we normalize the value of to 1. We set since the ratio of the population in developing countries to that in high income nations is roughly 5:1. We set since that gives us reasonable values of (about 2%) at the lowest imitation rate (2%). We are free to vary the value of . The highest imitation rate that we consider is 11% since for higher imitation rates wages in the South become higher than those in the North.

Figures 3, 4, 6 and 6 show the effects of changes in on growth, North’s terms of trade, Southern utility and Northern utility. The imitation rate is measured along the horizontal axis of all three graphs. As is clear from figure 3, decreases in or the stricter enforcement of IPRs increase the growth rate over the entire range. This is what we intuitively think is true. Figure 4 shows that decreases in increase the terms of trade of the North. Figure 5 shows that Southern welfare always decreases with increase in IPR enforcement. That is the gains to the South from higher growth are outweighed by the losses arising from decreases in their terms of trade. Figure 6 shows that Northern welfare always rises with increased IPR enforcement. Therefore, there will always be a conflict of interest between the North and the South over the issue of IPR enforcement in spite of an increase in innovation as a result of such enforcement.

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8 This may be a reasonable approximation for a large economy like the US with a relatively small trade share.

9 The long term growth rate of real GDP of the US economy is about 2% per year and corresponds to the long run total factor productivity growth rate (Barro and Sala-i-Martin 1995). While the increase in the number of varieties is not exactly the same as total factor productivity growth, it is reasonable to think that they are not very different from each other.

10 This can be thought of as the upper bound of the growth rate since the growth rate decreases as the imitation rate rises over the range of imitation rates that will be considered.
4.1 Comparison with the Helpman Model

This paper is different from the Helpman model because of the existence of the Y sector. This makes it possible for increased IPR enforcement to increase innovation in this model unlike in the Helpman model.

The steady state equations of the Helpman model can be described in terms of our variables by equations (33) and (34) along with equation (14) if $\gamma$ were set equal to 0. The equations for utility (37) and (38) would have to be modified by setting $\frac{1}{1+\gamma}$ equal to 1. We solved the Helpman model numerically for the same parameter values so that we can compare the results of the two models. Figures 7, 8, 9 and 10 show the effects of IPR enforcement on the four relevant variables. As one can see in figure 7, growth decreases throughout with an increase in IPR enforcement. This is the most striking difference between the two models. The terms of trade of the North increases with a decrease in $m$ as before (figure 8). Southern utility decreases with a decrease in $m$ since both growth as well as terms of trade decrease. Northern utility increases with decreases in $m$ up to a point since the terms of trade effects dominates the growth effect. However, at low levels of imitation, a stronger IPR regime leads to a decrease in Northern welfare also.

5 Conclusion

This paper presents a model in which the enforcement of intellectual property rights always seems to reduce Southern welfare even though it always increases innovation. This is because the South suffers a terms of trade loss from a stronger IPR regime whose effects outweigh any gains from increased innovation. This is true even when imitation rates are quite high. Since stricter IPR enforcement increases Northern welfare, there is always a genuine conflict of interest between the North and the South in the absence of adequate compensation schemes.
Appendix

To show that the \( V = 0 \) locus is positively sloped if the inequality (36) holds:

The \( V = 0 \) locus is defined by equations (33) and (30) along with (14). Using equations (33) and (30) and making use of the fact that \( ^2 = 1=(1_i \ 0) \) we get,

\[
\frac{3}{a \@ V} = (g + \frac{1}{2} + m) \frac{a \@ (g + \frac{1}{2} + m)}{1_i \ 0} + (1_i \ 34 \text{L}_{S} \frac{a \@ (g + \frac{1}{2} + m)}{1_i \ 0 \text{L}_{S}}(1_i \ 0)(g + \frac{1}{2} + m) \cdot 1_i \ 0 \cdot (39)
\]

An increase in \( V \) will increase the l.h.s. of the equation above and decrease the r.h.s. (since equation 14 implies a negative relationship between \( g \) and \( V \)). The variable \( ^o \) will have to change for the equation to hold. We want to show that \( ^o \) will have to increase for the equation to hold if \( V \) increases (since that will imply a positive relationship between \( V \) and \( ^o \)). This will be true only if the r.h.s. increases with \( ^o \).

In other words, we want the derivative of the r.h.s. of the equation with respect to \( ^o \) to be positive. That is, we want the following

\[
(g + \frac{1}{2} + m) \frac{a \@ (g + \frac{1}{2} + m)}{1_i \ 0} + (1_i \ 34 \text{L}_{S} \frac{a \@ (g + \frac{1}{2} + m)}{1_i \ 0 \text{L}_{S}}(1_i \ 0)(g + \frac{1}{2} + m) \cdot 1_i \ 0 \cdot (1_i \ 0)(1_i \ 0)^i \ 0 > 0
\]

A little manipulation of the inequality above leads to the following expression

\[
1_i \ 0 > [(1_i \ 34(1_i \ 0)) \text{L}_{S} \frac{1}{1_i \ 0}(g + m + \frac{1}{2})
\]

This immediately leads to (36).
References


Figure 1: The Determination of $\gamma$
Figure 2: The Phase Diagram of the System
Figure 3: Growth

Figure 4: Terms of Trade of the North \((p_N = p_S)\)

Figure 5: Southern Welfare
Figure 6: Northern Welfare
The Helpman Model

Figure 7: Growth

Figure 8: Terms of Trade of the North ($p_N = p_S$)

Figure 9: Southern Welfare
Figure 10: Northern Welfare