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UNCTAD-ICTSD Project on IPRs and Sustainable Development

Indicators of the Relative Importance of IPRs in Developing Countries

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For details on the activities of the Project and all available material, see http://www.ictsd.org/iprsonline

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FOREWORD

The present paper dealing with Indicators of the Relative Importance of Intellectual Property Rights (IPRs) to Developing Countries is one contribution of the joint UNCTAD-ICTSD Project on IPRs and Sustainable Development to the ongoing debate on the impact and relevance of intellectual property to development.

By categorizing countries according to different schema, based on technological activity, industrial performance and technology imports, the study concludes that countries will face different outcomes from strengthening IPRs (in particular patents), not just at different levels of development, but even at similar levels of income, depending on their pattern of technology development and imports. While there is no clear case that most developing countries below the newly industrializing economy stage will gain in net terms from TRIPS, the least-developed countries (LDCs) are most likely to lose. The gains that might accrue through increased technological inflows are likely to be realized over the long term, while the costs for the domestic industry (in terms of increased difficulties to copy or reverse engineer foreign technology) will accrue immediately. The paper stresses, however, that more evidence is needed before a positive link between foreign direct investment and the licensing of technology to domestic firms on the one side and IPRs on the other side can definitely be established.

In sum, without seeking to determine the amount of the costs or benefits, or identifying individual countries that will gain or lose from TRIPS, this study illustrates the wide differences between developing countries with respect to the impact of strengthened IPRs.

Intellectual property rights (IPRs) have never been more economically and politically important or controversial than they are today. Patents, copyrights, trademarks, industrial designs, integrated circuits and geographical indications are frequently mentioned in discussions and debates on such diverse topics as public health, food security, education, trade, industrial policy, traditional knowledge, biodiversity, biotechnology, the Internet, the entertainment and media industries. In a knowledge-based economy, there is no doubt that an understanding of IPRs is indispensable to informed policy making in all areas of human development.

Intellectual Property was until recently the domain of specialists and producers of intellectual property rights. The TRIPS Agreement concluded during the Uruguay Round negotiations has signalled a major shift in this regard. The incorporation of intellectual property rights into the multilateral trading system and its relationship with a wide area of key public policy issues has elicited great concern over its pervasive role in people's lives and in society in general. Developing country members of the World Trade Organization (WTO) no longer have the policy options and flexibilities developed countries had in using IPRs to support their national development. But, TRIPS is not the end of the story. Significant new developments are taking place at the international, regional and bilateral level that build on and strengthen the minimum TRIPS standards through the progressive harmonisation of policies along standards of technologically advanced countries. The challenges ahead in designing and implementing IP-policy at the national and international levels are considerable.

Empirical evidence on the role of IP protection in promoting innovation and growth in general remains limited and inconclusive. Conflicting views also persist on the impacts of IPRs in the development prospects. Some point out that, in a modern economy, the minimum standards laid down in TRIPS, will bring benefits to developing countries by creating the incentive structure necessary for knowledge generation and diffusion, technology transfer and private investment flows. Others stress that intellectual property, especially some of its elements, such as the patenting regime, will adversely affect the pursuit of sustainable development strategies by raising the prices of essential drugs to levels that are too high for the poor to afford; limiting the availability of educational materials for developing country school and university students; legitimising the piracy of traditional knowledge; and undermining the self-reliance of resource-poor farmers.

It is urgent, therefore, to ask the question: How can developing countries use IP tools to advance their development strategy? What are the key concerns surrounding the issues of IPR for developing countries? What are the specific difficulties they face in intellectual property negotiations? Is intellectual property directly relevant to sustainable development and to the achievement of agreed international development goals? Do they have the capacity, especially the least developed among them, to formulate their negotiating positions and become well-informed negotiating partners? These are essential questions that policy makers need to address in order to design IPR laws and policies that best meet the needs of their people and negotiate effectively in future agreements.

It is to address some of these questions that the joint UNCTAD-ICTSD Project on Intellectual Property and Sustainable Development was launched in July 2001. One central objective has been to facilitate the emergence of a critical mass of well-informed stakeholders in developing countries - including decision makers, negotiators but also the private sector and civil society - who will be able to define their own sustainable human development objectives in the field of IPRs and effectively advance them at the national and international levels.

Ricardo Meléndez-Ortiz
ICTSD Executive Director

Rubens Ricupero
UNCTAD Secretary General

EXECUTIVE SUMMARY[1]

A fair amount of uncertainty remains on the economic impact of the TRIPs Agreement in developing countries, and the new round of WTO negotiations adds considerable interest to this controversy. It is widely accepted that the effects of TRIPs on industry and technology will vary according to countries' levels of economic development. The need for, and benefits of, stronger patent protection seem to rise with incomes and technological sophistication.

In theory, society reaps *four kinds of benefits* from granting temporary monopoly rights to innovators through patents. These are: (i) the stimulation of private innovation; (ii) the use of the new knowledge in productive activity; (iii) the dissemination of new knowledge; and (iv) the stimulation of innovation by other enterprises. But the importance of patents fluctuates considerably according to two variables: the technological nature of the activity, and the nature of the economy.

Taking the first of these variables, the role of patents in stimulating research and development (R&D) depends on the activity. In industries where it is relatively easy to copy new products – fine chemicals and pharmaceuticals are the best examples – patents are vital for sustaining the large and risky R&D expenditures needed for product innovation. In industries where copying is very difficult and expensive (these industries account for the bulk of manufacturing in most countries), patents *per se* are not important for appropriating the benefits from innovation.

Turning to the second, the significance of patents varies by the level of development. The main beneficiaries of TRIPs are the advanced countries. There are few benefits in terms of stimulating local innovation in developing countries. Technological activity in the latter consists mainly of learning to use imported technologies efficiently rather than to innovate on the technological frontier. Weak patents can help local firms in early stages to build technological capabilities by permitting imitation and reverse engineering. This is certainly borne out by the experience of the Asian 'tigers', such as like Korea and Taiwan that developed strong indigenous firms in an array of sophisticated industries.

The available historical and cross-section evidence supports the presumption that the need for patents varies with the level of development. Many rich countries used weak patent protection in their early stages of industrialisation, increasing protection as they approached the leaders. Econometric cross-section evidence suggests an inverted-U shaped relationship between the strength of patents and income levels. The intensity of patenting first falls with rising incomes, as countries slacken patents to build local capabilities by copying, then rises as they engage in more innovative effort. The turning point is $7,750 per capita in 1985 prices, a fairly high-income level for the developing world.

In short, assessing the impact of TRIPs in the developing world requires one to distinguish between levels of development. There is no clear case that most developing countries below

the newly industrialising economy stage will gain in net terms from TRIPs; the least-developed ones are most likely to lose. The gains that might accrue through increased technological inflows are likely to be realised over the long term, while the costs will accrue immediately. In present value terms, therefore, one can expect a significant net loss. Indisputably, a differentiated approach to intellectual property rights is called for.

Classification of Countries by IPR Relevance

For the ICTSD-UNCTAD capacity-building project on intellectual property rights, we sought to identify indicators of the relative importance of patents for developing countries. This work involved categorising countries according to different schema, based on *technological activity*, *industrial performance* and *technology imports*.

The classification based on national technological activity was derived from two variables: *research and development financed by productive enterprises* and the *number of patents taken out in the United States*, both deflated by population to adjust for economic size. The two variables were standardised and averaged to yield an index of ‘technological intensity’. We derived four groups from the index values.

1. The world *technological leaders,* with intense technological activity and considerable innovative capabilities as shown by international patenting.

2. Countries with *moderate technological activity*. These countries conduct some R&D, have medium levels of industrial development and are likely on balance to benefit from stronger patents. However, some countries in this group may bear significant adjustment costs in changing patent regimes.

3. Countries with *low technological activity*. These countries are likely to have both significant costs and potential long-term benefits from stricter patents, depending on the level of domestic technological capabilities and their reliance on formal technology inflows. Those that are building their innovation systems on the basis of local firms copying foreign technology and importing technologies at arm’s length would gain less than those with a strong trans-national corporation (TNC) presence.

4. The fourth level comprises countries with *no significant technological activity*. These – the least-industrialised countries with the simplest technological structures – are likely to gain least, and lose most, from strict patent rules. They will tend to pay the costs (higher prices for protected products and technologies) but gain little by way of technology development or transfer.

Table 1: Average technology effort/country by technology groups, 1997-1998

Technology groups	R&D per capita (US$)	Total R&D (US$ b)	Patents/ 1000 people	Total patents
High	293.25	14.93	0.99	6,803
Moderate	14.01	0.41	0.02	50
Low	0.24	0.08	0.00	11
Negligible	0.00	0.00	0.00	0

Source: Calculated from UNESCO, Statistical Yearbook; OECD, Science, Technology and Industry Scoreboard 1999; Iberoamerican Network of Science and Technology Indicators; various national statistical sources.
Note: R&D is only that financed by productive enterprises. Patents are those taken out in the US. Total R&D and patents are average for each country.

We considered technological effort at the national level based on the data we generated for productive enterprise R&D and international patents. The 87 countries were surveyed could be subdivided as follows: 22 industrialised economies, seven economies in transition, and 58 developing economies. The data revealed the existence of four groups of countries as follows:

Group 1: This group has most industrialised countries, but there are interesting inclusions and exclusions. Perhaps the most important for the present discussion is the presence of the four mature Asian Tigers, Taiwan, Korea, Singapore and Hong Kong. These technological newcomers have followed different strategies to build up their capabilities. Weak IPRs played a vital role in the technological development of Korea and Taiwan, the two leading Tigers. They are the best recent examples of the use of copying and reverse engineering to build competitive *and innovative* technology-intensive industrial sectors. However, unlike many other developing countries with weak IPRs, they were able to use the opportunities offered because of investments in skill development, strong export orientation, ample inflows of foreign capital goods, and strong government incentives for R&D.

Group 2: This group of moderate technology performers includes the European economies in transition such as Russia, Poland and Hungary. From the developing world it has the main Latin American economies: Brazil, Argentina, Chile and Mexico.

Group 3: The group of low technology performers is very diverse. It has large countries with heavy industrial sectors like China, India and Egypt, along with dynamic export oriented economies like Thailand and Indonesia. But it also has countries with small industrial sectors and weak industrial exporters. In this group, the implications of stronger IPRs are likely to vary.

Economies with significant technological effort and/or strong local enterprises (e.g. India, China or Thailand) are likely to benefit from slack IPRs in some aspects and gain from strong IPRs in others. Those with little 'real' innovative capabilities or competitive enterprises may not be able to utilise slack IPRs to build up local technology, and may gain from FDI inflows by strengthening IPRs. At the same time, TRIPs may lead to net costs for some countries with no corresponding benefits. At this stage it is difficult to discern the net outcome.

Group 4: This group has no meaningful technological activity by either measure (and the countries are not ranked individually). It contains all the least-developed countries in the sample, and developing countries like Pakistan, Albania and El Salvador.

Industrial Performance

As expected, there generally is a strong relationship between the technology and industrial performance indices. Technological effort is intimately related to levels of industrialisation, success in export activity, and the sophistication of the production and export structures.

There is clearly a positive correlation between patents, industrial performance and technological effort. This does not mean, however, that patents are *causally* related to growth and development: each rises with development levels. Moreover, there is probably a strong *non-linearity* involved. Strong patents are probably beneficial *beyond a certain level* of industrial sophistication, while *below* this level their benefits for development are unclear.

In addition, the further down one goes in the scale the less evident the benefits become. In terms of the performance index, the 'very low' and 'low' performance groups are, on average, unlikely to benefit from TRIPs. In both 'medium' groups there is probably a mixture of beneficial and non-beneficial effects depending on the country, with a case for strengthening IPRs in the medium term. In the 'high' performance group the benefits are clearer. There is one important factor here that may have a bearing on IPRs: the growth of *'international production systems'*. While trans-national corporations (TNCs) have had export platforms in developing countries, the emerging trend has been for them to locate (tightly linked) processes in different countries to serve global or regional markets.

This trend is particularly marked in high-tech activities, led by electronics. The emergence of international production systems has enabled countries to move up the production, export and technological complexity ladder rapidly without first building a domestic technology base. Again, the East Asian economies bear this out. With the exception of Korea, Taiwan and Singapore, none has a strong domestic technology base in electronics. The electronics production system, however, only encompasses a limited number of developing countries.

Does the promise of integrated systems mean that developing countries should adopt stronger IPRs in the hope of attracting export-oriented TNCs?

The short-term answer is probably 'no'. Most TNC assembly activity has been attracted to developing countries without changing the national patent regime by isolating export-processing zones from the rest of the economy. China is a good example. For the longer term, however, the answer is likely to be 'yes' – at least for those countries seeking to attract high-tech production systems. Inducing TNCs to invest in such activities when competitors are offering stronger IPRs would force all aspirants to also have equally strong protection.

Moreover, countries that already have high-tech assembly operations would need to strengthen IPRs to induce TNCs to deepen their operations into more advanced technologies and functions like R&D and design. At the highest end of TNC activity, where developing countries compete directly with advanced industrial countries, the IPR regime would have to match the strongest one in the developed world.

However, as integrated systems are highly concentrated geographically, these considerations may not apply to many developing countries. Countries far from centres of activity, and with low technological capabilities, may continue to be marginalized from most TNC activities. The strengthening of IPRs may actually reinforce the tendency to concentrate high-value functions in a few efficient, well-located sites, implying that these other countries would, as a result of TRIPs, have fewer tools to build local capabilities in the future.

Technology Imports

The lack of correlation between technology effort and technology imports is not surprising. There is no *a priori* reason to expect that countries that do more R&D would also receive larger amounts of FDI relative to their economic size or spend more on foreign technology than other countries. In some cases, there is good reason to expect the opposite – a strong technology base may lead to more outward rather than inward FDI relative to GNP and to greater royalty receipts than payments. In other cases, strong FDI inflows and royalty payments may go with a weak local technology base.

This reinforces the conclusion that countries will face different outcomes from strengthening IPRs, not just at different levels of development but even at similar levels of income, depending on their pattern of technology development and imports. It may, of course, be argued that *all* countries should in the future be more receptive to FDI and licensing and that stronger IPRs will promote both. In fact, countries with exceptionally low levels of technology inflows should make special efforts to raise them. More evidence is needed, however, before we can say with certainty that FDI and licensing respond positively to intellectual property rights.

When we consider technology imports in the form of capital goods, we find that the pattern is very similar to other forms of technology imports: group averages change in line with the technology index, but with large variations between individual countries. Much of the variation has to do with the size of the economy (apart, obviously, from the level of development), with larger countries less dependent on imported equipment than smaller ones.

Food for Thought

This review illustrates the significant differences both between rich and poor countries and within the developing world itself in the variables that may affect the technological impact of TRIPs: domestic technical effort, industrial performance, and foreign technology imports. It has sought to put empirical flesh and bones on the intuition that different countries may face different outcomes by strengthening their patent regimes, without trying to measure what the costs and benefits might be. A word of caution: it is impossible to pick the countries that will lose or gain from TRIPs from indices generated from the indicators identified. Their use lies mainly in illustrating just how wide the differences are between developing countries in practically every aspect of technological and industrial performance.

1. INTRODUCTION

There remains considerable controversy on the economic impact of TRIPS (interpreted here as the tightening of IPRs) in developing countries; needless to say, the new round of WTO negotiations adds considerable interest to this controversy. This paper focuses on the long-term structural issues concerning the impact of TRIPS on industrial and technology development in poor countries. It does not, therefore, deal with such important current issues as the cost of medicines, agricultural inputs or genetic materials. Even in the analysis of technology development, it has a limited objective. It seeks to indicate the potential significance of IPRs by differentiating developing countries according to the *expected impact of stronger protection*.[2] It does not measure statistically the strength of IPR regimes or their impact on development as such.[3]

It is widely accepted that the effects of TRIPS on industry and technology will vary according to countries' levels of economic development.[4] The need for, and benefits of, stronger intellectual property protection seem to rise with incomes and technological sophistication. If this were so, there would be a case for adjusting TRIPS requirements to the specific conditions of particular countries. To quote a recent publication by the World Bank,

"Because the overwhelming majority of intellectual property … is created in the industrialized countries, *TRIPS has decidedly shifted the global rules of the game in favour of those countries*… Developing countries went along with the TRIPS agreement for a variety of reasons, ranging from the hope of additional access to agricultural and apparel markets in rich nations, to an expectation that stronger IPRs would encourage additional technology transfer and innovation. However, the *promise of long-term benefits seems uncertain and costly to achieve in many nations, especially the poorest countries*. In addition, the administrative costs and problems with *higher prices for medicines and key technological inputs* loom large in the minds of policy makers in developing countries. Many are pushing for significant revisions of the agreement.

There are reasons to believe that the enforcement of IPRs has a positive impact on growth prospects. On the domestic level, growth is spurred by higher rates of innovation – although this result tends to be *fairly insignificant until countries move into the middle-income bracket*. Nonetheless, across the range of income levels, IPRs are associated with greater trade and foreign direct investment (FDI) flows, which in turn translate into faster rates of economic growth. *The most appropriate level of IPRs enforcement therefore varies by income level*." (World Bank (2001), p. 129).

The Bank concludes as follows: "the strength of intellectual property protection depends on economic and social circumstances, which in turn affect perceptions of the appropriate trade-off between invention and dissemination… Countries with a high ratio of R&D in gross domestic product (GDP) or a high proportion of scientists and engineers in the labour force have markedly stronger patent rights than others… Interests in encouraging low-cost imitation dominate policy until countries move into a middle-income range with domestic innovative and absorptive capabilities… Least-developed countries devote virtually no resources to innovation and have little intellectual property to protect… Thus the majority of economic interests prefer weak protection." (World Bank, 2001, p. 131-2)

The Bank also notes that history does not provide a clear guide to the growth effects of IPRs: "at different times and in different regions of the world, countries have realised high rates of growth under varying degrees of IPR protection" (p. 135). Given the clear net short-term costs for less industrialised countries from IPRs – higher prices for technology and protected products – a valid economic case for them to accept TRIPS entails that they reap larger net long-term benefits (technology and FDI inflows and stimulus to local innovation). Moreover, the *present value* of these benefits – discounted at an appropriate interest rate – must more than offset the present value of these costs. Given the mechanics of compound interest, this requires that the benefits be very large and accrue in the medium term: any that accrue after, say, a decade would be practically worthless in terms of present value.

If these conditions are not met, other arguments can still be made for TRIPS, but these have little to do with the economic benefits to poor countries of stronger intellectual property protection *per se*. As the World Bank notes, many developing countries agreed to TRIPS in order to gain concessions from rich ones in *other* spheres of economic activity (or greater aid). Whether they actually did so remains an open question, since no one has quantified the costs of TRIPS and gains in related concessions.

These important issues remain largely unresolved. This paper is not intended to investigate them, but simply notes (section 2) some of the main arguments. It then analyses data on technological and related activity in 87 economies (developed, transition and developing), grouping them according to the expected effects of stronger IPRs. These are all the countries with significant industrial sectors on which comparable data are available for 1985-98.

2. THE IMPACT OF STRONGER IPRS ON DEVELOPING COUNTRIES

In economic analysis, intellectual property rights – a temporary monopoly on the use of knowledge – are a 'second best' solution to a failure in markets for knowledge and information. The nature of this failure is well known. Optimal resource allocation requires that all goods be sold at marginal cost, which in the case of new knowledge is assumed to be practically zero: its sale does not diminish the stock to the holder and information is assumed to be transmitted practically without cost. Optimisation thus demands that new knowledge be made available at marginal cost or for free to all those who can use it. Moreover, it is assumed that others can, if not legally prevented, easily imitate new knowledge at little or no cost. Thus, under perfectly competitive conditions, there would be no incentive on the part of private agents to invest in the creation of new productive knowledge.

Since the creation and diffusion of new knowledge are desirable for growth, it is necessary to trade off static optimisation in favour of dynamic considerations. The optimum solution would be for the governments of innovating countries to subsidise innovators until the costs of the subsidies equalled the benefits to society, and to then allow the dissemination of knowledge at marginal cost (Maskus, 2000, p. 30). It would be very difficult in practice to calculate the optimal research subsidy, and a practical second-best solution is to grant a temporary monopoly that enables innovators to reap 'rents' (profits in excess of normal competitive profits). It is admitted by analysts that this does not yield a perfect solution to the underlying market failure, but it is a workable compromise that has worked well in the past, at least in the industrial countries that are the source of the overwhelming bulk of innovation.

In theory, society reaps ***four kinds of benefits*** from granting temporary monopoly rights to innovators. Each is subject to qualifications as far as developing countries are concerned, taken up later.

- *The stimulation of private innovation*

It is the primary economic benefit of IPRs. The importance of this benefit rises with the pace of technical change – as at present – and with the 'imitability' of new technology, particularly in such activities as software. It also grows with globalisation, which leads innovators (in particular large trans-national companies) to gear their R&D to world rather than national markets. However, where the country in question has little or no local innovative capabilities, the strengthening of IPRs does not, by definition, stimulate domestic innovation.[5] The extent to which it stimulates *global* R&D then depends on its share of the market for particular innovative activities and its ability to pay for expensive new products.[6] Where the economy undertakes technological activity of an absorptive and adaptive kind – the great bulk of informal and R&D effort in newly industrialising countries – stronger IPRs may have no effect in stimulating it. On the contrary, to the extent that such effort involves copying and reverse engineering innovations elsewhere, it can constrict a vital source of learning, capability building and competitiveness.

- *The use of the new knowledge in productive activity*

Without such use, of course, there can be no financial reward to innovators in terms of higher prices and profits, it leads to higher incomes, employment, competitiveness and so on for the economy as a whole. If the knowledge is not exploited within the economy, and its products are provided at higher prices than in with weak IPRs, the gains are correspondingly less and the costs correspondingly higher. There may still be gains, if innovation *per se* is stimulated by the existence of that country's market and the new products represent a real gain in consumer welfare. This gain has to be set against not just the higher prices induced by IPRs but also against reductions in local economic activity as a result of the monopoly and longer term growth potential (say, from the constriction of local technological development based on copying and reverse engineering).

- *The dissemination of new knowledge to other agents*

With IPRs providing the legal instrument on which to base contractual agreements (e.g. for procurement, licensing or sales). Stricter IPRs may facilitate the transfer of technology across national borders as well as increase local diffusion by providing an enforceable legal framework. This is likely to be of special significance for technology-intensive products and activities, where innovators are averse to selling technology to countries with weak IPRs, where leakage is a real possibility. It is also significant for large innovators that seek to enter into technology alliances and contracts with each other: this is the main reason why firms in industries like electronics (where IPRs are not important to protect innovation) take out patents (Cantwell and Andersen, 1996). Note that *the legal framework raises the cost of technology to the buyer* – otherwise it would be redundant: the payoff for buyers lies in the higher quantity and quality of knowledge flows. The economic benefit in a developing country depends on the presence of local agents capable of purchasing, absorbing and deploying new technologies, particularly complex high technologies. If no such agents exist, strict IPRs offer no benefit for technology transfer. If they exist, the size of the benefits depends on two things: the extent to which strict IPRs raise the cost of buying technologies, and whether the alternatives of copying and reverse engineering would have been feasible, cheaper and more rewarding in building up local technological capabilities.

- *The stimulation of innovation by other enterprises*

Based on information disclosed in the patent. This is a very important benefit of the IPR system, but clearly its value is primarily to economies where there is intense innovative activity by large numbers of competing enterprises. Innovation 'around' a particular patent is one of the most dynamic sources of technological progress. However, this is of little or no value to poor and unindustrialised countries that lack a local innovative base.

These qualifications are, of course, acknowledged in the IPR literature. It is widely accepted that the importance of IPRs varies considerably by ***two variables***:

- *Technological nature of the activity*

The role of patents in stimulating R&D varies by activity. In industries where it is relatively easy for a competent firm to copy new products – fine chemicals and pharmaceuticals are the best examples – patents are vital for sustaining the large and risky R&D expenditures needed for product innovation. However, in industries where copying is very difficult and expensive (these industries account for a the bulk of manufacturing in most countries), patents *per se* are not important for appropriating the benefits from innovation. There is a high degree of 'tacit' knowledge (technology-specific skills, experience, learning, information and organisation needed to be competitive) in technological activities in these industries. The best examples are complex engineering, electronics and much of 'heavy' industry, but there are many others.

The classic analysis of these differences is by Mansfield (1986), who found large industry-wise differences in the innovation-promoting role of patents in the US. His analysis was based on responses from corporate executives about the share of innovative activity that would be deterred by the absence of patent protection. The results were: 65% in pharmaceuticals, 30% in chemicals, 18% in petroleum, 15% in machinery, 12% in metal products, 8% in primary metals, 4% in electrical machinery, 1% in other machinery and nil in office equipment, motor vehicles, rubber, and textiles. While executive responses may not always accurately reflect underlying economic forces, Mansfield's survey is in line with the findings of other studies. In particular, the special role of patents in pharmaceutical innovation is universally accepted. It also reflects what is known about industrial differences in tacit knowledge (Cantwell, 1999). Thus, the need for IPRs to promote innovation (or technology transfer) cannot be identical across activities; correspondingly, the ideal IPR regime must depend on the structure of economic activities in each country. Countries with little productive investment in IPR-sensitive activities need less strict regimes than those *with* such activities, at least as technological factors are concerned. Many developing countries have negligible industrial activities in the former category. In fact, to the extent that they have local pharmaceutical industries, they have much to gain by weak IPRs that allow them to build up domestic capabilities. It is only when they reach the stage of innovating that they need strong IPRs even in these activities.

- *Nature of the economy*

More relevant to the present discussion is that the significance of IPRs varies by the level of development. As the World Bank notes, the main beneficiaries of TRIPS are the advanced countries that produce innovations. There are few benefits in terms of stimulating local innovation in developing countries. On the contrary, while there certainly is technological activity in many such countries, it consists mainly of learning to use imported technologies efficiently rather than to innovate on the technological frontier. Weak IPRs can help local firms in early stages to build technological capabilities by permitting imitation and reverse engineering. This is certainly borne out by the experience of the East Asian 'Tigers' like Korea and Taiwan that developed strong indigenous firms in an array of sophisticated industries.

The available historical and cross-section evidence supports the presumption that the need for IPRs varies with the level of development. Many rich countries used weak IPR protection in their early stages of industrialisation to develop local technological bases, increasing protection as they approached the leaders.[7] Econometric cross-section evidence suggests that there is an inverted-U shaped relationship between the strength of IPRs and income levels. The intensity of IPRs first falls with rising incomes, as countries move to slack IPRs to build local capabilities by copying, then rises as they engage in more innovative effort. The turning point is $7,750 per capita in 1985 prices (cited in Maskus, 2000, and World Bank, 2001), a fairly high level of income for the developing world.

Theory also suggests that the benefits of IPRs rise with income and that at very low levels the costs of strengthening IPRs may well outweigh the gains. Maskus (2000) notes ***three potential costs***.

1. Higher prices for imported products and new technologies under IPR protection.
2. Loss of economic activity, by the closure of imitative activities
3. The possible abuse of protection by patent holders, especially large foreign companies.

Maskus goes on to argue, however, that these costs are more than offset by the ***longer-term benefits*** of IPRs, even in developing countries. These benefits are as follows (with qualifications noted):

1. IPRs provide "an important *foundation for sophisticated business structures*" and indicate that private property rights in general are well enforced. There may certainly exist an important *signalling function* of IPRs, particularly in countries that previously had policy regimes inimical to private investment and property rights. Note, however, that while strong IPRs may well be associated with sophisticated business structures, the causation is likely to run from the latter to the former. It is difficult to believe that strong IPRs actually *cause* the business systems to become more complex: many countries with sophisticated industrial and corporate structures have had lax IPRs. On the signalling function, more research is needed before it can be asserted with confidence that IPRs *by themselves* are important. It is possible that other signals are considered more important by investors or technology sellers, and that the overall environment for business matters more than IPRs. Casual empiricism suggests that lax IPRs have not deterred FDI in China or Brazil, or held back technology licensing in Korea and Taiwan, when these countries had weak protection.

2. *Other kinds of technological activity* in developing countries (i.e. apart from innovation) also benefit from strong IPRs. This applies, however, more to copyright and trademark protection (where strong protection can encourage quality improvement) rather than to patenting. As far as patenting goes, it is mainly the advanced newly industrialising countries that will need TRIPS to boost local R&D. The least developed countries are unlikely to benefit in any technological sense. Those between the two, countries still building technological capabilities by imitating and reverse engineering, may lose. Remember that the rationale of TRIPS is letting innovators (overwhelmingly in developed countries) charge higher prices for their protected (physical and intellectual) products. If TRIPS is at all effective, it must lead to more costly and restricted technology for local firms in poor countries.

3. Economies without advanced technological capabilities may, by strengthening IPRs, stimulate global innovation by adding to effective demand for new products. This argument would apply to activities in which poor countries constituted a significant share of the market catered to by innovators. However, in most activities in which patents matter for innovation, as in pharmaceuticals, the specific products needed by poor countries constitute a tiny fraction of global demand. So far, leading innovators have undertaken very little R&D of specific interest to poor countries – this is simply not profitable enough (UNDP, 2001, World Bank, 2001). There is therefore little reason to believe that global R&D would rise with stronger IPRs in these countries or that it would address their specific needs. The argument that strong IPRs in developing countries would promote global R&D has another fallacy. Small, poor countries are not only likely to remain irrelevant to innovation after TRIPS, they may suffer reduced industrial activity if industry leaders use IPRs to close local facilities and import the product from other production sites.[8] This is actually happening in a number of developing countries, but its full incidence needs further investigation.

4. Strong IPRs will stimulate greater technology transfer over the longer-term to developing countries.

This may apply to all its main forms: *capital goods, FDI* and *licensing*. The main evidence on this comes from some cross-country econometric tests (cited by Maskus, 2000) that suggest a positive correlation between the strength of IPRs and capital goods imports, inward FDI and licensing payments. These studies, however, are subject to caveats, and other studies have more ambiguous implications (World Bank, 2001). The correlation between IPRs and capital goods imports, for instance, may be due to unobserved variables that tend to rise with IPRs. For instance, higher levels of income, stronger technological capabilities, greater ability to pay, and so on, may be the cause of greater equipment purchases rather than stronger IPRs *per se*. This is not to deny that the sale of some high-tech equipment may be affected by weak IPR regimes. Even where this is true, it is likely to be significant only for economies with advanced industrial capabilities rather than to typical developing countries. For the latter, if TRIPS raises the price of equipment (which is the purpose of the exercise), there is a net loss to productive capacity. In any case, anecdotal evidence does not suggest weak IPRs in countries like Korea and Taiwan prevented them from buying advanced capital goods in their most intense periods of industrialisation.

As far as *FDI* goes, most studies suggest that IPRs come fairly low on the list of factors affecting TNC location decisions.[9] However, the general tightening of IPRs in recent years may itself have raised their *signalling value* to investors: countries with stronger property rights protection may, as a result, be regarded as more favourably inclined to private business. The extent to which this is so needs more empirical investigation. Even if this were found to be true, it would suggest failures in information markets affecting FDI location rather than the value to TNCs of intellectual property protection as such. Because of such unobserved variables, the cross-country econometric evidence on the positive and significant impact of IPR strength on FDI inflows is again of rather dubious value. What is more plausible is, as case study evidence suggests, that the deterrent effect of weak IPRs is fairly industry specific. As Mansfield (1994) notes in his survey of US TNCs, investment is likely to be sensitive to IPRs mainly in industries like pharmaceuticals. Other FDI – constituting the bulk of investment of interest to developing countries – is not likely to be affected by IPRs. In fact, the largest recipients of inward FDI in the developing world in the past two decades or so, led by China, have not been models of strong intellectual property protection. TNCs have had many other advantages that have served to effectively protect their proprietary intellectual assets.

Even in IPR-sensitive industries like pharmaceuticals, the evidence does not establish that TNCs have stayed away from developing countries with weak IPRs. TNCs have invested large sums in this industry in countries like Brazil or India, which have built up among the most advanced pharmaceutical industries in the developing world, in both local enterprises and TNC affiliates. Several pharmaceutical TNCs have been contracting R&D to national laboratories in India for the past 10-15 years. At the same time, weak IPRs have facilitated a massive growth of pharmaceutical exports by India, with local firms building capabilities in making generic products. It is difficult, therefore, to make a case that TRIPS would, by itself, lead to a significant surge in FDI to developing countries. It is possible to argue, however, that India has now reached a stage in pharmaceutical production where stronger IPRs would induce greater innovation by local firms (the benefits of which would have to be set off against the closure of other firms). This clearly does not provide a case for similar IPRs in countries in earlier stages of industrial development – if anything, it is an argument for lax IPRs to encourage the growth of local firms until they reach the stage of Indian firms today.

Note also that the TNC response to IPRs is likely to be function specific. Survey evidence suggests that high-level R&D is more likely to be affected by the IPR regime than basic production or marketing (Mansfield, 1994). The relocation of R&D is not of great practical significance to most developing countries, since very few can hope to receive such functions; it is only the more advanced NIEs that may suffer from lax IPRs.

Similar arguments apply to *licensing*. Lax IPRs are likely to deter licensing mainly in the advanced activities of interest to the leading NIEs. They are unlikely to affect technology transfer to other developing countries, which generally purchase more mature technologies. At the same time, the higher costs of technology transfer inherent in TRIPS are likely to impose an immediate penalty on them. It is suggested, however, that local *diffusion* of technology will benefit from stronger IPRs because of the clearer legal framework it provides. This is certainly possible, but the evidence on this needs to be more closely investigated. Anecdotal evidence does not however suggest that lax IPRs held back licensing of local firms in such economies as Korea and Taiwan.

All the arguments suggest, therefore, that it is vital to distinguish between levels of development in assessing the impact of TRIPS in the developing world. As Maskus rightly suggests, the relationships between IPRs and growth remain 'complex' and 'dependent on circumstances' (Maskus, 2000, p. 169). On the whole, there is no clear case that most developing countries below the NIE stage will gain in net terms from TRIPS; the least developed ones are most likely to lose. The gains that might accrue through increased technological inflows are likely to be realised over the long term, while the costs will accrue immediately. In present value terms, therefore, there is likely to be a significant net loss. What is indisputable is that a differentiated approach to TRIPS is called for.

To conclude, the jury is still out on the benefits of TRIPS for developing countries *as a whole*. We can agree that stronger IPRs are probably beneficial for countries launching into serious R&D activity in terms of promoting local innovation and attracting certain kinds of FDI and other technology inflows. There does not, however, seem to be a case for applying stronger IPRs uniformly across the developing world. As the outcome is likely to be context specific, economic considerations call for a differentiated approach to TRIPS according to levels of industrial and technological capabilities. Some differentiation exists already, as the World Bank (2001) notes. Whether or not this is sufficient to take due account of the development needs of many countries is not clear. Without more detailed investigation, it may be premature to draw any general conclusions about the net benefits for TRIPS.

3. CLASSIFICATION OF COUNTRIES BY IPR RELEVANCE

We now categorise countries (including mature industrial countries and some transition economies on which data are available) according to different schema, based on technological activity, industrial performance and technology imports. The classifications naturally have a great deal of similarity, but also some interesting differences. It is useful to consider each to see how the implications may differ with respect to IPRs. As noted, the focus here is on *technological factors* and the data used relate mainly to these elements of TRIPS (i.e. patents). There are, of course, many other important elements in TRIPS: copyrights, trademarks, geographical indications, industrial designs and so on. Some of these may be subject to similar technological considerations as patents (e.g. industrial designs, layout designs for integrated circuits). However, others, particularly copyrights and trademarks, may raise different issues with respect to costs and benefits for countries at low levels of development. This paper does not explore these aspects.

3.1 Technological Activity

The classification based on national technological activity is derived from two variables: *R&D financed by productive enterprises*[10] and the *number of patents taken out internationally (in the US)*[11], both deflated by population to adjust for economic size. Most researchers on international technological activity use US patent data, for two reasons. First, practically all innovators who seek to exploit their technology internationally take out patents in the USA, given its market size and technological strength. The pattern of patenting in the USA is in fact a good indicator of technological activity and R&D spending in all industrialised (and newly industrialising) countries (Cantwell and Andersen, 1996). Second, the data are readily available and can be taken to an extremely detailed level. We follow this convention, using US patents as an indicator of commercially valuable innovation.

The two variables are standardised[12] and averaged to yield an index of 'technological intensity'. We can derive four groups from the index values.

1. The world *technological leaders,* with intense technological activity and considerable innovative capabilities as shown by international patenting. They are likely to benefit from (and most already have) strong IPRs.
2. Countries with *moderate technological activity*. These countries conduct some R&D, have medium levels of industrial development and are likely on balance to benefit from stronger IPRs. However, some countries in this group may bear significant adjustment costs in changing IPR regimes.
3. Countries with *low technological activity*. These countries are likely to have both significant costs and potential long-term benefits from stricter IPRs, depending on the level of domestic technological capabilities and their reliance on formal technology inflows. Those that are building their innovation systems on the basis of local firms copying foreign technology and importing technologies at arm's length would gain less than those with a strong TNC presence.
4. The fourth level comprises countries with *no significant technological activity*. These are the least industrialised countries with the simplest technological structures that are likely to gain least, and lose most, from strict IPR rules. They will tend to pay the costs (higher prices for protected products and technologies) but gain little by way of technology development or transfer.

Table 1 shows the average technology performance data for each group of countries, and illustrates the striking differences between them. The value of R&D per capita in the high technology effort group is 21 times higher than in the moderate group, which in turn is 58 times higher than in the low effort group. The fourth group, as its name indicates, has negligible activity by all measures. Differences by international patenting are even greater,[13] suggesting that the innovativeness of R&D rises with its intensity and that different countries may have different propensities to take out patents internationally.

Table 1: Average technology effort (per country) by technology groups, 1997-98

Technology groups	R&D per capita (US$)	Total R&D (US $ b)	Patents/1000 people	Total Patents
High	293.25	14.93	0.99	6,803
Moderate	14.01	0.41	0.02	50
Low	0.24	0.08	0.00	11
Negligible	0.00	0.00	0.00	0

Source: Calculated from UNESCO, *Statistical Yearbook*; OECD, *Science, Technology and Industry Scoreboard* 1999; Iberoamerican *Network of Science and Technology Indicators*; various national statistical sources.

Note: R&D is only that financed by productive enterprises. Patents are those taken out in the US. Total R&D and patents are average for each country.

Let us now consider technological effort at the national level. Table 2 gives the data for productive enterprise R&D and international patents for 87 countries (those with significant industrial activity on which the necessary data are available). They come from the following groups:

- *Industrialised (22)*: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, New Zealand, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States,
- *Transition (7)*: Hungary, Poland, Czech Republic, Russian Federation, Romania, Albania and Slovenia.
- *Developing (58)*, consisting of the following sub-groups*:*
  - *East Asia (9)*: China, Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand.
  - *South Asia (5)*: India, Pakistan, Bangladesh, Sri Lanka and Nepal.
  - *Latin America and Caribbean (LAC) (18)*: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.
  - *Sub-Saharan Africa (SSA) (16)*: Cameroon, Central African Republic (CAR), Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zambia, Zimbabwe.
  - *Middle East and North Africa (MENA)(10)*: Algeria, Bahrain, Egypt, Jordan, Morocco, Oman, Saudi Arabia, Tunisia, Turkey and Yemen.

The choice of groups was based on getting a spread of more or less equal numbers in each, but there are clear 'breaks' in the technology index where the lines are drawn. The main features of the groups are as follows:

Group 1

This group has most industrialised countries, but there are interesting inclusions and exclusions. Perhaps the most important for the present discussion is the presence of the four mature Asian Tigers, Taiwan, Korea, Singapore and Hong Kong (in order of ranking). These are technological newcomers, and have followed different strategies to build up their capabilities (Lall, 1996). Korea and Taiwan used considerable industrial policy: import protection, export subsidies, credit targeting, FDI restrictions and slack IPR rules. Singapore combined widespread government interventions with a free trade regime and heavy reliance on (targeted) FDI to build a very high-tech industrial sector. Hong Kong was the least interventionist, confining government policy to infrastructure, subsidised land and housing and support for export activity and SMEs.

Taiwan appears in the technology index at an unexpectedly high position (8), largely because of its high rank in international patenting. Korea is in 15th place, with greater R&D than Taiwan but less US patenting; even so, it comes ahead of mature OECD countries like Austria, UK or Italy. Singapore comes 18th, which may be unexpected in view of its heavy TNC dependence. While it is generally the case that TNCs are slow to transfer R&D to developing host countries, Singapore has managed, by dint of targeted policies and a strong skill base, to induce foreign affiliates to set up significant R&D facilities there. At number 23, Hong

Kong brings up the rear among the Tigers and in the group as a whole; its R&D rank is very low (40) but its index position is pulled up by its patent rank (16); it is not clear what accounts for this discrepancy between R&D and patenting.

Table 2: Technology Effort Index (1997-98)

	Productive enterprise R&D per capita (US$)		Patents per 1,000 people		Technology Effort Index			Technology Group
1	Switzerland	859.9	USA	3.297	1	Japan	0.8649	HIGH
2	Japan	858.4	Japan	2.412	2	Switzerland	0.7858	
3	Sweden	653.9	Switzerland	1.884	3	USA	0.7709	
4	USA	465.9	Taiwan	1.622	4	Sweden	0.5957	
5	Germany	418.1	Sweden	1.421	5	Germany	0.4151	
6	Finland	413.4	Israel	1.275	6	Finland	0.4099	
7	Denmark	328.4	Germany	1.134	7	Denmark	0.3434	
8	France	297.6	Finland	1.118	8	Taiwan	0.3173	
9	Norway	275.5	Canada	1.090	9	Netherlands	0.2743	
10	Belgium	272.7	Denmark	1.005	10	France	0.2716	
11	Netherlands	258.8	Netherlands	0.817	11	Israel	0.2712	
12	Austria	214.4	Belgium	0.699	12	Belgium	0.2645	
13	S Korea	211.2	S Korea	0.657	13	Canada	0.2488	
14	Singapore	198.4	France	0.650	14	Norway	0.2344	
15	UK	174.5	UK	0.601	15	S Korea	0.2225	
16	Ireland	152.8	H Kong	0.540	16	Austria	0.2022	
17	Australia	148.0	Austria	0.511	17	UK	0.1926	
18	Canada	143.7	Norway	0.490	18	Singapore	0.1738	
19	Israel	134.0	Australia	0.402	19	Australia	0.1470	
20	Taiwan	122.5	Singapore	0.386	20	Ireland	0.1191	
21	Italy	90.1	N Zealand	0.356	21	Italy	0.0986	
22	Slovenia	73.3	Italy	0.305	22	N Zealand	0.0835	
23	Spain	55.2	Ireland	0.200	23	H Kong	0.0829	
24	N Zealand	50.7	Slovenia	0.076	24	Slovenia	0.0541	MODERATE
25	Czech Rep	32.3	Spain	0.072	25	Spain	0.0431	
26	Portugal	14.1	Hungary	0.045	26	Czech Republic	0.0200	
27	Brazil	13.7	S Africa	0.030	27	Hungary	0.0135	
28	Greece	13.5	Malaysia	0.017	28	S Africa	0.0121	
29	S Africa	12.8	Greece	0.016	29	Greece	0.0103	
30	Hungary	11.3	Bahrain	0.016	30	Portugal	0.0096	
31	Argentina	8.5	Venezuela	0.013	31	Brazil	0.0087	
32	Poland	8.3	Russian Fed	0.012	32	Argentina	0.0067	
33	Russian Fed	7.5	Argentina	0.011	33	Malaysia	0.0065	
34	Malaysia	6.7	Chile	0.011	34	Russian Fed	0.0062	
35	C Rica	5.5	Uruguay	0.009	35	Poland	0.0055	
36	Chile	5.3	Portugal	0.009	36	Chile	0.0047	
37	Turkey	4.8	Mexico	0.009	37	C Rica	0.0041	
38	Romania	2.5	Czech Rep	0.008	38	Venezuela	0.0033	
39	Venezuela	2.3	Saudi Arabia	0.006	39	Turkey	0.0029	
40	H Kong	1.8	Ecuador	0.006	40	Bahrain	0.0024	
41	Mexico	1.5	C Rica	0.006	41	Mexico	0.0022	
42	Panama	1.4	Brazil	0.005	42	Uruguay	0.0020	
43	Uruguay	1.1	Jordan	0.004	43	Romania	0.0015	

	Productive enterprise R&D per capita (US$)		Patents per 1,000 people		Technology Effort Index			Technology Group
44	China	0.9	Poland	0.004	44	Saudi Arabia	0.0009	LOW
45	Indonesia	0.8	Jamaica	0.004	45	Ecuador	0.0009	
46	India	0.4	Philippines	0.003	46	Panama	0.0008	
47	Mauritius	0.3	Thailand	0.002	47	Jordan	0.0008	
48	Thailand	0.3	Guatemala	0.002	48	China	0.0006	
49	Egypt	0.2	Colombia	0.002	49	Jamaica	0.0006	
50	Colombia	0.2	Honduras	0.002	50	Philippines	0.0006	
51	Jordan	0.2	Bolivia	0.001	51	Indonesia	0.0005	
52	Guatemala	0.1	Tunisia	0.001	52	Thailand	0.0005	
53	Algeria	0.1	Sri Lanka	0.001	53	Colombia	0.0004	
54	Saudi Arabia	0.1	India	0.001	54	India	0.0004	
55	Peru	0.1	Morocco	0.001	55	Guatemala	0.0003	
56	Morocco	0.1	China	0.001	56	Honduras	0.0003	
57	Philippines	0.1	Turkey	0.000	57	Sri Lanka	0.0002	
58	Honduras	0.1	Indonesia	0.000	58	Bolivia	0.0002	
59	Nicaragua	0.1	Peru	0.000	59	Mauritius	0.0002	
60	Sri Lanka	0.1	Kenya	0.000	60	Morocco	0.0002	
-	Yemen	0	Egypt	0.000	61	Tunisia	0.0002	
-	Tunisia	0	Nigeria	0.000	62	Egypt, Arab Rep.	0.0001	
-	Malawi	0	Pakistan	0.000	63	Peru	0.0001	
-	Madagascar	0	Albania	0.000	64	Algeria	0.0001	
-	Kenya	0	Algeria	0.000	65	Nicaragua	0.0001	
-	Jamaica	0	Bangladesh	0.000	66	Kenya	0.0001	
-	Ecuador	0	Cameroon	0.000	-	Nigeria	0.0000	NEGLIGIBLE
-	Albania	0	CAR	0.000	-	Pakistan	0.0000	
-	Bahrain	0	El Salvador	0.000	-	Albania	0.0000	
-	Bangladesh	0	Ethiopia	0.000	-	Bangladesh	0.0000	
-	Bolivia	0	Ghana	0.000	-	Cameroon	0.0000	
-	Cameroon	0	Madagascar	0.000	-	CAR	0.0000	
-	CAR	0	Malawi	0.000	-	El Salvador	0.0000	
-	El Salvador	0	Mauritius	0.000	-	Ethiopia	0.0000	
-	Ethiopia	0	Mozambique	0.000	-	Ghana	0.0000	
-	Ghana	0	Nepal	0.000	-	Madagascar	0.0000	
-	Mozambique	0	Nicaragua	0.000	-	Malawi	0.0000	
-	Nepal	0	Oman	0.000	-	Mozambique	0.0000	
-	Nigeria	0	Panama	0.000	-	Nepal	0.0000	
-	Oman	0	Paraguay	0.000	-	Oman	0.0000	
-	Pakistan	0	Romania	0.000	-	Paraguay	0.0000	
-	Paraguay	0	Senegal	0.000	-	Senegal	0.0000	
-	Senegal	0	Tanzania	0.000	-	Tanzania	0.0000	
-	Tanzania	0	Uganda	0.000	-	Uganda	0.0000	
-	Uganda	0	Yemen	0.000	-	Yemen	0.0000	
-	Zambia	0	Zambia	0.000	-	Zambia	0.0000	
-	Zimbabwe	0	Zimbabwe	0.000	-	Zimbabwe	0.0000	

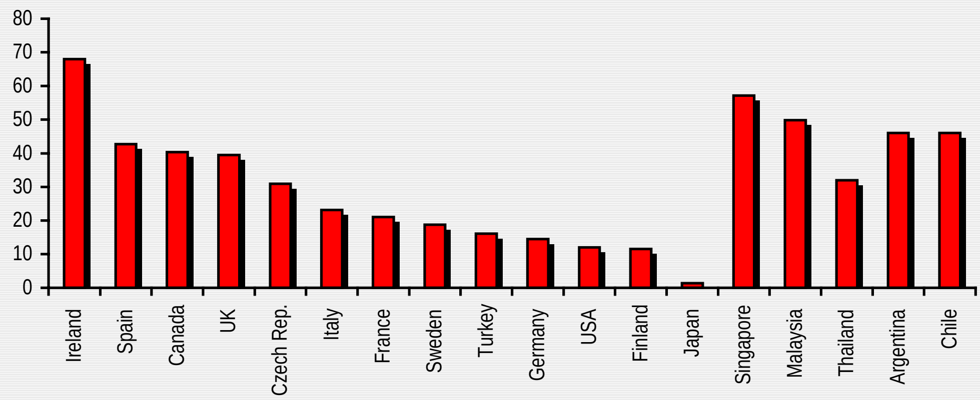
Note again that weak IPRs played a vital role in the technological development of Korea and Taiwan, the two leading Tigers. They are the best recent examples of the use of copying and reverse engineering to build competitive, technology-intensive industrial sectors with considerable innovative 'muscle'. However, unlike many other developing countries that had weak IPRs, they were able to use the opportunities offered effectively because of investments in skill development, strong export orientation, ample inflows of foreign capital goods and strong government incentives for R&D (Lall, 1996). It may also be the case that the political economy that allowed such strong industrial policy to work was difficult to replicate in other countries. Singapore, by contrast, had strong IPR protection. It is unlikely that it would have been able to build up TNC-based R&D without this. Note also that in recent years Korea and Taiwan have also moved to strong IPR regimes, partly under pressure from trading partners but also because their enterprise have now reached the technological stage where they need greater protection.

Among the interesting exclusions from Group 1 are South European countries like Spain, Greece and Portugal: the technological laggards of West Europe. The Russian Federation is also excluded. Not only has its R&D declined recently, it ranks low in terms both of enterprise funded R&D and of patents taken out in the US. Ireland is at the low end of the group, but its presence is creditable given its historic industrial backwardness. Its relatively recent entry into technology-intensive industrial activity has, like Singapore, been driven by electronics TNC (together with a substantial pharmaceutical presence), and its technological effort is also dominated by foreign affiliates.

In this context, it is interesting to look at the (patchy) data on the role of TNCs in host country R&D (Figure 1).[14] As expected, the technological leaders in the OECD, like Germany and USA, despite open FDI regimes, have a relatively low share of affiliate R&D. Japan has been traditionally hostile to FDI, so the share is particularly low (the same is probably true of Korea, but data are not available). At the other extreme, Ireland in the developed, and Singapore and Malaysia in the developing, world depend highly of affiliate R&D. We return to the role of FDI as such below.

Italy is known to be a relatively weak R&D performer (this also shows up in rank in international patenting) despite its advanced industrial sector. This is, however, in line with its specialisation in (skill intensive) fashion products and heavy industries (automobiles and machinery) of moderate R&D intensity. Australia and New Zealand also lag in the high technology group.

Figure 1: Shares for foreign affiliates in R&D (circa 1996-98)



Group 2

This group of moderate technology performers includes, as noted, the South European countries and Russia. It also contains other CEE countries like Slovenia, the Czech Republic, Hungary, Poland and Romania. From the developing world it has the main Latin American economies: Brazil, Argentina, Chile and Mexico, along with Costa Rica, Venezuela and Uruguay. Only Malaysia appears here from Asia, South Africa from SSA, and Turkey and Bahrain from MENA. Most of these countries have fairly large industrial sectors, and some have a significant TNC presence.

Group 3

The group of low technology performers is very diverse. On the one hand it has large countries with heavy industrial sectors like China, India and Egypt, along with dynamic export oriented economies (with a high reliance on TNCs) like Thailand and Indonesia. On the other it has countries with small industrial sectors and weak industrial exporters like Panama, Jamaica, Sri Lanka, Bolivia or Kenya. Some countries have fairly large and impressive technological activity in absolute terms – India and China stand out – but are lumped with economies that have very little (financed by the productive sector). The use of population to deflate the variables may distort the picture somewhat for such large countries, though it may be argued that technological effort in China and India is quite low relative to their economic size. These problems are inevitable in any such classification exercise, particularly as one approaches the lower limits.

In this group, therefore, the implications of stronger IPRs are likely to be fairly varied. Economies with significant technological effort and/or strong local enterprises (e.g. India, China or Thailand) are likely to benefit from slack IPRs in some aspects and gain from them in others. Those with little 'real' innovative capabilities or competitive enterprises may not be able to utilise slack IPRs to build up local technology, and may gain from FDI inflows by strengthening IPRs. At the same time, TRIPS may lead to net costs for some countries with no corresponding benefits. At this stage it is difficult to discern the net outcome.

Group 4

This group has no meaningful technological activity by either measure (and the countries are not ranked individually). It contains all the least developed countries (by the UN definition) in the sample, as well as South Asian countries like Pakistan, Bangladesh and Nepal, several countries in SSA, one East European economy (Albania) and El Salvador from LAC. The distinction between these countries and those at the bottom of Group 3 should not, for obvious reasons, be pushed too far. In essence, they can be considered together as the set of economies for whom IPRs are irrelevant for technology development and transfer and where the costs are likely to outweigh the benefits.

3.2 Competitive Industrial Performance

We now use 'competitive industrial performance' to rank countries and then combine the technology index with the performance index. The performance measures used here are MVA per capita, manufactured exports per capital, the share of medium and high technology (MHT) products in MVA and the share of MHT in manufactured exports. All the data are for 1998 (for further analysis and explanation see UNIDO, 2002). For a classification of traded products by technology levels see Annex Table 1.

In general, there is a strong relationship between the technology and industrial performance indices (correlation coefficient of 0.80). This is to be expected, since technological effort is intimately related to levels of industrialisation, success in export activity and the sophistication of the production and export structures. The causation runs both ways, of course, but most analysts would agree that strong technological capabilities contribute to all these aspects of performance. The elements of the industrial performance index are also strongly correlated with each other, with coefficients ranging between 0.57 and 0.81.

Table 3 shows the industrial performance index with all its components. There are five groups here, according to 'natural' breaks in the final performance index. There is little need to discuss the groups in detail, as the patterns are fairly self-evident.

Table 3: Industrial Performance Index

		MVA/capita ($)	Exports/ capita ($)	MHT share in MVA (%)	MHT share in manufactured exports (%)	Industrial performance index	Industrial performance groups
1	Singapore	6,178	32,713	80.00%	74.30%	0.883	High
2	Switzerland	8,315	10,512	63.00%	62.90%	0.751	
3	Ireland	7,043	15,659	65.00%	51.20%	0.739	
4	Japan	7,084	2,929	66.00%	81.10%	0.696	
5	Germany	5,866	5,939	64.00%	64.80%	0.632	
6	USA	5,301	2,035	63.00%	65.40%	0.564	
7	Sweden	5,295	8,396	61.00%	58.20%	0.562	
8	Finland	5,557	7,918	53.00%	49.80%	0.538	
9	Belgium	4,446	15,050	51.00%	46.90%	0.495	
10	UK	4,179	4,100	62.00%	62.90%	0.473	
11	France	4,762	4,486	53.00%	58.40%	0.465	
12	Austria	5,191	6,615	50.00%	49.10%	0.453	
13	Denmark	4,776	6,850	51.00%	39.50%	0.443	
14	Netherlands	3,953	8,894	60.00%	50.00%	0.429	
15	Taiwan	3,351	4,834	57.00%	61.30%	0.412	
16	Canada	3,489	5,383	51.00%	47.10%	0.407	
17	Italy	4,082	3,958	52.00%	50.90%	0.384	
18	S Korea	2,108	2,560	60.00%	62.30%	0.370	
19	Spain	2,365	4,275	49.00%	52.50%	0.319	
20	Israel	2,599	3,702	54.00%	46.10%	0.301	
21	Norway	3,803	3,432	50.00%	21.00%	0.301	
22	Malaysia	937	2,973	60.00%	65.10%	0.278	Medium-high
23	Mexico	855	1,082	36.00%	65.50%	0.246	
24	Czech	1,612	2,567	48.00%	51.90%	0.243	
25	Philippines	190	374	36.00%	74.70%	0.241	
26	Portugal	2,631.20	2,336	31.00%	39.70%	0.240	
27	Hungary	947	2,017	46.00%	58.80%	0.239	
28	Slovenia	2,365	4,275	50.00%	27.80%	0.221	
29	Australia	2,488	1,151	51.00%	14.60%	0.211	
30	H Kong	1,411	3,460	52.00%	36.80%	0.204	
31	N Zealand	2,611	1,626	40.00%	14.50%	0.186	
32	Thailand	585	731	39.00%	44.90%	0.172	
33	Brazil	912	234	58.00%	34.30%	0.149	
34	Poland	779	629	45.00%	35.70%	0.143	
35	Argentina	1,475	391	37.00%	23.30%	0.140	
36	C Rica	557	971	30.00%	32.60%	0.129	
37	China	287	135	51.00%	36.60%	0.126	
38	S Africa	557	322	44.00%	25.90%	0.108	
39	Turkey	695	361	38.00%	23.50%	0.108	
40	Greece	928	758	31.00%	17.90%	0.102	
41	Romania	466	339	34.00%	23.60%	0.095	Medium-Low
42	Bahrain	1,577	688	22.00%	5.70%	0.089	
43	Uruguay	1,125	472	21.00%	14.60%	0.087	
44	Russian Fed	663	202	41.00%	16.30%	0.077	
45	Tunisia	390	554	19.00%	15.50%	0.068	
46	Venezuela	607	337	32.00%	10.30%	0.060	
47	Chile	749	443	26.00%	6.30%	0.056	
48	Guatemala	237	129	35.00%	15.00%	0.056	

		MVA/capita ($)	Exports/ capita ($)	MHT share in MVA (%)	MHT share in manufactured exports (%)	Industrial performance index	Industrial performance groups
49	India	65	26	59.00%	16.60%	0.054	Medium-Low (con't)
50	Indonesia	115	132	40.00%	15.50%	0.054	
51	Zimbabwe	77	75	27.00%	15.30%	0.052	
52	El Salvador	426	134	28.00%	11.50%	0.051	
53	Morocco	219	112	25.00%	12.40%	0.048	
54	Saudi Arabia	605	702	54.00%	5.20%	0.047	
55	Colombia	322	104	35.00%	8.90%	0.041	
56	Mauritius	739	1,434	12.00%	1.40%	0.041	
57	Egypt	326	37	39.00%	8.80%	0.038	
58	Peru	585	91	25.00%	4.60%	0.035	
59	Oman	293	406	20.00%	5.80%	0.032	
60	Pakistan	73	56	34.00%	9.20%	0.031	
61	Ecuador	354	78	11.00%	4.20%	0.025	Low
62	Kenya	37	28	24.00%	7.60%	0.025	
63	Jordan	189	103	31.00%	5.00%	0.024	
64	Honduras	138	48	12.00%	6.00%	0.023	
65	Jamaica	372	446	25.00%	1.50%	0.022	
66	Panama	271	80	16.00%	4.00%	0.022	
67	Albania	184	53	19.00%	4.20%	0.021	
68	Bolivia	178	81	11.00%	5.00%	0.021	
69	Nicaragua	67	30	15.00%	3.90%	0.017	
70	Sri Lanka	125	162	16.00%	4.00%	0.017	
71	Paraguay	247	66	11.00%	2.20%	0.015	
72	Mozambique	22	4	12.00%	3.40%	0.013	
73	Bangladesh	60	37	28.00%	2.90%	0.011	
74	Algeria	154	95	29.00%	0.80%	0.009	Very low
75	Cameroon	65	34	11.00%	1.80%	0.008	
76	Senegal	82	35	16.00%	1.40%	0.008	
77	Zambia	40	11	24.00%	1.80%	0.007	
78	Nepal	18	16	15.00%	1.90%	0.006	
79	Nigeria	62	2	38.00%	1.50%	0.006	
80	Tanzania	16	3	25.00%	1.50%	0.005	
81	CAR	26	15	20.00%	0.80%	0.003	
82	Madagascar	27	9	10.00%	0.90%	0.003	
83	Malawi	21	6	29.00%	1.00%	0.003	
84	Uganda	24	1	15.00%	0.80%	0.003	
85	Ghana	9	22	17.00%	0.10%	0.001	
86	Yemen	34	2	20.00%	0.10%	0.001	
87	Ethiopia	8	1	9.00%	0.10%	0.000	

Source: Calculated from UNIDO database and UN Comtrade.

Note: 'MHT' stands for medium and high technology products. Classification taken from Lall (2001), Chapter 4.

What is the implication of industrial performance for IPRs? There is clearly a positive correlation between IPRs, industrial performance and technological effort. This does not mean, however, that IPRs are *causally* related to growth and development: each rises with development levels. As noted, the causation can run both ways. Moreover, there is probably a strong *non-linearity* involved. Strong IPRs are probably beneficial *beyond a certain level* of industrial sophistication, while *below* this level their benefits for development are unclear. Moreover, the further down one goes in the scale the less evident the benefits become. In terms of the performance index, the 'very low' and 'low' performance groups are, on average, unlikely to benefit from TRIPS. In both 'medium' groups there is probably a mixture of beneficial and non-beneficial effects depending on the country, with a case for strengthening IPRs in the medium term. In the 'high' performance group the benefits are more unambiguous.

There is one important factor here that may have a bearing on IPRs: the growth of *'international production systems'* under the aegis trans-national companies (UNCTAD, various). While TNCs have had export platforms in developing countries making complete products for some time, the emerging trend has been for them to locate (tightly linked) processes in different countries to serve global or regional markets. This trend is particularly marked in high-tech activities, led by electronics, where the high value-to-weight ratio of the products makes relocations of large numbers of processes economical. For instance, a semiconductor may be designed in one set of facilities (say, in the USA and Europe), the wafer fabricated elsewhere, and the assembly and testing done in others. Such shipping of intermediate electronics products across countries has made them the fastest growing segment of world trade, in conjunction with rapidly rising demand (Lall, 2001, chapter 4). Table 4 shows the per capita value of total high technology exports and of total electronics exports by each country in 1998. There is the usual dispersion of national performance, and the group averages are distorted by the performance of a few countries. Take for example the average for Group 3, where China, Philippines and Thailand are completely out of line with the rest.

The emergence of international production systems has made it possible for countries to move up the production, export and technological complexity ladder rapidly without first building a domestic technology base. Again, the East Asian economies bear this out. With the exception of Korea, Taiwan and Singapore, none has a strong domestic technology base in electronics. The electronics production system, however, only encompasses a small number of developing countries: Singapore, Malaysia, Thailand, Philippines and China in East Asia, and Mexico in Latin America. The implications of this for industrial and technological development are analysed at greater length in UNIDO (2002).

Does the promise of integrated systems mean that developing countries should adopt stronger IPRs in the hope of attracting export-oriented TNCs? In the short term the answer is probably 'no'. Most TNC assembly activity has been attracted to developing countries without changing the national IPR regime by isolating export-processing zones from the rest of the economy. China is a good example. In the longer term, however, the answer is likely to be 'yes' – at least for the countries that seek to attract high-tech production systems. Inducing TNCs to invest in such activities when competitors are offering stronger IPRs would force all aspirants to also have equally strong protection. Moreover, countries that are already have high-tech assembly operations would need to strengthen IPRs to induce TNCs to deepen their operations into more advanced technologies and functions like R&D and design. At the highest end of TNC activity, where developing countries compete directly with advanced industrial countries, the IPR regime would have to match the strongest one in the developed world.

However, as integrated systems are highly concentrated geographically, these considerations may not apply to many developing countries. There is also little reason to believe that the level of concentration will decline significantly in the foreseeable future. On the contrary, in a globalising world with low trade and investment barriers, there may be strong economic reasons for TNCs to centralise production and R&D bases in a few sites to reap economies of scale, scope and agglomeration. Countries far from centres of activity, and with low technological capabilities, may continue to be marginalized to most TNC activities (marketing and resource procurement apart). The strengthening of IPRs may actually reinforce the tendency to concentrate high value functions in a few efficient, well-located sites, making it easier to use these to sell to other countries. This may imply that these other countries would, as a result of TRIPS, have fewer tools to build local capabilities in the future.

Let us now combine the technology and industrial performance indices to derive a combined index, an indicator of overall 'domestic capabilities'. Table 5 shows the three indices, with countries ranked by the combined capability index. The picture that emerges is entirely plausible.

Countries are now divided into five groups. The implications are very similar to those drawn earlier and need not be repeated.

Table 4: High technology exports per capita and total electronics exports, 1998

	High-tech exports per capita ($)	Total electronics exports ($ m.)		High-tech exports per capita ($)	Total electronics exports ($ m.)
Group 1			**Group 2**		
Japan	908.75	97,573.2	Slovenia	543.13	577.8
Switzerland	2,574.39	5,303.4	Spain	258.54	6,758.0
USA	728.28	114,757.0	Czech Rep	317.45	2,341.6
Sweden	2,303.77	14,475.2	Hungary	471.21	4,334.8
Germany	1,129.59	53,830.8	S Africa	22.31	510.7
Finland	2,046.13	9,727.3	Greece	45.85	253.1
Denmark	1,437.84	4,267.6	Portugal	150.23	1,041.0
Taiwan	1,767.43	37,259.0	Brazil	19.25	1,476.4
Netherlands	2,598.19	33,239.5	Argentina	17.81	195.7
France	1,105.49	35,797.6	Malaysia	1,547.77	32,276.3
Israel	1,107.12	4,857.9	Russian Fed	16.61	1,077.7
Belgium	1,702.19	10,300.5	Poland	58.59	1,871.1
Canada	784.90	15,410.3	Chile	7.08	39.2
Norway	514.41	1,556.4	C Rica	363.21	1,176.8
S Korea	775.72	32,800.6	Venezuela	3.92	29.1
Austria	916.77	4,784.1	Turkey	22.66	1,156.3
UK	1,292.23	50,237.4	Bahrain	20.95	5.6
Singapore	19,699.59	59,674.4	Mexico	326.12	28,055.0
Australia	131.35	1,286.1	Uruguay	16.78	26.7
Ireland	6,805.59	19,629.0	Romania	11.21	189.5
Italy	425.52	14,537.7			
N Zealand	133.72	321.0			
H Kong	899.60	4,920.1			
Average	**2,251.68**	**27,241.1**	**Average**	**212.03**	**4,169.6**
Group 3			**Group 4**		
S Arabia	1.00	15.9	Nicaragua	0.90	3.2
Ecuador	2.80	5.5	Peru	1.79	11.1
Jordan	5.58	11.8	Albania	1.11	3.0
Panama	6.07	0.0	Bangladesh	0.10	4.2
China	27.02	28,605.5	Cameroon	0.08	0.9
Jamaica	0.36	0.1	CAR	0.06	0.2
Philippines	252.26	18,673.5	El Salvador	11.86	12.8
Indonesia	12.80	2,381.3	Ethiopia	0.00	0.0
Thailand	254.76	14,593.9	Ghana	0.04	0.5
Colombia	6.61	63.7	Madagascar	0.06	0.6
India	1.74	708.5	Malawi	0.01	0.1
Guatemala	9.50	15.1	Mozambique	0.15	1.9
Honduras	0.72	2.3	Nepal	0.03	0.7
Bolivia	3.09	4.3	Nigeria	0.03	3.0
Mauritius	3.23	3.6	Oman	45.49	47.3
Morocco	0.49	3.7	Pakistan	0.40	4.4
Sri Lanka	3.12	55.4	Paraguay	1.23	2.3
Tunisia	26.58	219.0	Senegal	0.09	0.6
Algeria	0.25	2.5	Tanzania	0.20	6.3
Egypt.	1.11	4.8	Uganda	0.02	0.3
Kenya	1.05	2.7	Yemen	0.00	0.0
			Zambia	0.06	0.5
			Zimbabwe	1.49	6.9
Average	**29.53**	**3,113.0**	**Average**	**2.84**	**4.8**

Table 5: Technology and industrial performance indices combined – the domestic capabilities index

		Technology effort index	Industrial per. Index	Combined index			Technology effort index	Industrial per. Index	Combined index
1	Japan	0.8649	0.6964	0.7806	41	Romania	0.0015	0.0954	0.0484
2	Switzerland	0.7858	0.7512	0.7685	42	Bahrain	0.0024	0.0891	0.0458
3	USA	0.7709	0.5641	0.6675	43	Uruguay	0.0020	0.0867	0.0444
4	Sweden	0.5957	0.5622	0.5789	44	Russian Fed	0.0062	0.0774	0.0418
5	Singapore	0.1738	0.8832	0.5285	45	Tunisia	0.0002	0.0676	0.0339
6	Germany	0.4151	0.6320	0.5235	46	Venezuela	0.0033	0.0597	0.0315
7	Finland	0.4099	0.5381	0.4740	47	Chile	0.0047	0.0557	0.0302
8	Ireland	0.1191	0.7392	0.4292	48	Guatemala	0.0003	0.0557	0.0280
9	Denmark	0.3434	0.4430	0.3932	49	Indonesia	0.0005	0.0543	0.0274
10	Belgium	0.2645	0.4949	0.3797	50	India	0.0004	0.0539	0.0272
11	France	0.2716	0.4650	0.3683	51	Zimbabwe	0.0000	0.0517	0.0259
12	Taiwan	0.3173	0.4123	0.3648	52	El Salvador	0.0000	0.0507	0.0254
13	Netherlands	0.2743	0.4287	0.3515	53	Morocco	0.0002	0.0476	0.0239
14	UK	0.1926	0.4725	0.3326	54	Saudi Arabia	0.0009	0.0467	0.0238
15	Canada	0.2488	0.4072	0.3280	55	Colombia	0.0004	0.0413	0.0208
16	Austria	0.2022	0.4528	0.3275	56	Mauritius	0.0002	0.0405	0.0204
17	S Korea	0.2225	0.3700	0.2962	57	Egypt	0.0001	0.0381	0.0191
18	Israel	0.2712	0.3014	0.2863	58	Peru	0.0001	0.0348	0.0174
19	Norway	0.2344	0.3005	0.2675	59	Oman	0.0000	0.0320	0.0160
20	Italy	0.0986	0.3844	0.2415	60	Pakistan	0.0000	0.0312	0.0156
21	Spain	0.0431	0.3194	0.1813	61	Ecuador	0.0009	0.0251	0.0130
22	Australia	0.1470	0.2113	0.1792	62	Jordan	0.0008	0.0241	0.0124
23	H Kong	0.0829	0.2041	0.1435	63	Kenya	0.0001	0.0246	0.0124
24	Malaysia	0.0065	0.2783	0.1424	64	Honduras	0.0003	0.0231	0.0117
25	Slovenia	0.0541	0.2210	0.1376	65	Panama	0.0008	0.0221	0.0114
26	N Zealand	0.0835	0.1861	0.1348	66	Jamaica	0.0006	0.0222	0.0114
27	Czech Rep.	0.0200	0.2426	0.1313	67	Bolivia	0.0002	0.0214	0.0108
28	Hungary	0.0135	0.2392	0.1263	68	Albania	0.0000	0.0214	0.0107
29	Portugal	0.0096	0.2399	0.1247	69	Sri Lanka	0.0002	0.0174	0.0088
30	Mexico	0.0022	0.2457	0.1240	70	Nicaragua	0.0001	0.0169	0.0085
31	Philippines	0.0006	0.2411	0.1209	71	Paraguay	0.0000	0.0151	0.0076
32	Thailand	0.0005	0.1721	0.0863	72	Mozambique	0.0000	0.0129	0.0064
33	Brazil	0.0087	0.1491	0.0789	73	Bangladesh	0.0000	0.0109	0.0054
34	Poland	0.0055	0.1434	0.0745	74	Algeria	0.0001	0.0092	0.0047
35	Argentina	0.0067	0.1395	0.0731	75	Cameroon	0.0000	0.0076	0.0038
36	C Rica	0.0041	0.1294	0.0667	76	Senegal	0.0000	0.0076	0.0038
37	China	0.0006	0.1256	0.0631	77	Zambia	0.0000	0.0066	0.0033
38	S Africa	0.0121	0.1075	0.0598	78	Nigeria	0.0000	0.0062	0.0031
39	Greece	0.0103	0.1023	0.0563	79	Nepal	0.0000	0.0062	0.0031
40	Turkey	0.0029	0.1080	0.0555	80	Tanzania	0.0000	0.0047	0.0024
					81	Malawi	0.0000	0.0033	0.0017
					82	Madagascar	0.0000	0.0033	0.0017
					83	CAR	0.0000	0.0031	0.0015
					84	Uganda	0.0000	0.0028	0.0014
					85	Yemen	0.0000	0.0014	0.0007
					86	Ghana	0.0000	0.0008	0.0004
					87	Ethiopia	0.0000	0.0000	0.0000

3.3 Technology Imports: FDI, Licensing and Capital Goods

Table 6 shows the average values of FDI inflows and licensing payments overseas by the four groups of countries, and Table 7 gives the values of the individual countries ranked by the technology effort index.[15] Capital goods imports are shown separately below.

Table 6: Average FDI inflows and Licensing Payments Abroad by Technology Groups

Technology groups	FDI/capita ($)	Total FDI ($ b)	FDI % GDI	FDI % GNP	Licensing/ capita ($)	Total licensing ($b)	Licensing % GNP
1. High	503.88	8.87	10.0%	2.1%	170.99	2,582.76	0.798%
2. Moderate	103.15	2.59	9.2%	2.2%	14.42	378.05	0.280%
3. Low	34.21	2.40	8.9%	2.2%	2.79	150.03	0.203%
4. Negligible	7.94	0.14	7.5%	1.3%	0.13	2.66	0.028%

Source: Calculated from UNCTAD *WIR* (various), IMF, World Bank and various national statistical sources.
Note: GDI stands for gross domestic investment.

It appears that on average, both FDI and foreign licensing in per capita terms decline with the intensity of national technological effort. This is also true of FDI as a percentage of gross domestic investment and licensing as a percentage of GNP, but not of FDI as a percentage of GNP. At the country level, however, the correlation between the technology effort and technology import variables is less strong or absent. For instance, FDI per capita is positively related to the technology index, but not very strongly (coefficient of 0.31), while royalty payments per capita are insignificant (coefficient of 0.11). When expressed as percentages of GNP the correlation is even lower (-0.11 for FDI and 0.01 for royalties).

A moment's reflection would suggest that the lack of correlation between technology effort and technology imports is not surprising. There is no *a priori* reason to expect that countries that do more R&D would also receive larger amounts of FDI relative to their economic size or spend more on foreign technology than other countries. In some cases, there is good reason to expect the opposite – a strong technology base may lead to more outward rather than inward FDI relative to GNP and to greater royalty receipts than payments. In other cases, strong FDI inflows and royalty payments may go with a weak local technology base. This gives rise to a fairly random pattern that is reflected in the national figures and correlations.

This reinforces the conclusion that countries will face different outcomes from strengthening IPRs, not just at different levels of development but also even at similar levels of income, depending on their pattern of technology development and imports. It may, of course, be argued that *all* countries should in the future be more receptive to FDI and licensing and that stronger IPRs will (if we accept the Maskus reasoning) promote both. In fact, countries with exceptionally low levels of technology inflows should make special efforts to raise them. More evidence is needed, however, before we can say with certainty that FDI and licensing respond positively to IPRs. As noted above, 'the jury is still out' in these matters.

Let us now consider technology imports in the form of capital goods. These are shown in Table 8, with countries again ranked by the technology effort index. The pattern is very similar to other forms of technology imports: group averages change in line with the technology index, but with large variations between individual countries. Much of the variation has to do with the size of the economy (apart, obviously, from the level of development), with larger countries less dependent on imported equipment than smaller ones.

Table 7: Inward FDI and technology licensing payments overseas by technology groups

		FDI 1993-7				Technology Licence Payments 1998		
		Per capita (US$)	**Total (US$ b)**	**As % of GDI**	**As % of GNP**	**Per capita (US$)**	**Total (US$ m)**	**As % of GNP**
1	Japan	7.1	1.07	0.07	0.02	70.8	8,947.30	0.219
2	Switzerland	529.8	4.47	6.60	1.37	151.7	1,078.20	0.380
3	USA	271.3	70.00	5.67	0.99	41.8	11,292.00	0.143
4	Sweden	922.5	8.10	25.25	3.66	106.0	938.50	0.414
5	Germany	77.1	6.81	1.32	0.28	59.6	4,893.40	0.224
6	Finland	260.2	1.46	7.57	1.21	79.8	411.40	0.329
7	Denmark	551.8	2.99	9.60	1.78	8.5	45.30	0.026
8	Taiwan	74.5	1.74	2.78	0.66	65.0	1,419.00	0.527
9	Netherlands	711.6	11.92	15.50	3.01	188.8	2,964.50	0.762
10	France	362.1	22.89	8.59	1.49	46.2	2,716.70	0.185
11	Israel	191.1	1.11	5.08	1.22	35.2	209.60	0.217
12	Belgium	1,116.2	10.58	24.16	3.91	107.7	1,099.20	0.424
13	Canada	292.8	8.06	8.08	1.49	68.4	2,073.20	0.357
14	Norway	589.3	2.62	7.73	1.81	76.9	341.00	0.224
15	S Korea	36.8	1.61	0.99	0.36	51.0	2,369.30	0.594
16	Austria	304.6	2.65	4.80	1.15	100.4	810.90	0.374
17	UK	367.6	20.91	12.07	1.90	103.7	6,122.70	0.484
18	Singapore	2,536.0	8.20	26.54	9.57	559.2	1,769.00	1.852
19	Australia	376.9	6.35	8.82	1.88	53.8	1,009.70	0.261
20	Ireland	484.2	1.47	15.11	2.64	1,683.1	6,235.80	8.998
21	Italy	63.0	3.55	1.90	0.33	20.1	1,154.90	0.100
22	N Zealand	735.0	2.69	22.31	4.79	70.4	266.90	0.482
23	H Kong	727.7	2.75	10.24	1.96	184.7	1,235.00	0.781
	Average Group 1	**503.88**	**8.87**	**10.0%**	**2.1%**	**170.99**	**2,582.76**	**0.798**
24	Slovenia	92.9	0.21	4.88	1.09	19.5	38.60	0.199
25	Spain	182.3	7.65	6.77	1.38	47.4	1,866.30	0.336
26	Czech Rep.	132.1	1.30	8.58	2.77	10.9	112.60	0.213
27	Hungary	236.1	2.39	23.57	5.58	21.2	214.60	0.470
28	S Africa	37.1	1.33	6.28	1.01	4.0	165.40	0.121
29	Greece	96.7	1.08	4.81	0.93	5.5	58.00	0.047
30	Portugal	149.0	1.53	6.32	1.54	29.1	290.00	0.273
31	Brazil	49.6	7.28	5.06	1.08	6.5	1,075.00	0.140
32	Argentina	149.1	5.39	10.34	1.94	11.7	422.00	0.145
33	Malaysia	229.5	4.63	14.10	5.73	107.8	2,392.00	2.942
34	Russian Fed	15.4	1.98	2.52	0.56	Neg.	2.00	0.001
35	Poland	86.3	3.13	13.27	2.65	5.0	195.00	0.129
36	Chile	229.4	3.38	20.23	5.26	3.8	56.00	0.076
37	C Rica	110.4	0.37	15.94	4.18	6.1	21.50	0.219
38	Venezuela	88.4	1.89	15.05	2.53	Neg.	Neg.	Neg.
39	Turkey	12.0	0.74	1.76	0.43	1.9	124.00	0.062
40	Bahrain	1.7	0.01	0.76	0.14	Neg.	Neg.	Neg.
41	Mexico	102.4	6.81	11.04	2.49	5.2	501.00	0.136
42	Uruguay	42.0	0.14	6.10	0.81	1.8	6.00	0.030
43	Romania	20.6	0.51	6.21	1.44	0.9	21.00	0.069
	Average Group 2	**103.15**	**2.59**	**9.2%**	**2.2%**	**14.42**	**378.05**	**0.280**

		FDI 1993-7				Technology Licence Payments 1998		
		Per capita (US$)	**Total (US$ b)**	**As % of GDI**	**As % of GNP**	**Per capita (US$)**	**Total (US$ m)**	**As % of GNP**
44	S Arabia	13.8	0.42	1.00	0.33	Neg.	Neg.	Neg.
45	Ecuador	46.3	0.51	15.75	3.04	5.6	68.0	0.370
46	Panama	189.0	0.46	20.74	6.13	6.4	17.6	0.212
47	Jordan	16.1	0.07	3.84	1.01	Neg.	Neg.	Neg.
48	China	30.1	37.81	13.54	5.51	0.3	420.0	0.045
49	Jamaica	58.7	0.14	10.59	3.63	11.6	30.0	0.667
50	Philippines	20.1	1.54	8.46	2.01	2.1	158.0	0.200
51	Indonesia	19.8	3.66	6.16	1.90	4.9	1,002.0	0.767
52	Thailand	38.0	2.45	4.07	1.48	13.1	804.0	0.610
53	Colombia	62.2	1.98	11.29	2.54	1.3	54.0	0.054
54	India	2.1	1.64	2.16	0.51	0.2	200.8	0.047
55	Guatemala	9.0	0.09	4.20	0.64	Neg.	Neg.	Neg.
56	Honduras	11.2	0.06	4.92	1.57	0.8	5.1	0.111
57	S Lanka	10.6	0.19	5.91	1.49	Neg.	Neg.	Neg.
58	Bolivia	49.5	0.30	30.89	5.22	0.6	5.2	0.065
59	Mauritius	25.7	0.03	2.65	0.74	Neg.	Neg.	Neg.
60	Morocco	19.4	0.51	7.72	1.63	6.2	171.5	0.498
61	Tunisia	41.2	0.38	8.39	2.22	0.2	2.6	0.014
62	Egypt	13.3	0.78	7.83	1.32	6.4	392.0	0.495
63	Peru	91.1	2.20	16.91	3.85	3.2	80.0	0.132
64	Algeria	0.4	0.01	0.07	0.02	Neg.	Neg.	Neg.
65	Nicaragua	18.8	0.07	16.79	4.50	Neg.	Neg.	Neg.
66	Kenya	0.5	0.01	0.92	0.15	1.3	39.9	0.391
	Average Group 3	**34.21**	**2.40**	**8.9%**	**2.2%**	**2.79**	**150.03**	**0.203**
-	Nigeria	13.5	1.23	30.72	5.36	Neg.	Neg.	Neg.
-	Pakistan	5.1	0.65	5.66	1.06	0.1	19.7	0.032
-	Albania	19.7	0.08	20.24	3.15	Neg.	Neg.	Neg.
-	Bangladesh	0.3	0.03	0.44	0.09	Neg.	5.1	0.012
-	Cameroon	1.2	0.01	1.13	0.18	0.1	1.0	0.012
-	CAR	0.4	Neg.	3.02	0.20	Neg.	Neg.	Neg.
-	El Salvador	2.1	0.01	0.71	0.14	1.1	6.9	0.061
-	Ethiopia	0.1	0.01	0.58	0.09	Neg.	Neg.	Neg.
-	Ghana	7.9	0.13	9.73	2.19	Neg.	Neg.	Neg.
-	Madagascar	0.8	0.01	2.81	0.32	0.6	9.8	0.264
-	Malawi	0.1	Neg.	0.34	0.06	Neg.	Neg.	Neg.
-	Mozambique	3.1	0.02	10.24	1.88	Neg.	Neg.	Neg.
-	Nepal	0.6	0.01	1.18	0.28	Neg.	Neg.	Neg.
-	Oman	37.3	0.07	3.43	0.63	Neg.	Neg.	Neg.
-	Paraguay	40.6	0.20	9.93	2.27	0.1	0.5	0.006
-	Senegal	6.6	0.06	7.58	1.34	0.2	2.2	0.047
-	Tanzania	3.3	0.09	9.20	1.77	0.1	4.7	0.065
-	Uganda	5.8	0.12	13.80	2.16	Neg.	Neg.	Neg.
-	Yemen	7.3	0.14	12.03	2.11	Neg.	Neg.	Neg.
-	Zambia	6.7	0.06	12.18	1.75	Neg.	Neg.	Neg.
-	Zimbabwe	4.2	0.04	3.06	0.61	0.5	6.0	0.084
	Average Group 4	**7.94**	**0.14**	**7.5%**	**1.3%**	**0.13**	**2.66**	**0.028**

Table 8: Capital goods imports per capita (average 1995-98, current dollars)

Group 1		Group 2		Group 3		Group 4	
Japan	305.98	Slovenia	741.28	Saudi Arabia	153.95	Nicaragua	47.07
Switzerland	1,905.21	Spain	468.31	Ecuador	84.11	Peru	77.97
USA	570.36	Czech Republic	529.98	Jordan	107.72	Albania	24.38
Sweden	1,337.17	Hungary	313.68	Panama	166.68	Bangladesh	5.85
Germany	796.17	S Africa	168.91	China	25.02	Cameroon	9.62
Finland	1,090.87	Greece	434.90	Jamaica	139.49	CAR	12.59
Denmark	1,439.22	Portugal	498.04	Philippines	65.93	El Salvador	71.26
Taiwan	992.28	Brazil	76.26	Indonesia	43.16	Ethiopia	3.29
Netherlands	1,784.49	Argentina	191.58	Thailand	209.67	Ghana	0.01
France	745.41	Malaysia	716.81	Colombia	92.45	Madagascar	6.28
Israel	871.98	Russian Fed	55.12	India	4.50	Malawi	7.38
Belgium	1,694.51	Poland	191.37	Guatemala	63.68	Mozambique	8.18
Canada	1,221.36	Chile	323.19	Honduras	68.31	Nepal	3.02
Norway	1,800.96	C Rica	191.27	Bolivia	73.65	Nigeria	10.14
S Korea	534.74	Venezuela	123.46	Mauritius	258.89	Oman	228.50
Austria	1,366.98	Turkey	162.09	Morocco	41.01	Pakistan	11.28
UK	858.41	Bahrain	244.61	Sri Lanka	13.71	Paraguay	133.69
Singapore	8,803.54	Mexico	178.05	Tunisia	130.33	Senegal	8.35
Australia	836.07	Uruguay	198.38	Algeria	43.20	Tanzania	8.43
Ireland	2,179.62	Romania	78.40	Egypt	34.11	Uganda	0.00
Italy	486.72			Kenya	22.11	Yemen	5.80
N Zealand	815.89					Zambia	11.16
H Kong	4,599.10					Zimbabwe	62.18
Average	**1,610.31**		**294.28**		**87.70**		**32.89**

Source: Calculated from UN Comtrade database.

The three forms of technology imports can be combined into a composite *technology import index* (Table 9). This index has some correlation with the domestic capability index (coefficient of 0.56), but there are many individual differences in ranking for reasons noted above. For instance, India ranks low in the technology import index but does better on the domestic capability index.

The countries in Table 9 are ranked according to the technology import index, and divided into four groups. There are a relatively large number of countries with very low use of foreign technology. The implications for IPRs are, as before, mixed. Countries with relatively high reliance on foreign technologies may need to strengthen IPRs to ensure continued access (if at higher prices), particularly for advanced proprietary technologies and high-tech capital goods. For other countries, with a need for more mature equipment, stronger IPRs would bring no benefit.

Table 9: Technology import index

Singapore	0.7774	Germany	0.0521	Oman	0.0135	Guatemala	0.0036
Ireland	0.4795	Spain	0.0511	Uruguay	0.0134	Albania	0.0035
H Kong	0.3064	Hungary	0.0471	Mauritius	0.0132	El Salvador	0.0032
Belgium	0.2322	Portugal	0.0442	S Africa	0.0121	Zimbabwe	0.0030
Netherlands	0.1985	Slovenia	0.0441	Colombia	0.0119	Nigeria	0.0021
Sweden	0.1929	Chile	0.0431	Brazil	0.0107	Sri Lanka	0.0019
Switzerland	0.1718	Czech Republic	0.0396	Paraguay	0.0104	Algeria	0.0017
Norway	0.1609	S Korea	0.0352	Tunisia	0.0104	Zambia	0.0013
N Zealand	0.1414	Panama	0.0324	Ecuador	0.0104	Senegal	0.0012
Denmark	0.1287	Italy	0.0307	Bahrain	0.0095	Yemen	0.0012
Austria	0.1117	Greece	0.0303	Bolivia	0.0094	Kenya	0.0011
UK	0.1013	Argentina	0.0292	Turkey	0.0081	Pakistan	0.0011
Canada	0.0983	Japan	0.0265	Saudi Arabia	0.0076	Ghana	0.0010
Australia	0.0918	C Rica	0.0229	Jordan	0.0062	Tanzania	0.0008
Finland	0.0913	Mexico	0.0212	Romania	0.0058	Uganda	0.0007
France	0.0850	Poland	0.0196	Philippines	0.0055	Mozambique	0.0007
Malaysia	0.0786	Venezuela	0.0163	Morocco	0.0053	Cameroon	0.0005
USA	0.0655	Peru	0.0155	Indonesia	0.0052	CAR	0.0005
Israel	0.0651	Thailand	0.0155	China	0.0049	India	0.0005
Taiwan	0.0602	Jamaica	0.0153	Egypt	0.0043	Madagascar	0.0004
				Nicaragua	0.0042	Malawi	0.0003
				Honduras	0.0042	Bangladesh	0.0002
				Russian Fed	0.0041	Nepal	0.0002
						Ethiopia	0.0001

3.4 Skills and ICT Infrastructure

Let us end with national figures on technical skills and modern (information and communication, ICT) infrastructure. Technical skills are measured here by *technical enrolments at the tertiary level in pure science, engineering and mathematics and computing*. This measure is, however, strongly correlated with other measures like years of schooling, so the choice of skill indicators does not matter greatly. ICT is measured by *telephone mainlines*, which is also highly correlated with other ICT indicators like mobile telephones, personal computers and Internet servers.

The picture is, not surprisingly, very similar to that yielded by other indices of technological effort and industrial performance (Table 10).

Table 10: Tertiary technical enrolments and telephone mainlines (1997-98)

	Tertiary Technical Enrolment			Telephone Mainlines		
		% Population	Numbers (thousand)		Per 1,000 people	Total number (thousand)
1	S Korea	1.65%	742.5	Switzerland	675.4	4,799.3
2	Finland	1.33%	68.0	Sweden	673.7	5,963.3
3	Russian Fed	1.18%	1,749.2	USA	661.3	178,751.0
4	Australia	1.17%	212.0	Norway	660.1	2,925.7
5	Taiwan	1.06%	226.8	Denmark	659.7	3,497.0
6	Spain	0.97%	379.7	Canada	633.9	19,206.0
7	Ireland	0.91%	32.6	Netherlands	593.1	9,310.6
8	Austria	0.78%	63.0	France	569.7	33,524.0
9	Germany	0.77%	631.1	Germany	566.8	46,505.0
10	UK	0.75%	439.1	Singapore	562.0	1,777.9
11	Sweden	0.73%	64.5	H Kong	557.7	3,729.2
12	Portugal	0.73%	72.6	UK	556.9	32,889.0
13	Chile	0.73%	103.1	Finland	553.9	2,854.5
14	Greece	0.72%	75.0	Greece	522.2	5,491.1
15	Canada	0.69%	203.2	Australia	512.1	9,601.4
16	USA	0.68%	1,792.9	Japan	502.7	63,540.0
17	N Zealand	0.68%	24.8	Belgium	500.3	5,104.6
18	Israel	0.68%	37.4	Austria	491.0	3,966.1
19	Norway	0.67%	29.3	N Zealand	479.1	1,816.8
20	Japan	0.64%	808.2	Israel	471.1	2,809.1
21	Italy	0.64%	364	Italy	450.7	25,954.0
22	France	0.61%	355.1	Ireland	434.7	1,610.4
23	Denmark	0.60%	31.4	S Korea	432.7	20,088.0
24	Panama	0.59%	15.6	Taiwan	420.1	9,174.8
25	Netherlands	0.56%	86.6	Spain	413.7	16,288.0
26	Philippines	0.55%	387.3	Portugal	413.5	4,121.4
27	Bahrain	0.52%	3.0	Slovenia	374.8	742.9
28	Switzerland	0.51%	36.0	Czech Rep.	363.9	3,746.2
29	Colombia	0.51%	197.1	Hungary	335.9	3,396.8
30	Slovenia	0.49%	9.7	Turkey	254.1	16,125.0
31	Romania	0.49%	111.2	Uruguay	250.4	823.5
32	H Kong	0.49%	30.2	Bahrain	245.5	157.8
33	Singapore	0.47%	14.1	Poland	227.6	8,800.4
34	Argentina	0.47%	162.3	Mauritius	213.7	247.8
35	Peru	0.46%	108.2	Chile	205.5	3,045.8
36	Czech Republic	0.46%	47.9	Argentina	202.7	7,323.6
37	Venezuela	0.45%	97.9	Malaysia	197.6	4,383.7
38	Mexico	0.44%	400.1	Russian Fed	196.6	28,879.0

	Tertiary Technical Enrolment			Telephone Mainlines		
		% Population	Numbers (thousand)		Per 1,000 people	Total number (thousand)
39	Belgium	0.43%	43.6	Colombia	173.5	7,078.7
40	Jordan	0.42%	17.5	C Rica	171.8	605.9
41	Algeria	0.41%	115.1	Jamaica	165.7	426.8
42	Poland	0.39%	151.9	Romania	162.4	3,653.4
43	C Rica	0.34%	11.5	Panama	151.3	418.3
44	Bolivia	0.34%	25.4	S Arabia	142.6	2,957.8
45	Turkey	0.33%	198.3	Brazil	120.5	19,989.0
46	Uruguay	0.29%	9.3	Venezuela	116.7	2,712.0
47	Ecuador	0.29%	32.7	S Africa	114.6	4,743.0
48	El Salvador	0.26%	15.0	Mexico	103.6	9,928.7
49	Morocco	0.25%	66.7	Oman	92.3	212.6
50	Tunisia	0.24%	21.4	Jordan	85.5	390.2
51	Indonesia	0.23%	439.1	Thailand	83.5	5,112.8
52	Nicaragua	0.22%	9.7	Tunisia	80.6	752.2
53	Honduras	0.20%	11.3	El Salvador	80.0	484.7
54	Thailand	0.19%	110.5	Ecuador	78.3	953.0
55	Brazil	0.18%	289.3	China	69.6	86,230.0
56	S Africa	0.17%	68.1	Bolivia	68.8	547.1
57	Guatemala	0.17%	17.0	Peru	66.7	1,654.8
58	Hungary	0.16%	16.7	Egypt	60.2	3,696.1
59	Malaysia	0.13%	26.7	Paraguay	55.3	288.4
60	S Arabia	0.12%	23.4	Morocco	54.4	1,509.9
61	India	0.12%	1,086.3	Algeria	53.2	1,591.5
62	Egypt	0.12%	69.6	Guatemala	40.8	441.1
63	Paraguay	0.11%	5.5	Honduras	38.1	234.8
64	Jamaica	0.11%	2.9	Philippines	37.0	2,782.6
65	Albania	0.11%	3.6	Nicaragua	31.3	150.3
66	China	0.10%	1,221.0	Albania	30.5	101.9
-	Zimbabwe	0.09%	9.5	S Lanka	28.4	532.7
-	S Lanka	0.08%	15.4	Indonesia	27.0	5,499.9
-	Nepal	0.08%	16.0	India	22.0	21,538.0
-	Bangladesh	0.08%	90.0	Pakistan	19.4	2,549.8
-	Nigeria	0.06%	63.3	Zimbabwe	17.3	201.6
-	Madagascar	0.06%	8.2	Senegal	15.5	140.1
-	Cameroon	0.06%	8.4	Yemen	13.4	221.9
-	Senegal	0.05%	4.4	Kenya	9.2	269.9
-	Pakistan	0.05%	63.4	Zambia	8.8	85.5
-	Oman	0.04%	0.9	Nepal	8.5	194.0
-	Mauritius	0.04%	0.5	Ghana	7.5	138.9
-	Zambia	0.03%	2.7	Cameroon	5.4	77.2
-	Yemen	0.02%	3.2	Mozambique	4.0	67.6
-	Kenya	0.02%	4.6	Nigeria	3.8	462.1
-	CAR	0.01%	0.4	Tanzania	3.8	121.9
-	Uganda	0.01%	2.5	Malawi	3.5	36.6
-	Tanzania	0.01%	3.6	Bangladesh	3.0	380.6
-	Mozambique	0.01%	2.1	Madagascar	2.9	42.1
-	Malawi	0.01%	0.8	Ethiopia	2.8	168.6
-	Ghana	0.01%	2.1	Uganda	2.8	57.9
-	Ethiopia	0.01%	6.5	CAR	2.7	9.5

4. CONCLUDING THOUGHTS

This review has illustrated the significant variations both between rich and poor countries and within the developing world itself in the variables that may affect the technological impact of TRIPS: domestic technical effort, imports of foreign technology and industrial performance. It has sought to put empirical flesh and bones on the intuition that different countries may face different outcomes by strengthening their IPR regimes, but without trying to measure what the costs and benefits might be. It has noted that costs and benefits are difficult to quantify, since the result depends on several complex factors, some of which are not open to assessment on the basis of past evidence. In a dynamic world, a certain amount of subjectivity – even crystal ball gazing – may be inevitable.

We concur with the World Bank (2001) that the application of TRIPS should take account of national economic and technological differences. The World Bank conducts a similar exercise to the one attempted here, and divides countries into three groups based only incomes – low, middle and high – and 'lists IPR standards that are likely to be most appropriate for each group' (p. 140). It suggests that even as it stands, TRIPS 'contains considerable flexibility in implementing and enforcing standards that are conducive to development' (139). It recommends that this flexibility be fully exploited to encourage development and allow longer periods for adjustment. This is certainly the right approach; we cannot, however, assess how far it should be taken and whether it will be sufficient to meet the technology development needs of poorer countries. It is quite possible that more action may be needed, calling for an examination of the TRIPS provisions *per se*.

For instance, investigation may focus on measuring, even roughly, the immediate effects of TRIPS in terms of the higher costs of technology and capital goods and the restriction of imitation and reverse engineering as a source of technological learning. It is also necessary to investigate the real impact of stricter IPRs on promoting technology inflows: cross-country econometric analysis is not the most reliable instrument for doing this. It may conceal more than it reveals, and it certainly does not show the strong inter-industry differences in the propensity to rely on IPRs for innovation or technology transfer. It also confuses the signalling effect of IPRs with that of other policies. If a positive effect of IPRs on technology transfer to the poorest segment of countries is actually found, it is important to assess if these gains outweigh, in present value terms, the more immediate costs.

If it is found, as is quite likely, that the present value of the benefits of TRIPS does not outweigh its costs for many poor countries, the other arguments for accepting TRIPS should be clearly stated. As noted, there may well be such arguments, but they should be presented clearly and not conflated with those based on economic benefits of stronger IPRs.

A final word of caution: it is not possible to pick the countries that will lose or gain from TRIPS from the above indices. Their use lies mainly in illustrating just how wide the differences are between developing countries in practically every aspect of technological and industrial performance. To the extent that there are theoretical grounds to expect the economic impact of TRIPS to vary on these grounds, the data provide some signposts for further investigation. They do not presume to do more.

ANNEX

Technological classification of exports (SITC 3-digit, revision 2)

Primary Products (PP)

001 live animals for food
011 meat fresh,chilld,frozen
022 milk and cream
025 eggs,birds,fresh,prsrvd
034 fish,fresh,chilled,frozen
036 shell fish fresh,frozen
041 wheat etc unmilled
042 rice
043 barley unmilled
044 maize unmilled
045 cereals nes unmilled
054 veg etc fresh,simply prsvd
057 fruit,nuts,fresh,dried
071 coffee and substitutes
072 cocoa
074 tea and mate
075 spices
081 feeding stuff for animls
091 margarine and shortening
121 tobacco unmnfctrd,refuse
211 hides,skins,exc furs,raw
212 furskins,raw
222 seeds for'soft'fixed oil
223 seeds for oth fixed oils
232 natural rubber,gums
244 cork,natural,raw,waste
245 fuel wood nes, charcoal
246 pulpwood,chips,woodwaste
261 silk
263 cotton
268 wool(exc tops),anml hair
271 fertilizers,crude
273 stone,sand and gravel
274 sulphur,unrstd irn pyrte
277 natural abrasives nes
278 other crude minerals
291 crude animal mtrials nes
292 crude veg materials nes
322 coal,lignite and peat
333 crude petroleum
341 gas,natural and manufctd
681 silver,platinum,etc
682 copper exc cement copper
683 nickel
684 aluminium
685 lead
686 zinc
687 tin

Resource Based Manufactures

RB 1: AGRO-BASED

012 meat dried,salted,smoked
014 meat prepd,prsvd,nes etc
023 butter
024 cheese and curd
035 fish salted,dried,smoked
037 fish etc prepd,prsvd nes
046 wheat etc meal or flour
047 other cereal meals,flour
048 cereal etc preparations
056 vegtbles etc prsvd,prepd
058 fruit preserved,prepared
061 sugar and honey
062 sugar candy non-choclate
073 chocolate and products
098 edible prodcts,preps nes
111 non-alcohl beverages nes
112 alcoholic beverages
122 tobacco,manufactured
233 rubber,synthtic,reclaimd
247 oth wood rough,squared
248 wood shaped,sleepers
251 pulp and waste paper
264 jute,oth tex bast fibres
265 veg fibre,excl cotn,jute
269 waste of textile fabrics
423 fixed veg oils,soft
424 fixed veg oil nonsoft
431 procesd anml veg oil,etc
621 materials of rubber
625 rubber tyres, tubes etc
628 rubber articles nes
633 cork manufactures
634 veneers,plywood,etc
635 wood manufactures nes
641 paper and paperboard

RB 2: OTHER

281 iron ore,concentrates
282 iron and steel scrap
286 uranium,thorium ore,conc
287 base metal ores,conc nes
288 nonferr metal scrap nes
289 prec mtal ores,waste nes
323 briquets,coke,semi-coke
334 petroleum products,refin
335 residual petrlm prod nes
411 animal oils and fats
511 hydrocarbons nes,derivs
514 nitrogen-fnctn compounds
515 org-inorg compounds etc
516 other organic chemicals
522 inorg elemnts,oxides,etc
523 othr inorg chemicals etc
531 synt dye,nat indgo,lakes
532 dyes nes,tanning prod
551 essentl oils,perfume,etc
592 starch,inulin,gluten,etc
661 lime,cement,bldg prods
662 clay,refractory bldg prd
663 mineral manufctures nes
664 glass
667 pearl,prec-,semi-p stone
688 uranium,thorium,alloys
689 non-fer base metals nes

Low technology manufactures

LT1: TEXTILE, GARMENT AND FOOTWEAR

611 leather
612 leather etc manufactures
613 fur skins tanned,dressed
651 textile yarn
652 cotton fabrics,woven
654 oth woven textile fabric
655 knitted,etc fabrics
656 lace,ribbons,tulle,etc
657 special txtl fabrc,prods
658 textile articles nes
659 floor coverings,etc
831 travel goods,handbags
842 mens outerwear not knit
843 womens outerwear nonknit
844 under garments not knit
845 outerwear knit nonelastc
846 under garments knitted
847 textile clthng acces nes
848 headgear,nontxtl clothng
851 footwear

LT2: OTHER PRODUCTS

642 paper,etc,precut,arts of
665 glassware
666 pottery
673 iron,steel shapes etc
674 irn,stl univ,plate,sheet
675 iron,steel hoop,strip
676 railwy rails etc irn,stl
677 irn,stl wire(excl w rod)
679 irn,stl castings unworkd
691 structures and parts nes
692 metal tanks,boxes,etc
693 wire products non electr
694 stl,coppr nails,nuts,etc
695 tools
696 cutlery
697 base mtl household equip
699 base metal mfrs nes
821 furniture,parts thereof
893 articles of plastic nes
894 toys,sporting goods,etc
895 office supplies nes
897 gold,silver ware,jewelry
898 musical instruments,pts
899 other manufactured goods

Medium Technology Manufactures		High Technology Manufactures
MT 1: AUTOMOTIVE	**MT 3: ENGINEERING**	**HT 1: ELECTRONIC AND ELECTRICAL**
781 pass motor veh exc buses	711 steam boilers & aux plnt	716 rotating electric plant
782 lorries,spcl mtr veh nes	713 intrnl combus pstn engin	718 oth power generatg machy
783 road motor vehicles nes	714 engines and motors nes	751 office machines
784 motor veh prts,acces nes	721 agric machy,exc tractors	752 automtic data proc equip
785 cycles,etc motrzd or not	722 tractors non-road	759 office,adp mch pts,acces
MT 2: PROCESS	723 civil engneerg equip etc	761 television receivers
266 synthetic fibres to spin	724 textile,leather machnry	764 telecom eqpt,pts,acc nes
267 other man-made fibres	725 paper etc mill machinery	771 electric power machy nes
512 alcohols,phenols etc	726 printg,bkbindg machy,pts	774 electro-medcl,xray equip
513 carboxylic acids etc	727 food machry non-domestic	776 transistors, valves, etc.
533 pigments,paints,etc	728 oth machy for spcl indus	778 electrical machinery nes
553 perfumery,cosmetics,etc	736 metalworking mach-tools	**HT 2: OTHER**
554 soap,cleansing etc preps	737 metalworking machnry nes	524 radioactive etc material
562 fertilizers,manufactured	741 heating,cooling equipmnt	541 medicinal,pharm products
572 explosives,pyrotech prod	742 pumps for liquids etc	712 steam engines,turbines
582 prod of condensation etc	743 pumps nes,centrfuges etc	792 aircraft etc
583 polymerization etc prods	744 mechanical handling equ	871 optical instruments
584 cellulose derivativs etc	745 nonelec machy,tools nes	874 measurng,controlng instr
585 plastic material nes	749 nonelec mach pts,acc nes	881 photo apparat,equipt nes
591 pesticides,disinfectants	762 radio broadcast receivrs	
598 miscel chem products nes	763 sound recordrs,phonogrph	
653 wovn man-made fib fabric	772 switchgear etc,parts nes	
671 pig iron etc.	773 electr distributng equip	
672 iron,steel primary forms	775 household type equip nes	
678 iron,stl tubes,pipes,etc	793 ships and boats etc	
786 trailers,nonmotr veh,nes	812 plumbg,heatng,lghtng equ	
791 railway vehicles	872 medical instruments nes	
882 photo,cinema supplies	873 meters and counters nes	
	884 optical goods nes	
	885 watches and clocks	
	951 war firearms,ammunition	

Note: Excludes ‘special transactions’ like electric current, cinema film, printed matter, special transactions, gold, works of art, coins, pets.

END NOTES

[1] This article was originally published in BRIDGES between Trade and Sustainable Development, Year 6, No 3, March/April 2002. It is a summary of a paper produced by professor Sanjaya Lall for the ICTSD/UNCTAD capacity building on IPR and sustainable development.

[2] Since the focus here is on technological considerations in the classification, the aspect of IPRs it refers most directly to is *patents*. Copyrights and trademarks raise different sets of issues, and the case for strengthening them across the board is probably clearer than for patents. While some technological issues can also arise for copyrights (say, in software), and a case can be made for lax IPRs to promote local learning and dissemination, this is not considered separately here.

[3] For such analysis, see references in Maskus (2000), Gould and Gruben (1996) and World Bank (2001).

[4] See, for instance, Braga *et al.* (1999) and Maskus (2000).

[5] Developing countries can undertake considerable technological activity to master, adapt and improve upon imported technologies. Indeed, as Lall (2001) notes, differences in such capability building are the main factor differentiating between success and failure in industrial development. However, this kind of technological activity does not lead to patentable innovation and so does not need strong IPRs; indeed, as noted later, lax IPRs may be beneficial because they permit a major form of learning: imitation and reverse engineering.

[6] Note that this is a purely economic argument based on the social gains from innovation. It does not take into account the (non-economic) argument that it is 'fair' or 'just' to reward innovators, and that all users of innovations should share equally in providing these rewards. On these grounds, those who avoid their share are 'free riding' and should be penalised. This kind of moral argument is often explicitly or implicitly used in the debate on IPRs. However, it can be argued just as plausibly that poor consumers of innovations *should* pay less than rich ones on moral, distributional or humanitarian grounds. The issue then becomes whether aid, redistribution or charity should be given in this form – of lax IPRs that allow for lower prices – than in the form of direct financial flows between governments. Again, a good case can be made for innovative products consumed by large sections of poor populations (medicines, for example) that the impact via product prices is far greater and more effective than via aid channelled through the government. See UNDP (2001) for a discussion of some of the issues concerning the pharmaceutical industry and human development.

[7] Chang (2001), Rasiah (2001).

[8] The main recourse countries have is compulsory licensing, but the use of this instrument is constrained in many poor countries by other factors like economic pressures brought by the home countries of innovators.

[9] See Braga *et al.* (1999), Luthria (1999), Chang (2001) and Rasiah (2001).

[10] The R&D data are in current US dollars. We prefer R&D financed by productive enterprises to total R&D because the latter includes expenditures on defence, agriculture and so on that are not directly relevant to innovation by private agents. However, both measures (in dollar terms) yield very similar national rankings, and the results would not change significantly if we used total R&D figures.

[11] Patents taken out internationally include those filed by affiliates of TNCs operating in the country. This does not matter for present purposes since local R&D by TNCs reflects the innovative capacity of the host country.

[12] The values for each variable are standardised according to the following formula.

$Index = \frac{X_i value - \text{minimum} X_i value}{\text{Maximum} X_i value - \text{minimum} X_i value}$, where the highest country in the rank scores 1 and the lowest scores 0.

[13] However, the ranks according to R&D and international patenting are very similar overall, with a the correlation coefficient of over 0.9.

[14] The data are drawn from OECD (1999) and various national sources.

[15] Licensing payments are taken from published national balance of payments statistics (from the IMF and national sources), and cover all types of royalty and technical fees paid abroad, as well as payments for trademarks and possibly consultancy services. Some countries do not break down their invisible payments overseas in detail; for these we estimated the figures based on proportions of service payments accounted for by licensing payments in other countries at similar levels of development and with similar trade and FDI policies.

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