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Developing Countries:

A Game-theoretic Model

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I. Introduction

Technological learning is a key determinant of economic growth. It has now been widely recognised in the literature that intellectual property rights (IPR) policy has very significant implications for technological learning and technological capability accumulation in developing countries (Lall 2001, IPR Commission 2002, Dutfield 2005). However, designing an appropriate IPR policy for driving the economy towards an optimum learning trajectory involves a complex public choice problem due to the trade-off between innovation and diffusion that it entails.

Economists belonging to the neo-liberal tradition do not hesitate to endorse the importance of incentives to innovate¹ and believes that a strong IPR regime that fosters such incentives for innovation (but restricts diffusion and learning through imitation and reverse engineering) would be the best policy option for a developing or emerging economy to embrace globalisation. Others, however, believe that developing countries are likely to lose out under strong IPR due to shrinking opportunities of imitative R&D and hence a weak IPR, facilitating diffusion and learning, could prove to be most important, for technological learning and catch-up (Helpman 1993, UNCTAD 1996, Lall 2001, Maskus 2000).

While, the debate on optimum IPR policy continues, one is tempted to conclude that a weak IPR policy would perhaps be preferred over a stronger one in the initial stages of technological learning and economic development. But, once a country reaches technology maturity to achieve major breakthroughs, the benefits of protecting knowledge through strong IPR (incentive to innovate) might outweigh the benefits of diffusion. Hence, a strong IPR policy that encourages innovation may be necessary at a later stage after the country in question acquires innovative capability through learning.

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¹ Note, however, that the strength of IPR regime may not always raise the incentive to innovation in a linear fashion, especially if innovation is a cumulative process based on a pioneer invention. See Nordhaus (1969), Scotchmer (1991), Lerner (2001), Gallini (2002).

This essentially reflects that IPR policy can not remain static or invariant over time. It needs to be modified, fine-tuned and adjusted at various points in the technological learning trajectory of a nation, according to the nature and level of technological capability already acquired through this learning process. At the same time the nature and extent of technological learning will also definitely be shaped by the IPR policy adopted. In other words, technological learning and IPR policy have a strong mutual interface in the way they evolve. There is significant historical evidence of this phenomenon. Dutfield and Sutharsanan (2005), for instance, documents “numerous instances of how today’s developed countries often ensured they had weaker IP regimes than those of the technologically more advanced countries with which they were seeking to catch up”.

Unfortunately, there is little theoretical analysis of this interface between IPR policy and technological learning. Our paper attempts to fill this gap in the economics literature. We seek to provide a theoretical understanding of the interface between technological learning and IPR policy, using tools of applied microeconomics. We develop a simple game theoretic model to explain the optimum IPR policy and the corresponding technological learning in a developing country. Our model identifies the nature and extent of domestic technological learning under different IPR regimes, both being endogenously determined.

We begin with a brief overview of the concept of the evolution of *technological capability* of developing countries in section II. This is followed by a brief discussion of the institution of IPR and the related debates in section III. Section IV presents the model and the results. Section V interprets the co-evolutionary character of technological learning and IPR policy from our results and discusses the implications of TRIPS agreement for the process of TC acquisition in developing countries.

II. Evolution of Technological Capability in Developing Countries

Technological progress is often (misleadingly) identified with major breakthroughs and movement of the frontier in the conventional neo-classical literature. This highly restrictive view has come under serious attack on grounds that it ignores that minor (as opposed to major) innovations are more likely to occur and act as a vital and continuous source of productivity gains in practically all industries.² This is particularly important in understanding technological progress in developing countries. Indeed, instead of recognising

² Lall (1987), Nelson and Winter (1982).

the key role played by the capability to invent around, the rise in competitiveness of Japanese industries in the mid-1960s was initially wrongly attributed to low labour cost advantage (along the lines of the product cycle paradigm).³

Lall (1985) defines technological capability in developing (TC) countries as their capacity to select, assimilate, adapt and improve given technologies. These stages of TC acquisition can be described as a process of path dependent evolution.⁴ It begins with *learning by doing* followed by *learning by adapting*, aiming at augmenting productivity through efficient utilisation and adaptation of technologies at the shop floor. We call this the stage of ***production engineering (PE)***. Next comes *learning by design* and *learning by improved design*, aiming at replicating processes and designs for better understanding and further improvement of given technologies. This stage is described as ***reverse engineering (RE)***. All this culminates into *learning by setting up complete production systems* and *learning by designing new processes* which ultimately sets the stage for technological capabilities of ***basic (frontier) research (BR)***.

Acquisition of technological capability, therefore, requires technological effort defined as “conscious use of technological information and accumulation of technological knowledge, together with other resources, to choose, assimilate and adapt and/ or to create new technology.”⁵ Clearly, therefore, diffusion of technology is also intimately linked to the process of TC acquisition by developing country enterprises through gradual learning and building up of absorptive capacity.⁶

The presence of multinational corporations (MNC) as a vehicle of technology transfer may be seen as an important factor in this regard. Domestic firms, at their nascent stage of technological capability may benefit from the superior technologies of MNC subsidiaries through spillovers. Gains from spillover, in this case, manifest itself in the form of easier diffusion by reducing the cost of search and imitation. .

The entire premise is predominantly based on the assumption that MNC subsidiaries have access to latest (or at least better) technologies from the “technology shelf” of their parent enterprises. Needless to mention that the benefits accruing to domestic firms in terms of spillover will depend on the vintage of technologies transferred by MNCs to their subsidiaries at host developing countries. Older technologies will accrue only marginal

³ Rosenberg and Steinmuller (1988).

⁴ Lall (1978)

⁵ Bell (1984).

⁶ Cohen and Levinthal (1989).

spillover gains to domestic enterprises since they are already well diffused. As against this, the spillover gains from latest (new) technologies would be substantially higher and would facilitate the technological catch-up process of domestic enterprises.

Apart from transfer of technologies by MNCs to their subsidiaries at developing country locations, another important source of spillover could be through locating their global R&D in host developing country locations. However, as Dunning (1988) suggests, most developing countries are unattractive as locations for research as they are weak in fundamental knowledge⁷ and often provide hostile political climate. “Few foreign companies are keen to place research centres in these nations, and where they have done so it is often as a result of political pressure.”⁸ We therefore ignore this channel of spillover in our model.

III. The Institution of Intellectual Property Rights (IPR) Regime

It is now widely accepted that institutions affect economic performance by reducing uncertainty, making behaviour predictable and thereby reducing transaction costs a la Williamson (1985). According to North (1990) “institutions are the rules of the game in a society or, more formally, humanly devised *constraints* that shape human interaction.” However, one can also offer a broader notion of institutions as a set of rules or “enabling constraints” that regulate and constitute behaviour (rather than only constraining it).⁹

The evolution of technology is shaped and fostered by several supporting institutions.¹⁰ In this paper, we confine our attention to one such (perhaps the most) important institution, namely the intellectual property rights (IPR) regime. The main reason why IPR is important is that it creates a legal means to appropriate knowledge. But the optimum degree of protection of knowledge would vary over time and across countries depending on the level of technological capability as well as the technological policy goals.¹¹ For simplicity, we categorise IPR regimes into two groups: (a) ***strong IPR regime***; and (b) ***weak IPR regime***

The strength of a patent regime may be defined in terms of characteristics such as *length and width of protection, patent fee, the burden of proof* in case of infringements, and various *limitation of patent award*, e.g. compulsory licensing. For our model, we simply

⁷ India may be an exception, but even there we have little evidence of MNCs locating their global R&D base.

⁸ Dunning (1988), page 133.

⁹ See Nooteboom (1999) pp. 39.

¹⁰ See Nelson (1994), Nelson & Nelson (2002), among others.

¹¹ Singapore, for example, adopted a FDI led growth driven by MNC-based R&D and therefore had strong IPR protection. See Lall (2001).

assume that a strong IPR regime is the one that is TRIPS compatible, namely, providing product as well as process patents for a period of 20 years). By contrast, a weak patent regime allows only process patents and for a much shorter duration (5 to 7 years). This encourages R&D towards reverse engineering.

Weak IPR would thus be preferred over a stronger one in the initial stages of technological capability and economic development if advancement of technological capability is an important policy objective of the developing country government. A weak IPR in this case provides a favourable selection environment for firms to grow by augmenting technological capabilities through imitation and reverse engineering. Once a country reaches technology maturity to achieve major breakthroughs, the benefits of protecting knowledge through strong IPR (incentive to innovate)¹² might outweigh the benefits of diffusion. This is evident from the experience of countries like Switzerland, Germany, Japan, and Korea.¹³

Historically, all these countries have had the flexibility to adapt IPR regimes to foster technological learning and creation of innovative capacities according to their needs and capabilities. This highlights the endogenous character of the institutional framework of IPR, as in the tradition of *institutional economics*. In this paper we attempt to show that there is a strong interface between the TC and IPR in their evolutionary process. In other words, TC and IPR are, ‘the two evolving entities interact causally with one another’,¹⁴ i.e, TC and IPR *co-evolve*.

With the advent of the TRIPS agreements under WTO, the flexibility of designing appropriate IPR regime by member nations has been removed. This would have serious implications for countries involved in the technological catch-up process by suppressing the interdependent co-evolutionary character of their TC and IPR institutions. These countries will now have to treat IPR institution as *given* or *exogenous*.

IV. The Model

¹² We may note that the strength of IPR regime may not always raise the incentive to innovation in a linear fashion, especially if innovation is a cumulative process based on a pioneer invention. See Nordhaus (1969), Scotchmer (1991), Lerner (2001), Gallini (2002).

¹³ See, for instance, the Report of the IPR Commission (2002).

¹⁴ Murmann (2003), page 24.

We begin with the premise that there is a strong interdependence between technological capability (TC) and IPR regime. In other words, both TC and IPR regime co-evolve with a strong interface between the two in their evolutionary process. We further argue that the nature of this interface or co-evolution may actually be one of strategic interaction between various economic agents.¹⁵ We develop a two-period game theoretic model of complete information to show that an optimum IPR regime for a developing country is an outcome of a strategic interaction between the government and the industry (domestic and multinational firms).

We propose a two period extensive form game of complete information with three players: the Government, a representative domestic firm and a representative foreign firm (MNC). It is assumed that all firms operating in the market can be grouped under either of the above two categories. We further assume that all firms belonging to a particular category are identical. The game is described in the usual format of player, strategy and pay-off.

Players:

The players are the Government (G), a domestic firm (D), a foreign firm (M).

Strategies:

The strategy set for G includes:

1. choosing a strong IPR regime with product and process patent (SIPR)
2. choosing a weak IPR regime with process patent only (WIPR).

The strategy set of D includes the following actions:¹⁶

1. Production Engineering (PE)
2. Reverse Engineering (RE)
3. Basic (frontier) research (BR).

The strategy set of M includes the following actions:

1. Transfer an old technology to the host LDC (TO)
2. Transfer a new technology to host LDC (TN)

¹⁵ North (1990) predicts that different economic groups would have different positions on the question of an institutional change depending on the associated perceived benefits and costs. Bijker et al (1987), among others also believe that institutional framework form a “negotiated order”.

¹⁶ These may not necessarily be mutually exclusive alternatives. A firm may choose its technology strategy as a combination of all three. Our model, however, assumes away this possibility. We only look at the overall R&D focus of the firm defined in terms of PE, RE and BR.

We consider an extensive form game with perfect recall where G moves first and decides the patent regime. In the second period, the two firms (D and M) play a simultaneous move game with full knowledge of the regime under which it is operating. At equilibrium all players will play *Subgame Perfect Nash Equilibrium* strategies.

Payoffs:

Payoffs are defined as returns net of costs for different technology strategies adopted by D and M. For D, the returns will clearly depend on the strategies of M while costs (C) may be simply viewed as the physical costs of adopting the technology strategy. For M, however, costs include not only the physical costs of carrying out their strategies but also costs due to spillover which in turn will vary according to D's strategy. The extent of such interactive influence on each others payoffs will, of course, depend on the IPR regime adopted by the LDC government. We define the firms' payoff in terms of costs and returns under the two different IPR regimes (WIPR and SIPR) as two distinct second period subgames along with the subgame Nash equilibria.¹⁷ The government's payoff matrix will be discussed next under the first period subgame which will then enable us to derive the subgame perfect Nash equilibrium.

(1) Second Period Subgame 1: under WIPR

D's payoff from strategy i (and depending on M's strategy j) can be generally written as: $D_{ij} = R_{ij} - C_i$ where R is returns from the strategy and C is the cost of the strategy.

On the cost side, it may reasonably be assumed that $C_{PE} < C_{RE} < C_{BR}$, irrespective and independent of M's strategies, i.e., $C_{ij} = C_i \forall j$ and $C_1 < C_2 < C_3$.

The R&D strategies PE, RE and BR yield outcomes leading to returns R_{PE} and R_{RE} and $p \cdot R_{BR}$ respectively, where p denotes the probability of success in basic research ventures. It is assumed that there is no uncertainty associated with PE and RE activities.

R_{PE} will perhaps not vary according to the strategy adopted by M. If we assume that PE is merely a survival strategy in a perfectly competitive market, then $R_{PE} = C_{PE} \forall j$, i.e.

$$D_{ij} = 0 \forall j.$$

Under WIPR allowing patented products to be produced with non infringing processes, RE yield a high return such that $R_{RE} > C_{RE}$. Furthermore, R_{RE} will be still higher if

¹⁷ In these second period subgames, the government does not enter as a mover and we do not include its payoff in these payoff matrices. Indeed, the government's payoff are not required to arrive at the second period subgame equilibria.

M chooses to transfer new technology compared to old, as the former facilitates exposure of the LDC firms to latest (less diffused) technologies for reverse engineering. In other words, $C_2 < R_{21} < R_{22}$. Hence $D_{22} > D_{21} > D_{1j} = 0$

Now we look at R_{BR} . WIPR allows imitation through reverse engineering and the new technology arising out of BR can be diffused, perhaps immediately. Consequently both BR and RE may be assumed to yield identical returns under WIPR, i.e., $R_{2j} = R_{3j} \forall j$. But costs of the two strategies differ ($C_2 < C_3$). Moreover, the probability of succeeding in BR may also rise if M adopts TN, i.e. $P_{31} < P_{32} \leq 1$. Accordingly,

$$D_{31} = P_{31} \cdot R_{21} - C_3 < R_{21} - C_2 < D_{21}$$

$$D_{32} = P_{32} \cdot R_{22} - C_3 < R_{22} - C_2 < D_{22}$$

Also $D_{31} < D_{32}$

The payoffs for M can be generally specified as:

$M_{ij} = G_j - K_j - S_{ij}$ where G stands for gains from its strategy, K the physical costs and S the spillover cost.

Let $G_1 = G$ be the returns from operating in the LDC by transferring old technology. This is enhanced by an amount (H) when it chooses to transfer new technology. It is presumed that the old technology is already well diffused, while the new technology will give the MNC exclusive market access reflected in gains (H). Hence, $G_2 = G + H$.

On the cost side, it may reasonably be assumed that $K_1 < K_2$, insofar as physical costs are concerned. The spillover costs are nil for TO as it is already well diffused. For TN, the spillover cost may be assumed to be equal to the entire additional gain (H) reflecting exclusive market access, under WIPR. This is of course subject to the condition that D adopts RE or BR since spillovers occur only if the domestic firm has adequate technological capability to absorb it.¹⁸ It will again be nil if D adopts PE. Accordingly,

$$S_{11} = S_{12} = S_{21} = S_{31} = 0$$

$$S_{22} = S_{23} = S_{32} = S_{33} = H$$

Hence the payoffs of M will be

$$M_{11} = G - K_1$$

$$M_{12} = G + H - K_2$$

¹⁸ Cohen and Levinthal (1989) emphasised the importance of absorptive capacity building in order to capture knowledge in the public domain.

$$M_{21} = G - K_1$$

$$M_{22} = G - K_2$$

$$M_{31} = G - K_1$$

$$M_{32} = G - K_2$$

The resultant payoff matrix for D and M in the second period subgame 1 therefore is:

M → ↓ Strategy of D	TO (transferring old technology)	TN (transferring new technology)
Production Engineering (PE)	$D_{11} = R_{11} - C_1$ $M_{11} = G - K_1$	$D_{12} = R_{12} - C_1$ $M_{12} = G + H - K_2$
Reverse Engineering (RE)	$D_{21} = R_{21} - C_2$ $M_{21} = G - K_1$	$D_{22} = R_{22} - C_2$ $M_{22} = G - K_2$
Basic Research (BR)	$D_{31} = P_{31} \cdot R_{21} - C_3$ $M_{31} = G - K_1$	$D_{32} = P_{32} \cdot R_{22} - C_3$ $M_{32} = G - K_2$

where we have assumed and argued that

- 1) $R_{11} = R_{12} = C_1$ implying that $D_{11} = D_{12} = 0$.
- 2) $C_2 < R_{21} < R_{22}$ implying that $D_{22} > D_{21} > 0$
- 3) $1 > P_{32} > P_{31}$ and $C_3 \gg C_2$ implying that $D_{31} < D_{21}$ and $D_{32} < D_{22}$
- 4) $K_2 > K_1$ implying $M_{21} > M_{22}$

Subgame Nash

Through iterated elimination of dominated strategies, **(RE, TO)** is obtained to be the unique Nash equilibrium of this subgame. RE is the dominant strategy of the domestic firm as it provides the highest pay-off irrespective of the strategy of the MNC. If rationality of players is common knowledge, then the MNC knows that the domestic firm would play RE and it is therefore better-off playing TO.

(2) Second Period Subgame 2: under SIPR

We shall stick to the same format for deriving the payoffs for D and M. Now the difference will be with respect to the IPR regime which protects knowledge completely and does not allow spillovers. Immediately we can say that RE will not yield any returns to D. Hence

$$R_{21} = R_{22} = 0$$

BR will not yield the same returns as RE as in the previous case. It will be strictly higher. Also D's returns from BR as well as the probability of success will perhaps not vary with M's strategy under SIPR. Hence

$$R_{31} = R_{32} > 0 \text{ and } P_{31} = P_{32} < 1$$

For M the spillover costs element disappears

M → ↓ Strategy of Strategy of D	TO (transferring old technology)	TN (transferring new technology)
Production Engineering (PE)	$D_{11} = R_{11} - C_1 = 0$ $M_{11} = G - K_1$	$D_{12} = R_{12} - C_1 = 0$ $M_{12} = G + H - K_2$
Reverse Engineering (RE)	$D_{21} = R_{21} - C_2 = -C_2 < 0$ $M_{21} = G - K_1$	$D_{22} = R_{22} - C_2 = -C_2 < 0$ $M_{22} = G + H - K_2$
Basic Research (BR)	$D_{31} = P_{31} \cdot R_{31} - C_3$ $M_{31} = G - K_1$	$D_{32} = P_{31} \cdot R_{31} - C_3$ $M_{32} = G + H - K_2$

Subgame Equilibrium:

The equilibrium would depend on the research capability of the domestic firm affecting its probability of success (P_{31}). We consider two cases.

Case I: Low P_{31} such that $(P_{31} \cdot R_{31}) < C_3$

The unique Nash equilibrium will be **(PE, TN)**.

Case II: High P_{31} such that $(P_{31} \cdot R_{31}) > C_3$

The unique Nash equilibrium will be **(BR, TN)**.

(3) First period Subgame

To solve for the Subgame Perfect Nash Equilibrium, we now analyse the first period subgame by folding back the two second-period subgames' equilibria. In this subgame, the player is the government who has to choose between WIPR and SIPR.

The payoff matrix of the government depends on the benefits and costs involved in imposing an IPR regime. On the cost side, WIPR involves lower costs of monitoring and administration

compared to SIPR and will therefore be preferred by the government, *ceteris paribus*. On the benefits side, we identify two major parameters determining the government's utility function: (1) acquisition of technological capability by domestic producers and (2) introduction of latest technologies to enhance consumer welfare. With respect to the first parameter the government would prefer BR over RE over PE and with respect to the second parameter it prefers TN over TO. Assuming domestic technological capability to be the overriding consideration, we can derive the following lexicographic preference ordering of the government:

$$\begin{aligned}
& U(G_1, D_1, M_2) > U(G_2, D_1, M_2) > U(G_1, D_1, M_1) > U(G_2, D_1, M_1) \\
& > U(G_1, D_2, M_2) > U(G_2, D_2, M_2) > U(G_1, D_2, M_1) > U(G_2, D_2, M_1) \\
& > U(G_1, D_3, M_2) > U(G_2, D_3, M_2) > U(G_1, D_3, M_1) > U(G_2, D_3, M_1)
\end{aligned}$$

where $G_1 = \text{WIPR}$, $G_2 = \text{SIPR}$

$D_1 = \text{BR}$, $D_2 = \text{RE}$, $D_3 = \text{PE}$

$M_1 = \text{TO}$, $M_2 = \text{TN}$

Subgame Perfect Nash Equilibrium: We derive the SPNE both for low and high values of p .

Case 1: Low P_{31} such that $(P_{31} \cdot R_{31}) < C_3$

In this case the government has to choose between (WIPR, RE, TO) and (SIPR, PE, TN). Since $U(G_1, D_2, M_1) > U(G_2, D_3, M_2)$, the **subgame perfect Nash equilibrium would be (WIPR, RE, TO)**.

Case 2: High P_{31} such that $(P_{31} \cdot R_{31}) > C_3$

In this case the government has to choose between (WIPR, RE, TO) and (SIPR, BR, TN). Since $U(G_2, D_1, M_2) > U(G_1, D_2, M_1)$, the **subgame perfect Nash equilibrium would be (SIPR, BR, TN)**.

V. Analysis

Our model shows that the optimum IPR will crucially depend on the level of indigenous innovative capability achieved by the country in question. This is reflected in the parameter P , the probability of success in *Basic Research*. The model offers two interesting implications.

A. Implications for a co-evolutionary path of TC and IPR

In this model, TC in developing countries begins with simple *production engineering* (PE). IPR has little role to play at this stage. PE can be carried out under both weak as well as strong IPR equally efficiently, without any impediment. However, transition to the next stage of TC, namely, *reverse engineering* (RE), can only be possible under the ‘enabling constraint’ of a weak IPR. In the model, we have shown that (RE, TO) is a subgame Nash under WIPR.

Reverse engineering, in our framework, is an essential prerequisite for building up innovative capability. We have captured this phenomenon in our model in terms of the parameter P , the probability of success in *basic research* (BR). At the initial stages of RE, this probability is expected to be almost negligible. But with continued reverse engineering fostered by the institutional environment of weak IPR, the value of P is expected to rise, making BR a viable strategic option only after it crosses a threshold value (of C_3/R_{31} as per our model specification). But BR will be sustainable only under a strong IPR to prevent the payoff from BR being reduced to that from RE due to diffusion as argued in the model. Therefore, strong IPR will be the Nash equilibrium strategy for the government as soon as P exceeds this threshold value. It has been shown that (SIPR, BR, TN) is subgame perfect Nash outcome of the strategic interaction among firms and government when $P > C_3/R_{31}$. However, till P reaches this threshold value, the Nash solution is (WIPR, RE, TO). This means weak IPR must prevail till then.

Our model, although neo-classical in character based on rational behaviour and optimisation, arrives at a Nelsonian conclusion of co-evolution of technology (learning) and institution (IPR regime) with a strong interface between the two in their evolutionary process (Nelson 1994). In this co-evolutionary framework, the technological learning begins with PE followed by RE under weak IPR till sufficient innovative capability is acquired for basic research. At this point IPR regime is made stronger to enable firms to adopt basic research as a viable (and sustainable) strategic option. Without the introduction of a strong IPR as a negotiated order at this juncture, the transition to basic research will perhaps prove to be difficult and unsustainable.

B. Implications of TRIPS Agreement

The economic impact of TRIPS on developing countries has remained a controversial issue. It has, however, been generally accepted that the effects of stronger IPR on industry and technology will vary according to the country's levels of economic development.¹⁹ The consensus, by and large, has been that developing countries loses out under strong IPR due to shrinking opportunities of imitative R&D.²⁰ Our model shows that the adverse impact of TRIPS agreement on TC in developing country will depend on whether or not they have been successful in reaching a critical minimum level of innovative capability before the strong IPR is imposed.

Imposition of a TRIPS-compatible strong IPR in countries, which have already achieved the innovative capability level represented by $P \geq C_3/R_{31}$, will not contradict the co-evolutionary character of TC and IPR described above. It is with respect to countries, which are actively engaged in RE but yet to reach the threshold level of innovative capability ($P < C_3/R_{31}$), TRIPS will have serious adverse implications. Pre-mature imposition of strong IPR, suppressing the evolutionary interface between TC and IPR, will not merely put a halt to the technological catch up process but will actually revert the learning trajectory back to PE. This is clear since the Nash equilibrium for the subgame under SIPR is (PE, TN) for $P < C_3/R_{31}$.

We conclude with Lall (2002) that, "there is reason to doubt the benefits of stronger IPRs for developing countries. The new TRIPS regime can promote innovation ... (but at the same it can also) restrict one of the most fruitful sources of learning and competitiveness development: imitation, local diffusion and reverse engineering."²¹

¹⁹ Lall (2001), Maskus (2000).

²⁰ See, for instance, Helpman (1993), UNCTAD (1996).

²¹ Lall (2002), page 103.

References

- Bell, M. (1984), "Learning and Accumulation of Industrial Technological Capacity in Developing Countries", in M. Fransman and K. King (eds) *Technological Capability in the Third World*, Macmillan, London
- Cohen, W.M. and Levinthal, D.A. (1989), "Innovation and Learning: The Two Faces of R&D", *Economic Journal*, Vol 99, pp 569-596.
- Dunning, J.H. (1988), *Multinationals, Technology and Competitiveness*, London: Unwin Hyman.
- Dutfield, G and Sutharsanan, U (2005), "Harmonisation or Differentiation in Intellectual Property Protection? The Lessons of History", *Prometheus*, Vol. 23, No. 2, pp 131-147.
- IPR Commission (2002), *Integrating Intellectual Property Rights and Development Policy*, Report of the Commission on IPR, London.
- Gallini, N.T. (2002), "The Economics of Patents: Lessons from Recent US Patent Reforms", *Journal of Economic Perspective*, Vol 16 (2), pp 131-154.
- Helpman, E. (1993), "Innovation, Imitation and Intellectual Property Rights", *Econometrica*, Vol 61, pp.1247-80.
- Lall, S. (1978), "Developing Countries as Exporters of Technology: A Preliminary Analysis", in Giersch (ed.) *International Economic Development and Resource Transfer Workshop*, Tubingen: J.C.B. Mohr.
- Lall, S. (1985), *Multinationals, Technology and Exports*, London: Macmillan.
- Lall, S. (1987), *Learning to Industrialize*, London: Macmillan
- Lall, S. (2001), *Indicators of the Relative Importance of IPRs in Developing Countries*, Draft Report for UNCTAD.
- Lall, S. (2002), "Transnational Corporations and Technology Flows", in D, Nayyar (ed.) *Governing Globalization*, Delhi: Oxford University Press.
- Maskus, K. (2000), *Intellectual Property Rights in the Global Economy*, Washington DC: Institute for International Economics, www.iie.com/publications/
- Nelson, R.R. (1994), "The Co-evolution of Technology, Industrial Structure, and Supporting Institutions", *Industrial and Corporate Change*, Vol. 3 (1), pp. 47-63.
- Nelson, R.R. and S.G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge: Harvard University Press.
- Nordhaus, W. (1969), *Invention, Growth and Welfare: A Theoretical Treatment of Technological Change*, MIT Press: Cambridge, MA.
- North, D.C. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge, Cambridge University Press.
- Scotchmer, S. (1991), "Standing on the Shoulders of Giants: Cumulative Research and the Patent Law", *Journal of Economic Perspective*, Vol 5 (1), pp 29-41.