Implications of Intellectual Property Rights for Dynamic Gains from Trade

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It is traditionally argued that the enforcement of intellectual property rights (IPRs) is necessary to compensate innovators for incurring the fixed costs of R&D. The argument in support of finite patent protection within a country is familiar. On one hand, patents provide monopoly rights to innovators to provide incentives to innovate. On the other hand, once the innovation has occurred it is socially optimal (in a one time game) for the government to renege on the promise of patent protection so as to lower the price of the invention and increase its use. In a repeated game, however, such a policy would severely dampen future innovations. Hence, the government legally maintains monopoly rights for the inventor, but only for a finite time. A similar trade-off exist between developed countries, where a majority of innovations occur, and developing countries that wish to have greater access to these innovations through lower prices. Developed countries have therefore pushed strongly for international enforcement of IPRs, while developing countries believe that international enforcement will slow technological acquisition and development. The importance of the Trade Related Aspects of Intellectual Property Rights (TRIPs) agreements in the Uruguay round highlights the perceived importance of enforcing IPRs *as developing countries liberalize trade.*

It is commonly assumed that developed countries will always find it optimal to have full international IPRs and that developing countries will always find it optimal to have no IPR enforcement. Recent work by Grossman and Lai (2003) consider a North-South environment where both countries have innovating firms, although the North has a greater capacity for innovation and generally has a larger market. They consider globally efficient regimes of patent protection within a variety expanding model. Within their environment, they find that, among policy combinations that give the same overall incentives for global innovation, the stronger the patent protection is in the South, the greater the gain for the North at the expense of the South. Here we introduce IPRs into a North-South model of technological diffusion through trade and imitation (Connolly and Valderrama 2004a). This model explicitly considers positive spillovers from innovation in the North to imitative research in the South through exposure to trade. The presence of these spillovers, in combination with feedback effects between innovating Northern and imitating Southern firms, implies that welfare in the North and the South both depend on how IPRs affect world growth. Rather than finding that increasing IPR protection in the South always increases Northern welfare at the expense of the South, we find that, for optimally designed IPRs, it will be welfare enhancing for both regions to increase Southern IPRs, especially during Southern trade liberalization. Similarly, poorly designed IPRs will be welfare decreasing for both regions. Our results do not necessarily imply that both regions' welfare will be maximized by exactly the same level of IPR protection. But it does mean that IPRs don't always favor developed nations at the expense of developing nations. This is relevant given the current efforts within the WTO to open markets in developing countries, while at the same time pushing TRIPS.

This paper gives important and potentially quantifiable insights into the value of internationally enforced IPRs from the perspective of both developing and developed nations. Importantly, these insights include numerical evaluations of dynamic growth effects both in transition and steady state that have not been considered in the existing literature on IPRs. Here we present only the salient features of this model and focus on its results. We refer the reader to Connolly and Valderrama (2004b) for greater details about the model and solution.

1 The Model

Consider a two-region model. The North represents innovating economies and the South represents currently non-innovating economies. We introduce two different IPR regimes into an existing model of technological diffusion through reverse-engineering of technology embodied in intermediate goods by Connolly and Valderrama (2004a). International trade with reverse engineering of intermediate goods leads to feedback effects between Northern innovators and Southern imitators who compete for the Southern market. Consequently, both regions face transition paths dependent on their relative technologies.

Consider a very simple IPR environment. There are full IPRs in the North, so domestic sales by Northern innovating firms can only be dislodged by future domestic innovations. However, Northern sales in the South can be wiped out both by future Northern innovation or by Southern imitation. There are two different possible IPR regimes in the South. In the first regime, a Southern firm must compensate (say through a licensing fee) the Northern firm it has imitated in order to be allowed to sell domestically. Without IPR enforcement that transfer is zero. As IPR enforcement rises, so does the licensing transfer payment. In the second regime, in a similar flavor to Helpman (1993), the level of IPR protection directly affects the ability to sell an imitated good. I.e. a Southern imitator will be able to sell with probability $p_C(1 - p_{IPR})$, where p_C is the probability of imitation (copying) and p_{IPR} is the probability of enforcement of Southern IPRs.

We assume balanced trade so there are no international capital flows. The domestic interest rate is therefore determined by domestic technology. With trade, firms can use imports of intermediate goods in final goods production. Southern firms import all intermediate goods that have not yet been copied, and export the Southern final good. Since the South can immediately import higher quality Northern intermediate goods for use in final goods production, it is not limited by its own ability to produce intermediate goods. This implies that with sufficiently low trade barriers, Southern output growth is determined by Northern technological progress.

A representative consumer in each country i makes consumption and savings decisions to maximize the present value of lifetime utility

$$\max_{\{C_i, C_i^*, v\}_{t\to\infty}} \int_0^\infty u(\bar{C}_i) e^{-\rho t} dt \tag{1.1}$$

$\bar{C}_i$ is a composite good given by a Cobb-Douglas aggregator of domestic and imported final goods. We assume that both countries spend equal proportions on each type of final good. The change in domestic assets is given by the difference in labor and interest income minus final consumption expenditures. Given the Cobb-Douglas aggregator, consumer demand for each good depends only on its relative price and the level of expenditures. Optimal control techniques yield the usual expression for consumption growth

$$\frac{\dot{\bar{C}}_i}{\bar{C}_i} = \frac{1}{\theta}\left(r_i - \frac{\dot{\bar{P}}_i}{\bar{P}_i} - \rho\right), \tag{1.2}$$

where $\frac{1}{\theta}$ is the constant intertemporal elasticity of substitution, r_i is the domestic interest rate and $\bar{P}_i$ is the consumption-based price index.

On the production side, we begin with a standard quality ladder model (Barro and Sala-i-Martin 1997). There are a fixed number, J, of intermediate sectors. With limit pricing, only the highest quality good is sold in each sector. The quality of each good increases with successful innovations. Each quality improvement can be thought of as stepping one rung further up a ladder. The size of each step reflects the size of quality improvements. We set the size of this step to be a constant, q, greater than 1. The rung at which the good is located on a quality ladder is denoted by k. Normalizing so all goods begin at quality level 1, the quality level of an intermediate good in sector j will rise from 1 to q with the first innovation, to q^2 with the second innovation, and to q^{k_j} with the k_jth innovation.

Since technology is embodied in intermediate goods, output growth in each country is driven by technological advances in the quality of domestically available inputs, regardless of country of origin. We have the following aggregate final goods production function, undertaken by many perfectly competitive firms, in the North (N) and the South (S)

$$Y_i = A_i L_i \sum_{j=1}^{J} \left(q^{k_{N_j}} \hat{x}_{ik_j} \right)^{1-\alpha}, \ i \in \{N, S\}. \tag{1.3}$$

A is a productivity parameter dependent upon the country's institutions, and L is the labor input used by the representative firm for final goods production. $q^{k_{N_j}} \hat{x}_{ik_j}$ is the quality-adjusted level of intermediate good j used in final goods production. This intermediate good can be domestic or foreign produced. Each country produces a different final good that can be used in research and can be costlessly transformed into intermediate goods. Let final good in North, Y_N be the numeraire, so $P_N = 1$. The Southern final good, Y_S, has price P_S.

Which country actually produces a particular intermediate good depends on each country's technological level, as well as trade barriers and IPR enforcement. By assumption, the North is the more technologically advanced country. Therefore, it must innovate to push forward its (and the world's) technology. The South can increase its domestic technology by imitating Northern technology, at least until the technology gap is eliminated.

Once knowledge of how to produce an intermediate good exists domestically, it can be produced using the final goods production function. Hence, the marginal cost of producing an intermediate good equals the marginal cost, MC_i, of producing the final good. With perfect competition in the final goods industry, this also equals the price of the final good. So the marginal cost of producing an intermediate good is independent of its quality level and is identical across all domestic sectors. We parameterize the model to yield higher marginal costs in the North than in the South ($MC_N > MC_S$) to enable successful imitating firms to underprice Northern competitors.

The lead innovating firm in each sector uses limit pricing to wipe out sales of lower quality goods. Innovations are drastic ($q > \frac{1+\tau_{x_S}}{MC_S}$). I.e. for given Southern tariffs on intermediates,

τ_{x_S}, and MC_S, the size of quality improvements is large enough for a Northern firm to hold the world market with a single quality level improvement over a Southern copy. A Southern firm captures the Southern market by imitating (and underpricing) the lead Northern good.

With monopolistic competition in the intermediate sector, expected profits depend on the closest competition faced by the firm. In the North, full IPR enforcement guarantees that Northern innovators always face the previous Northern innovator as their closest competitor. Assuming $q(1-\alpha) \leq 1$, they will choose a limit price slightly below, $qMC_N = q$. Since the latest innovation is q times more productive than its predecessor and since $MC_N = 1$, q is the lowest price at which the previous innovator could sell without earning negative profits. This limit price will wipe out Northern sales of all older technologies.

In the Southern market there are three types of firms: Northern exporting firms facing Northern competition, n^*_{NN}, Northern exporting firms facing Southern competition, n^*_{NS}, and Southern imitating firms facing Northern competition, n_S. Since there are J sectors, $J = n_C + n^*_{NS} + n^*_{NN}$. They will respectively have limit prices: $P^*_{NN} = q(1 + \tau_{x_S} + t)$, $P^*_{NS} = qMC_S$, and $P_S = 1 + \tau_{x_S} + t$.

In either country i, for a given limit price, $P_{x_{ij}}$, and final goods price, P_i, implied demand for intermediate goods in sector j is

$$x_{ij} = L_i \left[A_i (1-\alpha) q^{k_{ij}(1-\alpha)} \frac{P_i}{P_{x_{ij}}} \right]^{\frac{1}{\alpha}} \tag{1.4}$$

Firms choose the resources to devote to research based on the expected present value of profits for successful research, which depends on the probabilities of innovation and imitation. Within an intermediate goods sector j, presently at quality level k_{Nj}, $p_{Ik_{Nj}}$ is the probability per unit of time that the next innovation occurs. $p_{Ik_{Nj}}$ follows a Poisson process, which depends positively on resources devoted to research, $z_{Ik_{Nj}}$, and past industry specific domestic learning-to-learn, $\vartheta_{k_{Nj}}$, and negatively on the complexity, $\varphi_{Ik_{Nj}}$, of the good upon which firms are attempting to improve:[1]

$$p_{Ik_{Nj}} = z_{Ik_{Nj}} \vartheta_{k_{Nj}} \varphi_{Ik_{Nj}}, \text{ where} \tag{1.5}$$
$$\vartheta_{k_{Nj}} = \beta_I q^{k_{Nj}}, \text{ and } \varphi_{Ik_{Nj}} = \frac{1}{\zeta_I} q^{\frac{-k_{Nj}}{\alpha}}.$$

β_I reflects a positive spillover from past experience, while ζ_I is a fixed cost of innovative research. The probability, $p_{Ck_{Nj}}$, of imitating the current technology, k_{Nj}, is

$$p_{Ck_{Nj}} = z_{Ck_{Nj}} \vartheta_{k_{Sj}} \varphi_{Ik_{Nj}}, \text{ where} \tag{1.6}$$
$$\vartheta_{k_{Nj}} = \beta_C q^{k_{Sj}}, \ \varphi_{Ck_{Nj}} = \frac{e^{\omega}}{\zeta_C \hat{q}_j^{\sigma}} q^{\frac{-k_{Nj}}{\alpha}}, \ \sigma > 1,$$
$$\hat{q}_j = \frac{q^{k_{Sj}}}{q^{k_{Nj}}}, \ \omega = \left(\frac{M}{Q_N}\right)^{\eta}, \text{and } Q_N = \sum_{j=1}^{J} q^{\frac{k_{Nj}(1-\alpha)}{\alpha}}.$$

Learning in the South depends on the highest experience within that sector gained through imitation. The spillover from innovative experience, β_I, is greater than that from imitation, β_C. Relative to the cost of innovation, two new factors affect the cost of imitation, $\frac{\zeta_C \hat{q}_j^{\sigma}}{e^{\omega}}$. Firstly, the cost of imitation depends positively on the sector j South/North technology ratio, $\hat{q}_j$, and reflects the increasing cost of imitation as Southern technology approaches that of the North. This implies decreasing returns to imitation as the pool of goods that can be targeted for imitation decreases. Secondly, e^{ω} reflects lower costs of gathering information about foreign goods with greater interaction, ω, between the two countries, as measured by Southern imports of intermediate goods, M, scaled by the aggregate Northern technology level, Q_N. Since the cost of imitation increases as the technology gap decreases, the probability of imitation, and consequently the probability of innovation, both change in transition to steady state.

A Northern firm loses its profits from sales to the Northern market when the next innovation occurs. It loses its expected Southern profits when it is imitated by a Southern firm or when the next innovation occurs. A Southern firm loses its profits when the next innovation occurs. Free entry into innovative and imitative research will guarantee that research costs (Z_I and Z_C respectively) will exactly equal the expected present discounted value of profits.

Entry and exit into n_S, n^*_{NS}, and n^*_{NN} depends on p_{IPR} and the average p_C and p_I:

$$
\begin{aligned}
\dot{n}^*_{NN} &= p_I(1-p_C)n^*_{NS} - [p_I p_C + (1-p_I)(1-p_{IPR})p_C]n^*_{NN} \\
\dot{n}^*_{NS} &= p_I(p_C n^*_{NN} + n_S) - [(1-p_I)(1-p_{IPR})p_C + p_I(1-p_C)]n^*_{NS} \\
\dot{n}_S &= (1-p_I)(1-p_{IPR})p_C(n^*_{NN} + n^*_{NS}) - p_I n_S
\end{aligned} \tag{1.7}
$$

Note that in our first IPR scenario, $p_{IPR} = 0$.

Finally, there are two world resource constraints

$$
\begin{aligned}
Y_N &= C_N + X_N + Z_N + C^*_N + n^*_{NS}X^*_{NS} + n^*_{NN}X^*_{NN} \\
Y_S &= C_S + n_S X_S + Z_S + C^*_S.
\end{aligned} \tag{1.8}
$$

where Z_i represent aggregate research costs and the X represent intermediate goods in different categories

Solutions are found using the free entry conditions, sector category expressions, two world resource constraints, a balanced trade condition, two consumer demand conditions, two consumption growth conditions, and the functional forms for p_I and p_C.

2 Results

First consider trade liberalization in the South independently of any Southern IPRs. Lowering Southern intermediate goods tariffs causes large initial increases in imitation, which then falls in transition to steady-state but remains above its previous steady-state level. Innovation drops slightly on impact, but then rises gradually until it reaches its new higher steady state level equal to that of imitation. This leads to higher world growth. In steady-state, this is welfare enhancing for both countries. However, there are transition costs, borne principally by the North. The transitional welfare loss outweighs the North's steady-state welfare gain. In the next experiments we see that this welfare loss is due to a lack of internationally enforced IPRs rather than Southern trade liberalization per se.

Consider the two possible IPR regimes mentioned above. In the first regime, imitation is allowed to continue, but imitators are forced to partially remunerate the Northern innovators that they have imitated. For simplicity we have simulated this by considering a one time transfer (licensing fee) from the Southern imitator to the innovator. This raises the fixed cost of imitation and helps offset some of the fixed costs of future innovation. Liberalizing Southern trade in combination with this licensing fee leads to a jump up in innovation and a fall in imitation on impact. In transition the innovation slows but remains at a higher steady state level. Imitation gradually increases in transition until it equals the rate of innovation. This scenario yileds faster rates of innovation and growth than with Southern trade liberalization alone. This is due to the presence of spillovers from Northern innovation to Southern imitative research through exposure to the Northern technology embodied in imported intermediates. As IPR enforcement increases in the South, this spillover is being partially internalized since the Northern firms are receiving some remuneration for this externality. Hence, the rate of innovation increases by more than in the case of trade liberalization without concurrent increases in Southern IPRs. Welfare (including the transition) increases unambiguously both for the North and the South. Moreover, because of this added boost to technological progress, Southern welfare increases by more than if it had liberalized without imposing this licensing arrangement.

In the second IPR regime, the government raises p_{IPR} from zero to some positive value less than one, at the same time as Southern trade is liberalized. In this case, Northern firms effectively face less competition from Southern imitators. In equilibrium however, facing less competition causes them to slow their rate of innovation. Hence, imposing IPRs that limit competition from the South end up being welfare reducing for both countries.[2]

Analyzing the imposition of two different IPR regimes in the context of trade liberalization for a developing region, highlights four important points. First, the welfare implications for IPR strengthening in developing countries differ greatly depending on the design of the IPR regime. Second, the optimal IPR regime depends on whether or not technological diffusion is occurring, and whether or not there are feedback effects between innovating firms and imitating firms. Third, it is important to consider not only steady-state results, but also the transition paths when determining welfare effects. Finally, the presence of these feedback effects suggest that unlike most previous findings, there may not be direct conflict on optimal IPR levels from the perspective of DCs and LDCs. Namely, in a model of technological diffusion, both regions ultimately care about the same world growth rate. Hence, IPR policies that maximize this world growth rate will be in the interest of both regions.

References

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Notes

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[1]The forms assumed for ϑ and φ guarantee constant returns to innovative research with respect to technology levels. This is needed to consider a steady-state balanced growth path and is reasonable if there are an infinite number of potential innovations.

[2]This result is in line with Helpman's (1993) findings where he considered the implications of higher IPRs as decreasing the rate of imitation in a dynamic North-South model.