Innovation versus Imitation: Intellectual Property Rights in a North-South Framework

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Abstract

This paper examines differences in the optimal strength of intellectual property rights protection in a North-South endogenous growth model where it is possible for the South to engage in imitation, innovation or both. The possibility of Southern innovation implies sharp breaks in optimal policy at different stages of development in the South depending on whether it is optimal to induce innovation in the South. These sharp breaks imply strong policy conflict between the North and the South at intermediate levels of development but policy agreement elsewhere.

Keywords: Intellectual property rights; Innovation; Economic development

1 Introduction

Recent decades have seen certain less developed countries playing an increasingly important role in the world economy. Countries such as South Korea, China and India have seen sharp rises in per capita income and, although relatively small, North-South trade is now amongst the fastest growing components of world trade. Furthermore there is increasing evidence that at least some of these countries are engaged not only in adopting products and processes developed elsewhere, but are also beginning to develop or improve

products for themselves (see for example Puga [19], Rodrik [20] and Kochhar et al [14]). At the same time, with the inclusion of the Agreement on Trade Related Intellectual Property Rights (TRIPs) in the statute of the World Trade Organization in 1994, the issue of intellectual property rights (IPRs) has become one of the most debated in international trade negotiations.

This paper examines how the optimal degree of IPRs protection by rich and poor countries changes in response to the ability to innovate, the suitability of technologies and country size. It is related to several different strands of literature. Firstly, as it involves trade-offs between growth and monopoly rights it is related to the literature on optimal patent design that began with Nordhaus's [18] observation that monopoly rights ought not to be indefinite because, once the costs of the innovation are recovered, the distortions caused by monopoly rights have no offsetting benefit to the economy. Gallini & Scotchmer [9] provide an overview of the literature on the advantages and disadvantages of funding innovation through IPRs, prizes or procurement. This paper applies the central insight of this literature, namely the trade-off between static and dynamic efficiency, and analyses it in a two country general equilibrium framework.

The second strand of literature is perhaps more directly related, namely that on North-South trade and technological change, The foundation of this literature is Vernon's [22] work on product cycles (see also Krugman [15] and the more sophisticated approach of Antràs [2]) in which products and processes are developed and standardised before being moved offshore. Grossman and Helpman ([10] and [11]) allow for active knowledge acquisition in developing countries, but this is imitation rather than the innovation that is starting to be observed. Van Elkan [21] and Arnold [3] both examine the growth effects of moving of imitation and innovation in an open economy but not the welfare implications. These papers don't examine the effects of IPRs, which are addressed in Acemoglu et al [1]. They model IPRs protection as affecting the cost of standardization and so the cost of transferring production to the South, although again it neglects the possibility of Southern innovation and assumes a global planner, neglecting possible policy conflicts between countries.

There have been a number of papers examining the role of IPRs protection, Chin and Grossman [5] and Deardorff [7] analyse the welfare effects of increasing IPRs protection in the South, but assume that the South has no innovative capacity and examine only the case where the South has full or no IPRs protection. Helpman [13] uses a dynamic model to look at the effect of

marginal changes in IPRs, where IPRs are the exogenous probability of imitation by the South, and finds that the North prefers stronger IPRs than the South. Lai and Qiu [16] obtain similar results using a multi-sectoral North-South trade model with both countries engaging in innovation and costless imitation. Grossman and Lai [12] is somewhat similar but has more general preferences and an explicit treatment of R&D technology. They include two kinds of IPRs protection, patent length and the degree of enforcement, and show that the two are equivalent so that one of them is redundant in modelling the issue. However, this paper is basically partial equilibrium with an exogenous market size which excludes a significant part of the income effect when comparing the welfare consequences of different policies, and it also has preferences such that undifferentiated, homogeneous goods take a larger share of expenditure in rich countries.

The mechanism in these papers on IPRs protection is generally that the South is willing to respect Northern IPRs despite the reduction in Southern output this implies because doing so raises Northern research and thus global growth. They generally find that optimal IPRs policy is single peaked for both countries, but that different benefits from Northern innovation and Southern imitation imply differences in optimal policy. However all of these papers either assume that the South only imitates or must imitate and innovate, they do not address the possibility that strengthening IPRs can lead the South to begin innovating. This has significant implications because if strengthening IPRs can lead Southern firms to begin innovating then previous papers may be missing part of the impact of IPRs on growth. Therefore, the main contribution of this paper is analysing optimal IPRs where the South can engage in imitation only, innovation only, or both simultaneously and how this changes as workforce size and research costs change.

This paper uses a North-South model where Northern firms develop goods that can be traded and Southern firms can choose either to copy existing Northern goods or to develop their own goods. Their decision will be based on the costs and profitability of imitating versus innovating, which will in turn depend to some extent upon the degree of protection of IPRs. Stronger IPRs reduce the profitability of copying and thus affect the decision of whether to innovate or imitate. Therefore the level of IPRs has implications for the location of production so that IPRs have an effect on output in each country as well as on global growth and countries take account of this when deciding their preferred IPRs policy. This model is related to that of Currie et al [6] in examining the decision facing Southern policymakers in choosing whether

to foster innovation or imitation, but does so through analysing IPRs policy rather than research subsidies.

The first result of the paper is that the desired level of IPRs protection may be very different if the South is able to choose to engage in either innovation or imitation than if it is not. Costly imitation and the possibility of Southern innovation tends to reverse previous findings and optimal policy is now U-shaped, optimal policy is either weak protection to benefit from the efficient distribution of the production of goods developed in the North or strong protection to induce Southern innovation and expand the range of goods available. This would imply that countries either differ significantly in their desired degree of protection or not at all. Therefore, if the Southern innovation has little potential effect on the world economy both North and the South will prefer weak IPRs, if Southern innovation has a large effect both countries will prefer stong IPRs. However, for intermediate levels of Southern development the North may prefer strong protection, whilst the South prefers weak protection.

The rest of the paper is organised as follows: In the next section a relatively simple model is outlined to illustrate the trade-offs, section 4 analyses a more complete model and uses it to address the question of what optimal IPRs should be and section 5 concludes.

2 Basic model

2.1 Preferences and production

There are two countries North and South $[N, S]$, each with a single representative household with preferences goods given by

$$U_t = \int_t^\infty e^{-\rho s} \ln\left(C(s)\right) ds, \alpha, \rho \in (0,1)$$

$$\text{where } C(s) = \left(\int_0^{N(s)} \left(l(s,i)\right)^\alpha di \right)^{\frac{1}{\alpha}}, \alpha, \rho \in (0,1)$$

The variable $l(s,i)$ represents the consumption of goods of type i at time t, where N(t) is the measure of different types of goods at time t. These preferences imply that $p(s,i) = \left(l(s,i)\right)^{\alpha-1} E_t \left(\int \left(l(s,i)\right)^\alpha \right)^{-1}$ where $p(s,i)$ is the price of a good of type i at time t and $E = \left(\int_0^{N_s} \left(p(s,i)\right)^{-\frac{\alpha}{1-\alpha}} di \right)^{-\frac{1-\alpha}{\alpha}} \left(\int_0^{N_s} \left(l(s,i)\right)^\alpha di \right)^{\frac{1}{\alpha}}$

is the total expenditure by the household, with prices normalised to be constant over time. An Euler equation can be derived that implies that on the balanced growth path (BGP) $r = \rho$, where r is the interest rate. From now onwards time and industry subscripts will be dropped unless appropriate

Each type of good is produced by a monopolistically competitive firm, with x_J referring to a variable x (such as price or quantity) linked to a good developed and produced in country J, and x_S^* to a good developed in the North and now produced in the South. Goods developed in the South will not be produced in the North, but will be exported there. Labour is the only input into production, and the quantity of labour needed to produce one unit of output is $1/q_J$. Cross-country differences in labour productivity can be thought of as stemming from a variety of sources such as differences in human capital or infrastructure. Additionally it is possible that goods developed in one country might be better suited to production in that country, due, for example, to differences in factor intensity. The assumptions that Northern workers have higher production efficiency than Southern workers and that Southern workers are more productive with goods developed specifically for them ($q_N \geq q_S \geq q_S^*$) is maintained. Profit maximisation by monopolistically competitive firms implies that, given wages denoted by w_J, $p_N = w_N/(\alpha q_N)$, $p_S = w_S/(\alpha q_S)$ and $p_S^* = w_S/(\alpha q_S^*)$.

Learning how to produce a new type of good is costly, and so is learning how to produce goods developed by other firms[1]. In this model the South may have lower wages because its labour is less efficient at production (lower q) or because it is less efficient in copying existing goods or creating new ones, or for both of these reasons. It is assumed that two firms producing the same type of good engage in price competition, and therefore the price will fall to the cost of production. This implies that the only copying will be Southern firms copying goods first developed in the North, as Northern firms copying either goods developed in either the North or the South are unable to undercut the incumbent, while Southern imitators are unable to undercut Southern incumbents. The cost of learning how to produce a good also implies that, in markets with a single Southern imitator who is able to undercut the incumbent, the imitator has a degree of market power without needing any legal protection, and it is this market power that enables

[1]This assumption is based on Mansfield's 1981 finding, and while not crucial to the result that at a certain research efficiency optimal policy changes from weak to strong protection, it does simplify the analysis.

them to recover the cost of learning how to produce the good. This means the paper is neglecting the impact of domestic protection in order to focus on the international protection of IPRs[2]. The share of types of Northern goods that are produced by Southern imitators is given by θ, which may be determined by either the cost and profitability of copying or the degree of IPRs protection. For simplicity it is assumed that IPRs protection is global, so that θ is constant across countries[3], and the analysis will only consider economies that are on the BGP.

With the inelastically supplied labour force in country J given by L_J, and labour used in research given by R_J, labour market clearing in the two countries implies that relative wages and total combined expenditure in the two countries are given by

$$\frac{w_N}{w_S} = \left(\frac{L_S - R_S}{L_N - R_N} \frac{(1-\theta) N_N (q_N)^{\frac{\alpha}{1-\alpha}}}{\theta N_N (q_S^*)^{\frac{\alpha}{1-\alpha}} + N_S (q_S)^{\frac{\alpha}{1-\alpha}}} \right)^{1-\alpha} \tag{1}$$

$$E = \frac{w_N}{\alpha} L_N \left(1 + \left(\frac{\theta (q_S^*)^{\frac{\alpha}{1-\alpha}} N_N + N_S (q_S)^{\frac{\alpha}{1-\alpha}}}{(q_N)^{\frac{\alpha}{1-\alpha}} (1-\theta) N_N} \right)^{1-\alpha} \left(\frac{L_S - R_S}{L_N - R_N} \right)^{\alpha} \right). \tag{2}$$

To close the model it is assumed that trade must balance in every period, so that

$$E_N = E - E_S = \frac{w_N}{\alpha} L_N \tag{3}$$

$$E_S = \frac{w_N}{\alpha} L_N \left(\frac{\theta N_N (q_S^*)^{\frac{\alpha}{1-\alpha}} + N_S (q_S)^{\frac{\alpha}{1-\alpha}}}{(1-\theta) N_N (q_N)^{\frac{\alpha}{1-\alpha}}} \right)^{1-\alpha} \left(\frac{L_S}{L_N} \right)^{\alpha} = \frac{w_S}{\alpha} L_S. \tag{4}$$

[2]In addition, it is assumed that there is an epsilon cost of being prepared to produce in each period and that prices in each period can be set after observing whether there is another firm that is prepared to produce. These costs are separate from knowing how to produce and act merely to enable imitators to charge their desired price without facing competition from the incumbent firm (as long as they can undercut it). This assumption will be dropped later

[3]Relaxing the assumption of a common global level of IPRs protection complicates the analysis without changing the basic results.

These equations imply that total output of each type of good is given by

$$l_S^* = \frac{q_S^* \left(L_S - R_S\right) \left(q_S^*\right)^{\frac{\alpha}{1-\alpha}}}{\theta N_N \left(q_S^*\right)^{\frac{\alpha}{1-\alpha}} + N_S \left(q_S\right)^{\frac{\alpha}{1-\alpha}}}$$

$$l_S = \frac{q_S \left(L_S - R_S\right) \left(q_S\right)^{\frac{\alpha}{1-\alpha}}}{\theta N_N \left(q_S^*\right)^{\frac{\alpha}{1-\alpha}} + N_S \left(q_S\right)^{\frac{\alpha}{1-\alpha}}}$$

$$l_N = \frac{\left(L_N - R_N\right) q_N}{\left(1-\theta\right) N_N}.$$

2.2 Research and IPRs

The present discounted value of research is given by the discounted flow of expected profits. For Northern firms these expected profits depend on the likelihood of being imitated and driven out of the market by a Southern competitor. Here, for simplicity it is assumed that replacement either takes place immediately or not at all, and then this probability is given by the share of goods that are produced in the South. The present discounted value of innovation is given by the following equation:

$$V_N = \int_0^{\theta} \left(1-\theta\right) \pi_N e^{-(g+\rho)t} dt = \frac{1-\alpha}{\alpha} \frac{L_N - R_N}{\rho + g} \frac{w_N}{N_N}. \tag{5}$$

Labour is the sole input into research and the amount of labour needed to develop a good is given by a_J/K, where a_J is a country specific parameter and K is the global level of technology, which grows at the exogenous rate $g \geq 0$. Thus the growth rate of both countries on the balanced growth path will be constant and given by g and the level of IPRs protection determines the income level for given K. Thus model captures the dynamic trade off involved in determining IPRs policy through the ratio of the number of goods developed for a given knowledge level and the BGP growth rate is exogenous. It is assumed that learning how to produce an existing good is less expensive than developing a new good, so that $a_J > a_J^*$. Furthermore it is assumed that $\left(q_S^*\right)^{\frac{\alpha}{1-\alpha}} a_S > a_S^* \left(q_S\right)^{\frac{\alpha}{1-\alpha}}$. If this didn't hold then the productivity gain from developing goods specifically for the South rather than adapting Northern goods would be enough to offset the higher research costs and no copying would be undertaken. If no Southern imitation occurs, Southern wages must be below Northern wages, as if Southern wages were higher than Northern

wages then Southern imitators would be unable to profitably undercut Northern firms and so a smaller range of goods would be produced in the South, leading to lower Southern wages (equation 1).

Free entry into research in the North implies

$$\frac{N_N}{K} = \frac{L_N}{a_N}\frac{1-\alpha}{\rho\alpha+g} \text{ and } L_N - R_N = \alpha L_N \frac{r+g}{\alpha r+g}.$$

It is worth noting that here a larger share of goods produced in the North has no effect on the number of goods developed in the North. This is because there are two effects on expected profits that cancel out. The first, direct, effect is the higher likelihood of earning monopoly profits due to fewer goods being copied and produced abroad. The second, general equilibrium, effect is that the larger number of varieties being produced in the North reduces the quantity of each variety being produced (as labour is spread more thinly), and so reduces profits of each variety that is produced in the North.

The share of types of goods developed in the North that are allowed to be produced by Southern firms is defined as $\phi \in [0,1]$, and δ is defined as the share of goods that are copied by Southern firms. Strong protection of IPRs implies a low value of ϕ and if IPRs protection binds ($\theta = \phi < \delta$) then Southern firms do not know whether they will be allowed to produce a good before they invest in learning how to produce it. This corresponds approximately to a patent of limited duration, where research costs may be low enough to enable firms to profitably copy goods before they are permitted to produce them. Free entry into copying then would ensure copying before protection has expired. This framework implies that $\theta = \min(\phi, \delta)$ and the probability of the imitator being able to produce is θ/δ. Free entry into imitative research in the South implies that

$$\frac{a_S^*}{K} \geq \frac{\theta}{\delta}\frac{1}{r+g}\frac{1-\alpha}{\alpha}\frac{(q_S^*)^{\frac{\alpha}{1-\alpha}}(L_S - R_S)}{\theta N_N (q_S^*)^{\frac{\alpha}{1-\alpha}} + N_S (q_S)^{\frac{\alpha}{1-\alpha}}} \tag{6}$$

$$\frac{a_S}{K} \geq \frac{1}{r+g}\frac{1-\alpha}{\alpha}\frac{(q_S)^{\frac{\alpha}{1-\alpha}}(L_S - R_S)}{\theta N_N (q_S^*)^{\frac{\alpha}{1-\alpha}} + N_S (q_S)^{\frac{\alpha}{1-\alpha}}}. \tag{7}$$

Free entry into innovative research in the South implies eqn. [7] is an equality if $N_S > 0$. If IPRs protection is less than complete and $w_S/q_S^* < w_N/q_N$ then

equation [6] is an equality. From this it can be shown that

$$\text{If } N_S = 0 \text{ then } \delta = \frac{a_N}{a_S^*}\frac{L_S}{L_N} \tag{8}$$

$$\text{If } N_S > 0 \text{ then } \delta = \phi\frac{a_S\left(q_S^*\right)^{\frac{\alpha}{1-\alpha}}}{a_S^*\left(q_S\right)^{\frac{\alpha}{1-\alpha}}} \tag{9}$$

$$\frac{N_S}{N_N} = \max\left[0, \frac{L_S}{a_S}\frac{a_N}{L_N} - \theta\frac{\left(q_S^*\right)^{\frac{\alpha}{1-\alpha}}}{\left(q_S\right)^{\frac{\alpha}{1-\alpha}}}\right] \tag{10}$$

$$L_S - R_S = \alpha L_S\frac{r+g}{\alpha r+g}$$

Therefore innovation in the South only occurs if

$$\frac{L_S}{L_N}\left(\frac{q_S}{q_S^*}\right)^{\frac{\alpha}{1-\alpha}}\frac{a_N}{a_S} > \theta = \min(\phi,\delta). \tag{11}$$

Equation [11] implies that there is no discontinuity in δ and that the more imitation that occurs in the South the less likely innovation is to occur. Combining equation [9] with the inequality $\left(q_S^*\right)^{\frac{\alpha}{1-\alpha}} a_S > a_S^*\left(q_S\right)^{\frac{\alpha}{1-\alpha}}$ implies that innovation only occurs when $\delta > \phi$, which implies that innovation only occurs when IPRs protection binds.

There is a constraint on θ given by the requirement that $w_S/q_S^* < w_N/q_N$, as if this does not hold then imitating firms are unable to undercut the North and recover the imitation costs. This gives

$$\theta < \frac{\left(q_S^*\right)L_S - \frac{N_S}{N_N}\frac{\left(q_S\right)^{\frac{\alpha}{1-\alpha}}}{\left(q_S^*\right)^{\frac{\alpha}{1-\alpha}}}\left(q_N\right)L_N}{\left(\left(q_N\right)L_N + \left(q_S^*\right)L_S\right)} = \bar{\theta}.$$

For simplicity it is assumed that the South is sufficiently inefficient in research that only imitation and not innovation occurs as θ approaches $\bar{\theta}$. Then θ can get arbitrarily close to $\bar{\theta}$ but will not reach it. This is a result of the assumption that Northern firms exit the market when imitated and so Southern innovators can charge the full monopoly price, this assumption is relaxed later on,when the possibility of limit pricing is allowed.

Holding everything else constant, innovation is more likely the stronger protection (lower ϕ) is, the greater the productivity advantage from developing goods for the South compared to adapting Northern goods (higher

q_S/q_S^*), the easier it is to develop new goods in the South compared to doing so in the North (lower a_S/a_N), the larger the relative Southern labour force (higher L_S/L_N), and the easier it is to imitate Northern goods (lower a_S^*/a_S). The efficiency of Northern research matters because this affects the number of Northern developed goods and so the number that can be imitated and the likelihood of IPRs binding. The Southern labour force size matters because, given other parameters, a larger Southern workforce implies higher profits from research in the South through higher sales, while the given level of IPRs prevents firms taking advantage of this larger workforce by copying Northern products. Greater Southern ability to imitate also makes it more likely that IPRs protection binds and so more likely that the possibility of innovation in the South has to be considered.

In summary, stronger protection reduces the share of types of goods developed in the North that are produced in the South and makes it more likely that the South will engage in innovation. Low levels of IPRs protection may mean that the South is unable to produce as many types of goods as are permitted, either because copying is costly or because producing the additional types of goods would raise the demand for Southern labour and so Southern wages sufficiently that Southern imitators are unable to undercut the Northern incumbent. Allowing Southern firms to innovate changes the welfare effects of IPRs protection as strong protection reduces the number of imitations produced in the South but may lead the South to develop its own technologies.

2.3 Welfare

This section compares the welfare effects in steady state of different policies regarding the protection of intellectual property rights. To analyse welfare we need to compare two situations, one where the South is only imitating and another where it is innovating. In the later case it must be the case that IPRs are binding, and the level of θ can be chosen directly by policymakers. The welfare analysis in the former case is done by examining the optimal θ. It is possible that the South will not be able to copy this proportion of Northern goods due to research inefficiency, but in this case it is best if the South is not constrained by IPRs unless innovation by the South is desired. The South only ought to be constrained if otherwise it would imitate more than this optimal level of θ or if innovation by the South is desired. The two countries may differ over their preferred level of θ.

Since the long run growth rate is exogenous, maximising the present discounted value of household welfare in country J on the balanced growth path is achieved by maximising C_J. These are given below, where C is global welfare)

$$C_N = \frac{E_N}{E}C \text{ and } C_S = \frac{E_S}{E}C$$

$$C = \left[(L_S - R_S)^{\alpha}\left(\theta N_N \left(q_S^*\right)^{\frac{\alpha}{1-\alpha}} + N_S \left(q_S\right)^{\frac{\alpha}{1-\alpha}}\right)^{1-\alpha} + (L_N - R_N)^{\alpha}\left(q_N\right)^{\alpha}\left((1-\theta)N_N\right)^{1-\alpha}\right]^{\frac{1}{\alpha}}.$$

If the South only engages in imitation then these become:

$$C = \alpha\left((1-\alpha)\frac{L_N}{\rho a_N}\right)^{\frac{1-\alpha}{\alpha}}\left(\frac{r+g}{r\alpha+g}\right)^{\frac{1}{\alpha}}\left[(1-\theta)^{1-\alpha}L_N^{\alpha}q_N^{\alpha} + L_S^{\alpha}\theta^{1-\alpha}\left(q_S^*\right)^{\alpha}\right]^{\frac{1}{\alpha}}$$

$$C_N = \frac{(1-\theta)^{1-\alpha}L_N^{\alpha}q_N^{\alpha}}{(1-\theta)^{1-\alpha}L_N^{\alpha}q_N^{\alpha} + L_S^{\alpha}\theta^{1-\alpha}\left(q_S^*\right)^{\alpha}}C$$

$$C_S = \frac{L_S^{\alpha}\theta^{1-\alpha}\left(q_S^*\right)^{\alpha}}{(1-\theta)^{1-\alpha}L_N^{\alpha}q_N^{\alpha} + L_S^{\alpha}\theta^{1-\alpha}\left(q_S^*\right)^{\alpha}}C$$

It is possible to show (see appendix) that C, C_N and C_S are single peaked in θ and that the peak lies in the range $(0,1)$. Furthermore the North prefers stronger protection (lower θ) than the South, and the optimum global level is in the range bounded by that of the North and the South. The North gains from weak protection through the availability of cheap goods produced in the South, but loses some income by the shift in production. The South gains from weak protection through the ability to earn income by selling goods. In all cases optimal θ increases (and so IPRs weaken) as q_S^*/q_N and L_S/L_N rises. This is because, as the South is better able to exploit the technology, there is less to be gained through production in the North.

The appendix shows that, without innovation in the South, global welfare is maximised when the price of goods is equal regardless of whether the goods are produced in the North or the South (i.e. $w_S/q_S^* = w_N/q_N$) and that the North desires stronger protection than this, while the South would prefer to copy more goods than it is able to. Intuitively the global optimum implies that production is distributed efficiently while both countries want to produce more than this domestically in order to capture the profits. Thus the optimum policy from both a global and the South's perspective would

be no protection, but the North would prefer a somewhat stronger level of protection.

Whether these optimal IPRs policies are possible depends on whether the South can copy sufficient goods to reach this θ (a_S^* is low enough). If the South is unable reach this θ the best policy without Southern innovation is no IPRs protection. To address the question of how the optimal policy without Southern innovation compares to one where innovation is induced we need to consider optimal policy with Southern innovation. If the South engages in innovation then the welfare functions become

$$C = \left(\alpha\frac{r+g}{\alpha r+g}\right)^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{\alpha\rho a_N}\right)^{\frac{1-\alpha}{\alpha}}\left[L_S\left(\frac{a_N}{a_S}\right)^{1-\alpha}(q_S)^{\alpha}+q_N^{\alpha}(1-\theta)^{1-\alpha}L_N\right]^{\frac{1}{\alpha}}$$

$$C_N = \frac{q_N^{\alpha}(1-\theta)^{1-\alpha}L_N}{L_S\left(\frac{a_N}{a_S}\right)^{1-\alpha}(q_S)^{\alpha}+q_N^{\alpha}(1-\theta)^{1-\alpha}L_N}C$$

$$C_S = \frac{q_S^{\alpha}\left(\frac{a_N}{a_S}\right)^{1-\alpha}L_S}{L_S\left(\frac{a_N}{a_S}\right)^{1-\alpha}(q_S)^{\alpha}+q_N^{\alpha}(1-\theta)^{1-\alpha}L_N}C$$

Now the optimal strategy for everyone is full protection ($\theta = 0$), although how much they desire it varies across countries.

The assumption that copying goods developed elsewhere is costly implies that the innovators have a degree of protection without the need for IPRs protection. If innovation in the South were not possible then optimal policy for both the South and the representative world consumer would be no protection, whilst the North would prefer a degree of protection. However, allowing the South to innovate implies that, if innovation by the South is desirable, then it is best to go to full protection to encourage as much innovation as possible. Therefore the key question in deciding optimal policy in this framework is whether it is optimal for the South to innovate, and this can only be determined by comparing optimal policy if innovation is not induced with the welfare accruing from full protection. It is possible to show that, as with optimal policy without innovation, the two countries differ on when it is optimal to induce innovation, with the North preferring to induce innovation at a lower level of Southern income per capita. It is also possible to show that, for both countries, inducing innovation is more likely to be optimal the better the South is at innovating (lower a_S) and the less suited

Northern goods are to production in the South (lower q_S^*/q_N). However, it is not possible to show the full conditions for when to switch to full protection analytically, at least in part because optimal policy without innovation for the North is the product of a non-linear equation, albeit one with a unique solution. Therefore the model will be parameterised and simulated in the next section.

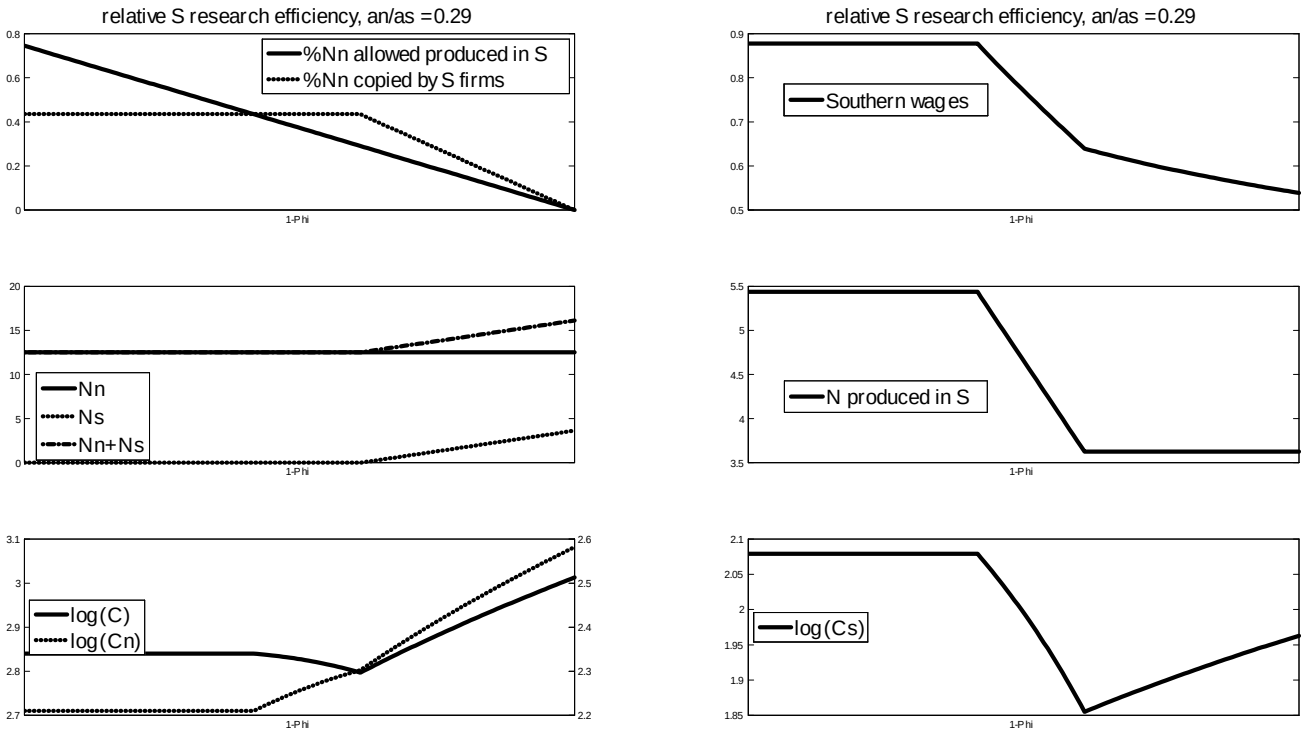
2.3.1 Comparison of optimal policy

When deciding on optimal IPRs protection from the perspective of the world, the North or the South there are two possible cases for each. Firstly, if the South is unable to copy the desired proportion of Northern varieties, then it needs to be decided whether the optimal policy is full protection to induce innovation or no protection to encourage imitation by the South. Secondly if the Southern firm is able to copy the desired proportion of Northern varieties then it needs to be decided whether the optimal policy is full protection to induce innovation or sufficient protection to allow the South to produce the desired share of varieties but no more. Whether or not full protection is the better policy depends on parameter values, which are chosen as follows. The numeraire, Northern wages, is set to 1 and a_S^* is set in line with the empirical work of Mansfield. The baseline calibration for the parameters is given below

α	q_N	q_S	q_S^*	L_N	L_S	a_N	a_S	a_S^*	w_N	ρ	g
0.5	1	1	1	1	1	1	$\frac{a_N}{0.29}$	$\frac{2}{3}a_S^*$	1	0.03	0.025

Figure 1 then shows how welfare changes for different levels of protection, where high ϕ (close to zero on the x-axis) implies low protection. Low levels of protection means that IPRs protection doesn't bind and θ remains constant at about 0.2. As IPRs protection strengthens eventually it binds (from about $\phi = 0.2$) and further increases in protection leads to lower Southern wages and lower global and Southern welfare, but higher Northern welfare. As expected, stronger protection eventually leads Southern firms to begin innovating (from about $\phi = 0.1$) and then welfare is increasing in the strength of protection. Welfare is increasing because of the larger variety of goods being produced, Southern wages continue to fall as a smaller range of goods are produced in the South, but even in the South this is dominated by the global variety effect. Thus there is a U-shaped relationship between welfare and IPR protection and the relevant comparison is between full protection (implying Southern innovation) and weaker protection to allow the optimal

Figure 1: Basic model



distribution of the production of goods developed in the North. Whether the increase in welfare from innovation is enough to offset depends on the parameters and in figure 1 it clearly does so for the world as a whole as well as for the North, but not for the South. If the South is relatively unproductive in research then there is less to be gained from Southern innovation. As the South gets better at research there are four stages of optimal policy. First nobody desires Southern innovation, then, as the South gets better at research, first the North desires Southern innovation, then it is in the interests of the representative global household, and finally the South also desires Southern innovation[4]. Given the other parameters, each of these stages corresponds

[4]Relaxing the assumption that learning how to produce copies is costly eliminates the region where IPRs do not bind and leads to welfare being single-peaked in the region without Southern innovation, which corresponds to much of the previous literature. The

to a particular range of a_S, and this is the subject of the next section.

It is worth comparing these results with earlier papers, such as Grossman and Lai [12], which found welfare to be single peaked in IPRs protection. They assumed that imitation was costless, so that the constraint on imitation was IPRs, which corresponds in the figure to the range where IPRs bind, and excludes the left-hand side of the figure. In their work, stronger IPRs did not fundamentally shift the type of research being undertaken, thus also excluding the extreme right of the figure where the South is innovating and welfare is increasing in IPRs protection. Over the intermediate range of IPRs optimal policy thus looks similar to that in Grossman and Lai, however the existence of imitation costs implies a degree of IPRs protection separate from patents so that the optimal amount of imitation may not be feasible if it is low. The possibility of inducing a different type of research, and the fact that once this occurs welfare is increasing in IPRs protection, means that the "optimal" level of imitation may no longer be optimal if this level implies high (but not complete) protection.

3 Full model

The previous section contained two simplifying assumptions in order to get some analytical results. The first was the ability of an imitating Southern firm to charge the full monopoly price even when this would allow the Northern incumbent to remain in the market profitably. Relaxing this implies that $p_S^* = \min(w_S/(\alpha q_S^*), w_N/q_N)$, and this in turn relaxes the constraint that $\theta < \bar{\theta}$ which had to be imposed as now a similar relationship is an equilibrium outcome. The second simplifying assumption was that a fixed share of goods were given IPRs protection, and if Southern firms copied more than this share then they faced a simple probability of enforcement. This meant that IPRs protection only affected the number of varieties through N_S, because stronger protection meant a higher probability of production in the North, but the effect of this on expected profits was exactly offset by the greater demand for labour in the North raising Northern wages and so the quantity sold. With IPRs protection taking the form of a fixed duration monopoly the two features do not exactly offset each other and the strength of IPRs protection has an effect on N_N, however it also leads to the degree of copying

result that welfare is increasing in IPRs protection once the South begins innovating remains, and so the possibility of sharp changes in optimal policy remains.

being a non-linear equation. This section demonstrates the effect of these changes.

The basic model outlined in section 2.2 remains the same (at least as long as $p_S^* = w_S/(\alpha q_S^*)$), with $\theta = e^{-gT}$ where T=max(τ, Υ) is the newest copied good that is in production, τ is age of goods when copied, and Υ is the duration of the patents (note that now strong protection implies high Υ). The differences are in research, where the free entry condition into research in the North is now:

$$a_N \frac{N_N}{K} = \frac{1-\alpha}{\alpha} \frac{L_N - a_N g \frac{N_N}{K}}{1-e^{-gT}} \frac{1-e^{-(g+\rho)T}}{\rho+g}$$

$$\rightarrow \frac{N_N}{K} = \frac{L_N}{a_N} \left(\frac{1-e^{-gT}}{1-e^{-(g+\rho)T}} \frac{(\rho+g)\,\alpha}{1-\alpha} + g \right)^{-1} \tag{12}$$

It is useful to compare equations [5] and [12], the difference is given by the discount factor $\rho = r$. Positive interest rates imply that firms cares more about current profits than future profits and so when they are replaced matters, while for output it is the number of firms that are replaced and not the age. Comparing N_N under the two protection schemes, using patent length rather than the probability of enforcement results in a large number of varieties being developed in the North unless there is complete protection (T$\rightarrow \infty$ or $\theta = 0$). This follows from the fact that firms get a higher expected value from new firms getting monopoly profits and old firms not than if the same share of firms got monopoly profits but some firms got them throughout their lives and others never getting them. This concern for the timing of profits also means that using patent length implies stronger protection have an effect on N_N, unlike in the previous model. Longer protection means the entrants expected value goes up by earning profits in some additional future period, however it also implies more goods being produced in the North in each period and so lower profits in each period. Thus stronger protection here means lower expected future profits (r>0) as the size of profits in each period falls by a factor $1 - e^{-gT}$, while the value from additional periods of monopoly profits increases by a factor $1-e^{-(g+\rho)T}$. Thus the number of products developed in the North declines slightly as IPRs protection strengthens.

The Southern research equilibrium without limit pricing is given by

$$a_S^* \frac{e^{-gT}N + N_S}{K} \geq \frac{1-\alpha}{\alpha}\left(L_S - R_S\right)\frac{e^{-(g+\rho)(T-\tau)}}{\rho+g} \tag{13}$$

$$a_S \frac{e^{-gT}N + N_S}{K} \geq \frac{1-\alpha}{\alpha}\frac{L_S - R_S}{r+g}. \tag{14}$$

Again, free entry into innovative research in the South implies eqn. [14] is an equality if $N_S > 0$, and if IPRs protection is less than complete and $w_S/q_S^* < w_N/q_N$ then equation [13] is an equality. The unknowns in these two equations are τ, T and N_S and these equations imply

If $N_S = 0$ then

$$e^{-gT} = \left(\frac{L_S a_N}{a_S^* L_N}\frac{1-e^{-gT}}{1-e^{-(g+\rho)T}} + \frac{1-\alpha}{\alpha}\frac{g}{\rho+g}\left(\frac{L_S a_N}{a_S^* L_N} - e^{-g\tau}\right)\right)e^{-(g+\rho)(T-\tau)} \tag{15}$$

$$\text{if } N_S > 0 \text{ then } \left(\frac{a_S^*}{a_S}\right)^{\frac{1}{g+\rho}} e^T = e^\tau \tag{16}$$

$$\frac{N_S}{N_N} = \max\left[0, A\right] \text{ where} \tag{17}$$

$$A \equiv \frac{a_N L_S}{L_N a_S}\left(\frac{1-e^{-gT}}{1-e^{-(g+\rho)T}}\frac{(\rho+g)\,\alpha}{\rho\alpha+g} + \frac{1-\alpha}{\rho\alpha+g}g\right)$$
$$- e^{-gT}\frac{(q_S^*)^{\frac{\alpha}{1-\alpha}}}{(q_S)^{\frac{\alpha}{1-\alpha}}}\left(\frac{1-\alpha}{\rho\alpha+g}g\left(\frac{a_S^*\,(q_S)^{\frac{\alpha}{1-\alpha}}}{a_S\,(q_S^*)^{\frac{\alpha}{1-\alpha}}}\right)^{\frac{\rho}{g+\rho}} + \frac{(\rho+g)\,\alpha}{\rho\alpha+g}\right)$$

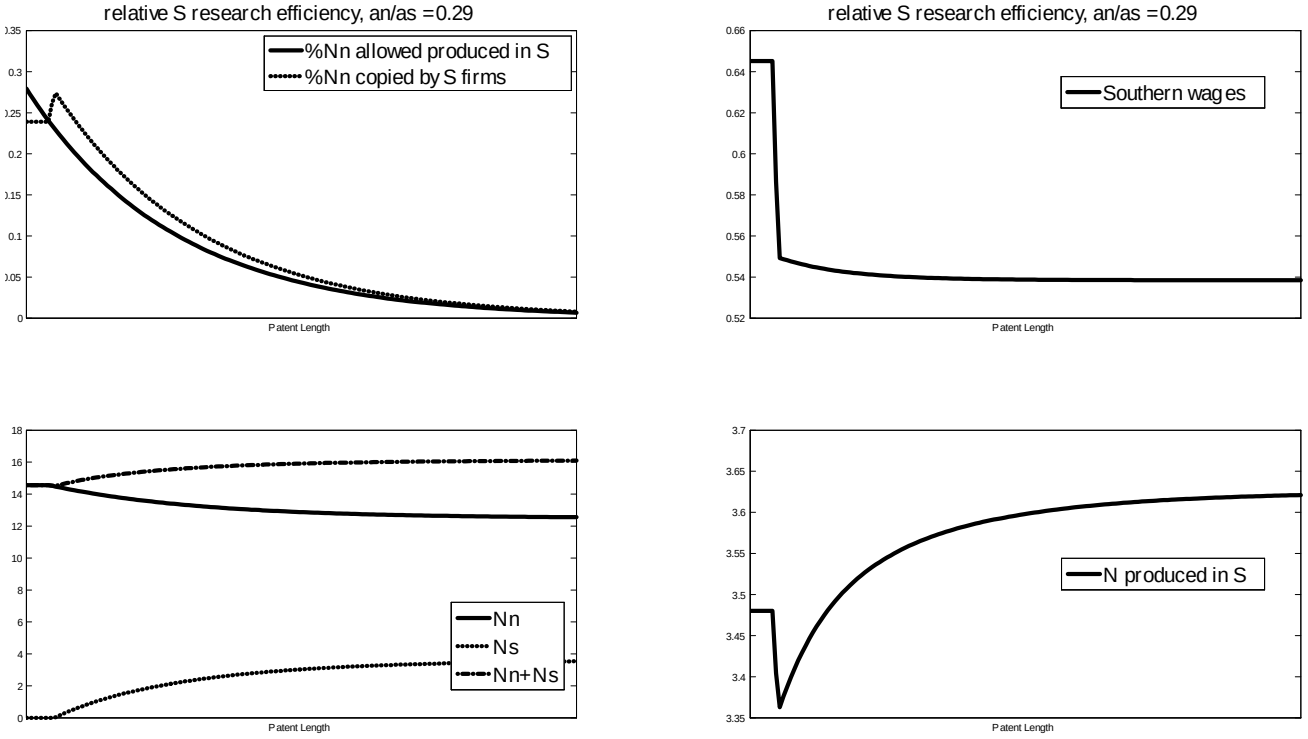
Again, Southern firms only innovate if IPRs protection binds (equation [16]) and becomes more likely to do so the stronger IPRs protection is (equation [18]). If there is no innovation in the South then equation [15] holds (see the appendix for an outline of existence and uniqueness) and if there is innovation then equations [16-17] hold. The condition for innovation in the South is now

$$\frac{a_N L_S}{L_N a_S}\left(\frac{1-e^{-gT}}{1-e^{-(g+\rho)T}}\frac{(\rho+g)\,\alpha}{\rho\alpha+g} + \frac{1-\alpha}{\rho\alpha+g}g\right) \tag{18}$$

$$> e^{-gT}\frac{(q_S^*)^{\frac{\alpha}{1-\alpha}}}{(q_S)^{\frac{\alpha}{1-\alpha}}}\left(\frac{1-\alpha}{\rho\alpha+g}g\left(\frac{a_S^*\,(q_S)^{\frac{\alpha}{1-\alpha}}}{a_S\,(q_S^*)^{\frac{\alpha}{1-\alpha}}}\right)^{\frac{\rho}{g+\rho}} + \frac{(\rho+g)\,\alpha}{\rho\alpha+g}\right). \tag{19}$$

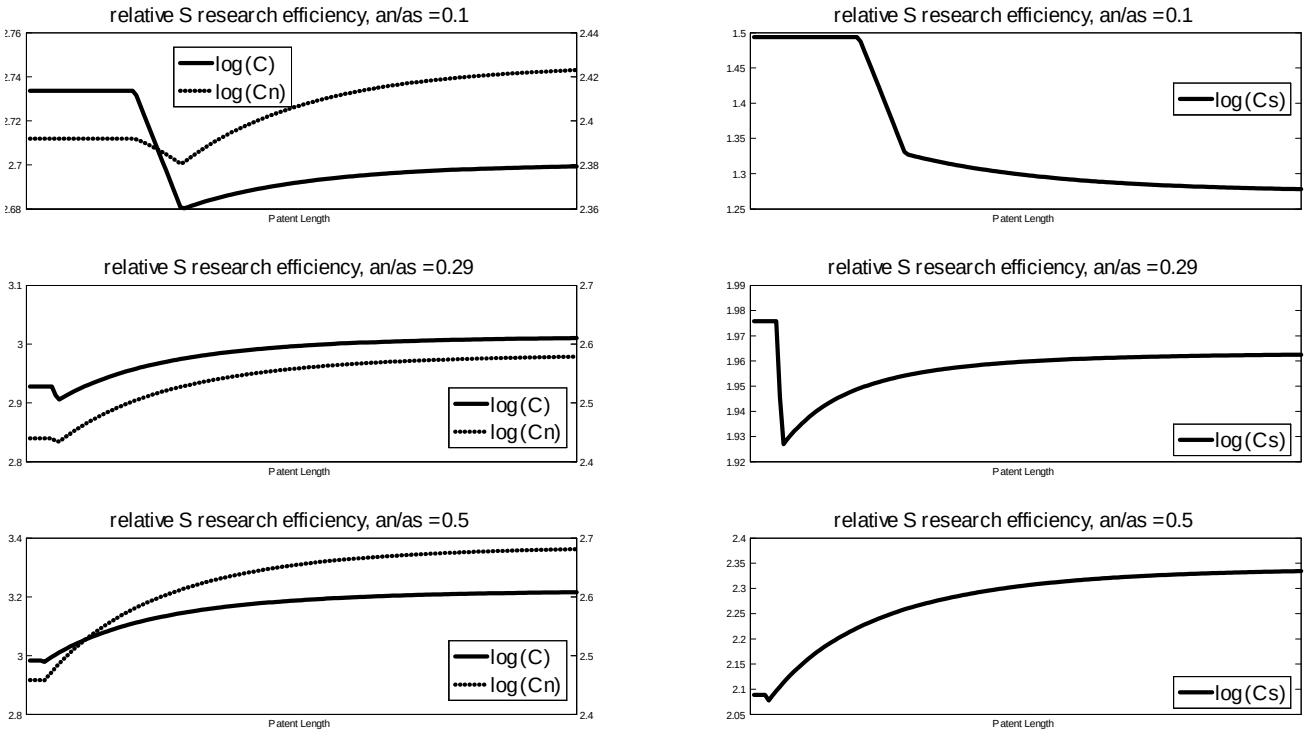
The non-linear nature of equation [15] means that we have to calibrate the system to draw any conclusions, and figure 2 demonstrates the effect of increasing IPRs protection using the previous calibration. The same pattern as before is observed, with first weak protection (low on the x-axis) meaning IPRs have no effect, then, once IPRs protection binds not all copied goods enter production immediately and the demand for Southern labour in production falls slightly, resulting in lower Southern wages and an increase in imitation activity by the South (even though this imitation is not immediately profitable). As the protection of IPRs increases the South eventually begins to innovate, and from this point onwards changes in the degree of protection has less effect on Southern wages as stronger protection leads to labour moving from producing copies to producing new goods rather than into initially unprofitable research.

Figure 2: Full model baseline responses



The key difference from the previous case is that now stronger protection results in less innovation in the North. This follows because lengthening patents means a longer monopoly (and so positive profits for longer) for the Northern innovator, however it also means a larger range of goods produced in the North and so lower profits in every period for each individual Northern producer. With a positive interest rate ($\rho > 0$) the latter effect dominates and stronger protection means fewer goods developed in the North as a larger share of Northern labour is employed in production rather than research. Once Southern innovation is induced stronger protection leads to an increase in the global variety of goods ($N_N + N_S$) as the small decrease in Northern research is offset by the diversion of Southern labour from developing and producing existing goods to developing and producing new goods.

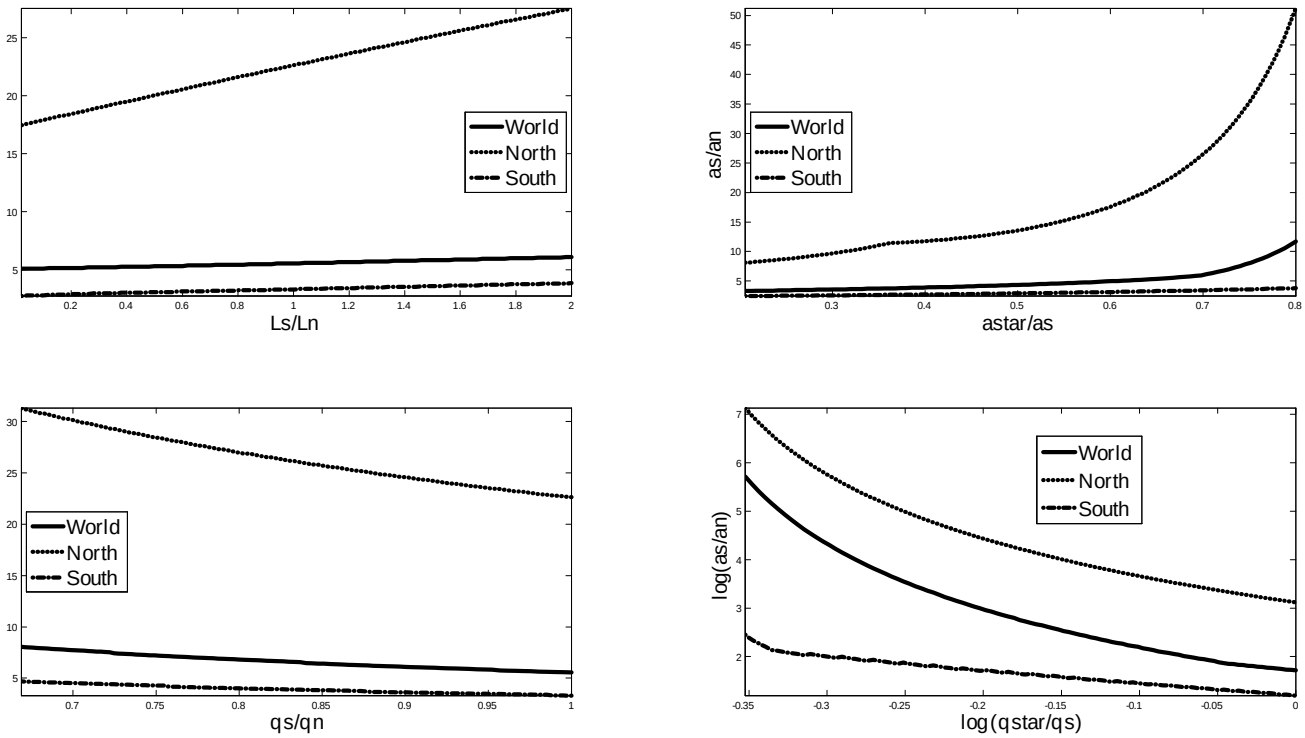
Figure 3: Welfare & Southern research efficiency



The welfare effects of stronger protection for varying levels of Southern

research efficiency (a_S) are shown in figure 3. It is no longer always the case that, once the South begins innovating, welfare is increasing in the degree of IPRs protection. Stronger IPRs protection leads to less research in the North and this tends to reduce the benefits from stronger protection compared to the model in the previous section. If the increased global range of goods from stronger IPRs protection is small then it may not be enough to offset the fall in welfare from the South producing a smaller range of Northern goods. This is more likely if the gain from Southern innovation is small (high a_S and α or low q_S). This does not change the basic result from the previous model, namely that the policy decision is between strong IPRs to induce Southern innovation and expand the global variety of goods, and weak protection to encourage the efficient distribution of production.

Figure 4: Level of Southern research efficiency at which it is optimal to induce Southern innovation



The implications of this are that optimal policy is either strong protection to induce Southern innovation if the South is relatively good at research or weak protection to encourage the productive use of Southern labour if the South is relatively inefficient at research. There exists a threshold $\bar{a}_S$ above which it is optimal to have weak protection to encourage imitation in the South and below which it is optimal to have strong protection to encourage innovation in the South This means that optimal policy will not be a gradual increase in the level of protection as a country becomes better at research, but rather an abrupt shift from permitting imitation to encouraging innovation. The differential distribution of the benefits of Southern innovation imply that countries will differ in when they make the shift, but in general both countries will prefer weak (strong) protection if a_S is high (low), but that there will exist a range of a_S where the North prefers strong protection and the South weak protection, implying policy conflict.

Figure 4 provides a comparison of how this threshold responds to changes in the size of the labour force or the relative efficiency of labour, where all the parameters are as in the baseline case, except those being varied. As might be expected a larger Southern workforce (L_S), greater Southern production efficiency (q_S/q_N), lower Southern productivity with goods developed in the North (q_S^*/q_S) and higher relative copying costs (a_S^*/a_S) all make it more preferable for the South to begin innovating at an earlier stage. High values of L_S/L_N or low values of q_S^*/q_S increase the likelihood of conflict, as the range of values of a_S for which there is disagreement between North and South becomes larger. A relatively larger Southern workforce or the South being less well suited to the production of Northern goods increases the benefits of the South innovating, either by making them better able to contribute to the global variety of products or being able to produce a larger quantity of existing goods, and the North benefits more than the South from the switch to innovation.

4 Conclusion

This paper seeks to develop a general equilibrium model of North-South trade with innovation and imitation. The model is used to analyze the optimal protection of intellectual property rights for rich and poor countries, and how this is altered by allowing the South to engage in innovation. It shows that the desired level of optimal IPRs protection are different in this

framework than if, as in several earlier papers, Southern firms are unable to choose between innovation and imitation. Southern innovation can be induced through strong IPRs and this increases the degree of policy conflict but is likely to reduce its persistence as countries develop. This finding of a U-shaped relationship between optimal IPRs and economic development is supported by the empirical work of Chen and Puttitanun [4]. In addition, if the technology developed in the North is less suitable for the South then this increases the incentives for the South to engage in innovation**.** International disagreements over the protection of intellectual property rights are likely to be greatest with large countries and with poor countries that are able to use Northern technologies effectively. It also shows that choosing the right international policy regime generally matters significantly more for poor countries than for rich ones.

Directions for further work include allowing for foreign direct investment and licensing, so that firms make a decision not just on whether to innovate, but also on where to locate production and research. Another useful step would be looking at the behaviour off the balanced growth path to see whether it is possible to be trapped in a non-optimal IPRs strategy due to adjustment costs. However the paper provides a plausible explanation of why intellectual property rights are of greater concern to the North as trade costs fall and large poor countries become better able to undertake research. Together these may help to explain why intellectual property rights is so debated at a policy level in the current climate of globalization and the growth miracles in some large developing countries.

A Appendix

A.1 Analytical model

A.1.1 Existence and Uniqueness of optimal policy with $N_S = 0$

To show that optimal policy is single peaked when the South only engages in imitation, and that the North prefers lower θ than the South, with the level that maximises C lying between them.

$$C = \alpha \left((1-\alpha) \frac{L_N}{\rho a_N} \right)^{\frac{1-\alpha}{\alpha}} \left(\frac{r+g}{r\alpha+g} \right)^{\frac{1}{\alpha}} \left[(1-\theta)^{1-\alpha} L_N^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha} \right]^{\frac{1}{\alpha}}$$

$$C_N = \frac{(1-\theta)^{1-\alpha} L_N^{\alpha} q_N^{\alpha}}{(1-\theta)^{1-\alpha} L_N^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}} C$$

$$C_S = \frac{L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}}{(1-\theta)^{1-\alpha} L_N^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}} C$$

Maximising aggregate welfare yields

$$\frac{1}{C}\frac{dC}{d\theta} = (1-\alpha) \frac{-(1-\theta)^{-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{-\alpha} (q_S^*)^{\alpha}}{(1-\theta)^{1-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}}$$

$$FOC \rightarrow \theta_G = \frac{L_S q_S^*}{L_S q_S^* + L_N q_N}$$

Maximising Northern welfare yields

$$\frac{1}{C_N}\frac{dC_N}{d\theta} = \frac{1-\alpha}{\alpha} \left[-\frac{\alpha}{1-\theta} + (1-\alpha) \frac{-(1-\theta)^{-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{-\alpha} (q_S^*)^{\alpha}}{(1-\theta)^{1-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}} \right]$$

$$FOC \rightarrow (1-\theta_N)^{-\alpha} (L_N)^{\alpha} q_N^{\alpha} = \left(\frac{1-\alpha-\theta_N}{1-\theta_N} \right) L_S^{\alpha} \theta^{-\alpha} (q_S^*)^{\alpha}$$

The left-hand side of this is increasing in θ_N while the right-hand side is decreasing in θ_N, so any solution will be unique. Existence comes because $\lim_{\theta \to 0} \frac{dC_N}{d\theta} = \infty$ and $\lim_{\theta \to 1} \frac{dC_N}{d\theta} = -\infty$. The value here is less than at θ_G, as, when evaluated at θ_G, $\frac{1}{C_N}\frac{dC_N}{d\theta} < 0$.

Maximising Southern welfare yields

$$\frac{1}{C_S}\frac{dC_S}{d\theta} = \frac{1-\alpha}{\alpha} \left[\frac{\alpha}{\theta} + (1-\alpha) \frac{-(1-\theta)^{-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{-\alpha} (q_S^*)^{\alpha}}{(1-\theta)^{1-\alpha} (L_N)^{\alpha} q_N^{\alpha} + L_S^{\alpha} \theta^{1-\alpha} (q_S^*)^{\alpha}} \right]$$

$$FOC \rightarrow \frac{\theta_S - \alpha}{\theta_S} (L_N)^{\alpha} q_N^{\alpha} = L_S^{\alpha} \left(\frac{1-\theta_S}{\theta_S} \right)^{\alpha} (q_S^*)^{\alpha}$$

The left-hand side of this is increasing in θ_N while the right-hand side is decreasing in θ_N, so any solution will be unique. Existence comes because $\lim_{\theta \to 0} \frac{dC_S}{d\theta} = \infty$ and $\lim_{\theta \to 1} \frac{dC_S}{d\theta} = -\infty$. The value here is greater than at θ_G, as, when evaluated at θ_G, $\frac{1}{C_S}\frac{dC_S}{d\theta} > 0$. Therefore the optimal IPR order is $\theta_S > \theta_G > \theta_N$, but $\theta_G = \bar{\theta}$ implies θ_S is not possible.

A.1.2 Comparing optimal policy and $\bar{\theta}$

As shown in the text, the highest possible level of θ is constrained by $w_S/q_S^* < w_N/q_N$. In addition we have shown that with innovation the optimal policy is full protection so that we only need to consider the case where the level of θ is constrained by $w_S/q_S^* < w_N/q_N$ without innovation

$$\theta < \frac{(q_S^*)\, L_S}{(q_N)\, L_N + (q_S^*)\, L_S} = \bar{\theta}$$

Global welfare is maximised when $\theta = \frac{L_S q_S^*}{L_S q_S^* + L_N q_N}$ which implies that the costs of production are equalised. Thus, ignoring the possibility of innovation in the South, the South favours more copying than is possible and the North less than is globally optimal.

A.2 Full model

To show that equation [15] has a unique solution

$$e^{-gT} = \left(\frac{L_S a_N}{a_S^* L_N} \frac{1 - e^{-gT}}{1 - e^{-(g+\rho)T}} + \frac{1-\alpha}{\alpha} \frac{g}{r+g} \left(\frac{L_S a_N}{a_S^* L_N} - e^{-g\tau} \right) \right) e^{-(g+\rho)(T-\tau)}$$

There are two cases to consider, when IPRs bind and when they don't. In the first case the equation becomes

$$e^{-g\tau} = \frac{L_S a_N}{a_S^* L_N} \frac{1 - e^{-g\tau}}{1 - e^{-(g+\rho)\tau}} + \frac{1-\alpha}{\alpha} \frac{g}{r+g} \left(\frac{L_S a_N}{a_S^* L_N} - e^{-g\tau} \right)$$

The left-hand side is decreasing in τ and the right-hand side is increasing. Existence comes because limit pricing implies that copying ceases to be profitable as $\tau \to 0$ and $\lim_{\tau \to \infty} RHS > \lim_{\tau \to \infty} LHS = 0$.

When IPRs bind the right-hand side is increasing in τ so any solution will be unique. Existence comes because $\lim_{\tau \to \infty} RHS > \lim_{\tau \to \infty} LHS$ and needs $\lim_{\tau \to 0} RHS < \lim_{\tau \to \infty} LHS$ which must hold.

$$e^{-gT} = \left(\frac{L_S a_N}{a_S^* L_N} \frac{1 - e^{-gT}}{1 - e^{-(g+\rho)T}} + \frac{1-\alpha}{\alpha} \frac{g}{r+g} \left(\frac{L_S a_N}{a_S^* L_N} - e^{-g\tau} \right) \right) e^{-(g+\rho)(T-\tau)}$$

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