OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

WORKING PAPERS

The Role of Intellectual Property Rights in Technology Transfer and Economic Growth: Theory and Evidence

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

The Role of Intellectual Property Rights in Technology Transfer and Economic Growth: Theory and Evidence

By

Rod Falvey

Leverhulme Centre for Research on Globalisation and
Economic Policy, School of Economics, The University of Nottingham

and

Neil Foster

Department of Economics, University of Vienna

In cooperation with

Olga Memedovic

UNIDO, Strategic Research and Economics Branch

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2006

This publication was prepared by Olga Memedovic, UNIDO staff member from the Strategic Research and Economics Branch drawing on the background paper prepared for the UNIDO Research Project "Public Goods for Economic Development", by Rod Falvey and Neil Foster. Rod Falvey is Professor of International Economics, Leverhulme Centre for Research on Globalisation and Economic Policy, School of Economics, The University of Nottingham. Neil Foster is Assistant Professor of economics at the Department of Economics, University of Vienna. The publication has benefited from the valuable comments provided by Professor David Greenaway during the finalization of this publication. UNIDO intern Robert Lambertus van Lavieren provided assistance during various stages of preparing this publication. The authors are grateful to Michael Bailey for proofreading the final document.

Comments and suggestions on the issues raised in this paper may be addressed to:

Olga Memedovic
Strategic Research and Economics Branch
UNIDO
P.O. Box 300
1400 Vienna
Austria

Tel: (+43-1) 26026-4676
Fax: (+43-1) 26026-6864
E-mail: omemedovic@unido.org

Abstract

Following the conclusion of the TRIPS Agreement, much has been written on the potential costs and benefits of stronger Intellectual Property Rights (IPRs) protection in terms of growth and technology transfer, particularly for developing countries. This paper reviews this literature and provides new evidence linking protection of IPRs to economic growth, innovation and technology diffusion. Results suggest that while stronger IPR protection can ultimately reap rewards in terms of greater domestic innovation and increased technology diffusion in developing countries with sufficient capacity to innovate, it has little impact on innovation and diffusion in those developing countries without such capacity and may impose additional costs. There is a considerable incentive, therefore, for countries at different stages of development to use the flexibilities in the TRIPS Agreement to maximize its net benefits for their development.

Contents

Executive summary

Introduction

Knowledge is typically non-excludable in that it is not possible to prevent others from applying new knowledge even without the authorization of its creator. If a new technology is valuable, it is therefore likely to be copied or imitated, reducing the potential profits of the original inventor and potentially removing the incentive to engage in innovative activities. Intellectual property rights (IPRs) encourage innovation by granting successful inventors temporary monopoly power over their innovations. The consequent monopoly profits provide the returns on successful investment in research and development (R&D), which must be large enough to compensate for the high share of R&D investment that is unsuccessful.

Once an innovation has been created, its non-rival character suggests that its benefits will be maximized if its use is free to all at marginal cost. Although this availability to all will yield benefits in the short run, it will also severely damage the incentive for further innovation. But, excessive IPR protection is likely to lead to an inadequate dissemination of new knowledge, which in itself could slow growth to the extent that access to existing technology is necessary to induce further innovation. Weak IPR protection has actually stimulated R&D activity in many countries by encouraging knowledge spillovers from transnational corporations (TNCs) and other domestic firms. Giving innovators too much protection may also lead to permanent monopoly. Entry by rivals may be impeded, and successful innovators may have reduced incentives for developing and exploiting subsequent innovations. Choice of IPR policy then reflects a balancing of these considerations. The awarding of a temporary monopoly, although second best, is intended to restore the incentive to innovate, which in turn should encourage long-run growth and improved product quality.

Developed countries, with many potential innovators, have tended to opt for relatively strong IPR systems, with the aim of encouraging inventive and creative activities that are seen as an important source of long-run economic growth. With R&D spending concentrated in a handful of the world's richest countries, genuinely innovative activities are limited in most developed and developing countries. The majority of countries in the world have taken a different approach, providing only weak IPR protection, if any, as a way of allowing the rapid diffusion of knowledge through imitation as a significant source of technological development. Providing stronger IPR protection is seen as shifting profits from domestic imitative firms to foreign firms and reducing output in the domestic economy, rather than encouraging domestic innovative activity. The counter argument is that stronger IPR protection can help reward creativity and risk-taking even in developing economies, while weak IPR protection can make developing countries remain dependent on dynamically inefficient firms that rely on counterfeiting and imitation.

The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) was established during the Uruguay Round (1986-1994) of trade negotiations in order to strengthen the international IPR regime. The TRIPS Agreement is the first comprehensive and global set of rules covering IPR protection. The TRIPS Agreement specifies minimum standards that should be attained by a designated time. The areas covered are copyrights and related rights, trademarks, geographical indications, industrial designs, patents, the layout designs of integrated circuits and undisclosed information including trade secrets and test data.

Intellectual property rights and economic growth

If we look at the world as being composed of two types of countries: a developed, innovating "North" and a developing, imitating "South"[1], then the impact of stronger IPR protection benefits the innovating North, but its impact in the South where innovation is limited or non-existent is ambiguous, depending inter alia on the channels through which technology is transferred. Research indicates that stronger IPR protection is only found to benefit the South when R&D is highly productive, thus resulting in significant cost reductions, and when the South comprises a large share of the overall market of the product.

Research also shows that the benefits of increased innovation through stronger IPR protection become weaker as more and more countries strengthen their IPR regimes, because the extra market covered and the extra innovation that can be stimulated by such protection diminishes. Since IPR holders engage in monopoly pricing that distorts consumer choice, strengthening IPR protection can lead to welfare reductions, particularly in a country that undertakes little or no R&D and would otherwise be able to free ride on foreign innovations.

Trade channel

When technology is transferred through trade, then successful southern imitation results in shifting the competitive advantage for the production of imitated products from the North to the South. Stronger IPR protection in the South decreases southern imitation and increases northern innovation in the short run, as innovation becomes more profitable. In the long run, though, innovation in the North may fall, because if new products are produced for a longer time span in the North, fewer resources are available for innovation there. Stronger IPR protection in the South may then reduce global

[1]The use of the terms "North" and "South" is a simplification of reality often used in the literature. UNIDO (2005) notes that this simplification ignores inequality within the North and the South.

growth. But weak IPR protection in the South may have effects besides reducing the incentive for innovation in the North. Northern exporters may be able to "mask" their production technologies, thereby limiting the extent to which these can be imitated through traded goods. The potential gains from technology transfer through weak IPR protection in the South might then be offset by increases in northern masking.

Foreign direct investment channel

When foreign direct investment (FDI) is considered as a source of technology transfer, northern innovators may shift production to the South, reducing competition for resources in the North. Stronger IPR protection can then encourage FDI and lead to increased innovation. However, if it is easier to imitate TNC products produced in the South than products produced in the North, then production may be shifted back to the North, leaving fewer resources available for innovation in the South.

Licensing channel

If technology is transferred through licensing, stronger IPR protection in the South results in greater innovation in the North, and increased licensing to the South. Licensing has the advantage to northern firms of higher profits due to lower production costs in the South, but involves other costs in terms of contract negotiations, transferring the necessary technology and in the rents that the innovator must give to the licensee to discourage imitation. By reducing the risk of imitation, stronger IPR protection in the South also reduces the costs of licensing, thus encouraging licensing and freeing up resources in the North for innovation.

In sum, much depends upon the channels of transmission available and the ability of the South to take advantage of the technology to which it is exposed. While IPR protection would be expected to enhance growth in countries that move toward free trade and have a comparative advantage in innovative technology-intensive activities, its impact on countries lacking such advantages is less clear. An overview of the literature that directly tests whether stronger IPR protection is likely to result in higher growth is presented in table 2. These studies tend to measure the strength of IPR protection using indices based on the perceived strength of a country's patent law.

The literature reviewed in table 2 provides evidence that strengthening an IPR regime can enhance growth, depending on country characteristics. IPR protection seems to lead to higher growth in more open economies, other things equal. It also seems to lead to higher growth in the developed and least developed countries (LDCs), but has no significant effect on growth in middle-income countries. The developed countries benefit the most in terms of growth from stronger IPR protection, because stronger IPR protection encourages domestic innovation and technology transfer. Findings also imply that the LDCs, with little capacity to imitate and innovate, benefit from growth from a stronger IPR regime, but the available evidence is not clear on the exact channels through which the LDCs may benefit: a stronger IPR regime is found to have little positive impact on many technology diffusion channels, including trade, FDI and licensing.

The middle-income countries are likely to have some capacity to imitate, and for them stronger IPR protection can have two offsetting effects, encouraging technology transfer through increased imports and FDI, on the one hand, but reducing technology transfer by limiting the extent of imitation on the other.

Intellectual property rights and innovation

The main benefit claimed for strong IPR protection is that by allowing innovators to appropriate a share of the benefits of their creative activities, R&D is encouraged, which leads to innovation and higher long-run growth. The cross-country evidence reviewed in this paper linking IPRs to domestic innovation (section 3 of the paper), technology diffusion (section 4) and growth (section 2) is summarized in table 4.

The impact of IPR protection on domestic innovation is likely to vary with a country's level of development and its factor endowments. More generally, we may expect IPRs to impact on domestic innovation differently in countries with significant innovative capacity as opposed to those with few resources available for domestic innovation. The evidence summarized suggests that stronger IPR protection can encourage domestic innovation in countries that have significant domestic capacity for innovation, but that it has little impact on innovation in countries with a small innovative capacity.

Intellectual property rights and international technology diffusion

International technology transfer or diffusion refers to the process by which a firm in one country gains access to and employs technology developed in another country. Some transfers occur between willing partners in voluntary transactions, but many take place through non-market transactions or spillovers.

The impact of stronger IPR protection on technology diffusion is ambiguous in theory and depends on a country's circumstances. On the one hand, stronger IPR protection could restrict the diffusion of technology, with patents preventing others from using proprietary knowledge and the increased market power of IPR holders potentially reducing the dissemination of knowledge due to lower output and higher prices. On the other hand, IPRs could play a positive role in knowledge diffusion, since the information available in patent claims is available to other potential inventors. Moreover, strong IPR protection may encourage technology transfer through increased trade in goods and services, FDI, technology licensing and joint ventures. Despite this theoretical ambiguity, the diffusion of technology from countries at the technological frontier to other countries is considered the main potential benefit of the TRIPS Agreement, particularly for developing countries that tend not to innovate significantly. The findings of several studies relating IPRs to technology diffusion through international trade, FDI, licensing and patenting are summarized in table 6 (annex IV). The evidence suggests that stronger IPR protection can encourage technology transfer through a number of channels, though once again its impact has been found to depend upon other factors related to a country's imitative ability and level of development.

Country specific evidence

Based on the experience of the Republic of Korea, it is argued that strong IPR protection will hinder rather than facilitate technology transfer and indigenous learning activities in the early stages of industrialization, when learning takes place through reverse engineering and duplicative imitation of mature foreign products. It is only after countries have accumulated sufficient indigenous capabilities and an extensive science and technology infrastructure capable of undertaking creative imitation that IPR protection becomes an important element in technology transfer and industrial activities. Similarly, the development experience of India indicates the importance of weak IPR protection in building up local capabilities, even when countries are at very low levels of development.

Research findings indicate that the static effects of stronger IPR protection on prices, employment and output are likely to be negative for most industries in the Lebanon. It is suggested however that dynamic gains from stronger IPR protection are possible, through increased FDI, increased product development by local firms (particularly in cosmetics, food products, software applications, publishing and film production), and the increased ability to enter into joint ventures or product licensing. Further, to the extent that these lead to additional technology transfer and local product development, the average quality of local products may rise.

Survey evidence from China reveals that managers of foreign enterprises are reluctant to locate R&D facilities in China for fear of misappropriation and patent infringement. Enforcement problems and weak penalties were also a concern. These factors led firms that transferred technology to China not to use the latest technology, but technologies that were at least five years behind the frontier. Chinese firms were also found to suffer from trademark infringement, which in the long run is likely to be particularly damaging to enterprise development.

Summary of empirical results

Following the literature reviewed by this paper, it seems clear that the implications of stronger IPRs depend, inter alia, on a country's level of development (measured by per capita gross domestic product (GDP) or human capital). For most high-income countries, strengthening IPRs raises growth at least partly, due to increased innovation and technology diffusion. The IPR regimes in these countries already meet or exceed the TRIPS standards, leaving them free to strengthen further their IPR regime if they wish.

For middle-income countries, the evidence suggests that strengthening IPRs has little effect on growth. On one hand, a stronger IPR regime encourages both domestic innovation and technology diffusion through foreign patenting and international trade and both domestic innovation and technology diffusion can impact positively upon growth. On the other hand, the beneficial impact of stronger IPR protection on domestic innovation and technology diffusion is to a certain extent offsetting the growth-enhancing benefits otherwise obtained from imitation and now precluded by the stronger IPR regime. The IPR regimes in these countries will need to be strengthened in order to meet the TRIPS standards. The policy focus of these countries should be to encourage domestic firms to shift from imitation to innovation and to facilitate other activities with growth-enhancing technology spillovers.

For low-income countries, evidence suggests that strengthening IPRs encourages growth, but the exact channels through which this occurs are not yet identified. In these countries, stronger IPRs appear to have no effect on innovation and the evidence reviewed suggests that the impact on international trade is negative.

In the lowest income countries, while stronger IPR protection is found to encourage foreign patenting it had no significant effect on growth. These are countries whose IPR regimes will need to be strengthened to meet the TRIPS standards. It may be that most will not have significant imitative or innovative capability in the near future. Those which do must be concerned that TRIPS will inhibit their firms from passing through the imitative stage that seems to be the precursor to gaining innovative capability in relatively high-tech industries. The TRIPS obligations may make WTO membership less attractive for those countries with imitative aspirations.

International trade

A country's openness to international trade seems also to affect the relationship between IPRs and growth. The evidence suggests that stronger IPRs have a significant and positive impact on growth in more open economies. The exact mechanism through which this occurs has yet to be revealed, but it appears to involve the substitution of domestic innovation for technology produced abroad, since stronger IPRs seem to lead to less domestic patenting and more foreign patenting. And it is not just that economies that are more open receive more foreign patents but that the growth-enhancing effects of foreign patenting also appear to be stronger in economies that are more open.

In addition, IPRs are also found to influence trade. Evidence suggests that stronger IPR protection leads to larger trade flows, albeit mainly for countries with imitative capability and not necessarily in products of industries considered high-tech or patent sensitive.

Licensing and FDI

Since most innovation occurs in a few advanced countries, FDI and technology licensing are often perceived as the major formal channels for international technology transfer. But while there is some evidence that stronger IPRs encourage licensing, the evidence on whether stronger IPRs encourage FDI is largely inconclusive. Most host countries anticipate that FDI or licensing will yield further benefits from technology spillovers to domestic firms. By their nature, such spillovers are difficult to measure, so perhaps it is not surprising that there is little conclusive evidence of growth-enhancing spillovers through inward FDI, at the economy-wide, industry or firm level.

Foreign patenting

Considering technology diffusion through foreign patenting, the evidence indicates that a country's market size may be important in determining whether increased foreign patenting encourages or inhibits growth. Results for developing countries reported in the paper suggest that foreign patenting has a positive impact on growth in countries with relatively high levels of IPR protection, for relatively open economies, and for countries with relatively large markets. These findings combined with the findings that stronger IPR protection encourages foreign patenting in developing countries are consistent with broad conclusions in the literature that stronger IPR protection encourages technology diffusion. Benefits of technology diffusion are greater in more open economies, countries that are more developed, and in countries with larger markets and where foreign firms have less market power.

Policy responses

From the summary of empirical evidence it follows that the policy implications should fall along the lines of a country's level of development and its level of imitative or innovative capacity. In low-income countries, the policy priority should be to improve the investment environment, with liberal trade policies to encourage imports of technology embodied in goods. Such countries should not be required to apply and enforce strong IPR obligations; particularly where this would increase the cost of importing IPR protected goods. Developed countries can also play a role here through the promotion of differential pricing schemes to lower the consumption cost of technology-intensive imports to low-income countries. For other developing countries, with relatively high levels of innovative potential, the stronger IPR protection required by TRIPS can encourage domestic firms to switch from imitation to innovative activities. By encouraging technology diffusion through international trade and foreign patenting, stronger IPR protection will also help offset any adverse growth effects from lost imitative opportunities.

In sum, policies related to the implementation of the TRIPS standards should be country-specific. Ranges of policies that can assist countries in enhancing the benefits from TRIPS have been discussed in the literature. These include:

Intellectual property rights related policies

Policies related to patent fees, the scope of patentability and the novelty requirements in patents can all contribute to the development of a domestic innovative sector and to the international diffusion of knowledge. The fees for patent applications and for the renewal of patents and trademarks can be configured in such a way that both innovation and diffusion will be promoted. Developing countries can also limit the scope of patents and encourage rapid publication of patent applications, allowing domestic firms to invent around the patent.

Countries could also set high standards for the novelty requirements of patents in order to prevent routine discoveries from being patented. This could be combined with a system of utility models to encourage local firms to invent around patents and to improve their manufacturing methods.

Competition policies

By creating market power for patent holders, stronger IPR protection can lead to lower sales at higher prices, which in turn can limit the extent of technology diffusion. A number of policies consistent with TRIPS can offset these effects, including price controls through reference prices or administrative ceilings, allowing parallel imports, and compulsory licences, entitling a domestic licensee to exploit the patent for a fixed period during the patent life.

Complementary policies

There are other policy options available that may enhance the impact of IPR protection on innovation. Tax policies and regulatory regimes can be structured so as not to discourage innovation. Investment in education, particularly in science and technology, may also encourage domestic innovation. Evidence suggests that the development of a local innovative sector through these means can also enhance the benefits from international technology diffusion.

Technology diffusion

For most developing countries advanced technologies will be imported. International technology transfer occurs through imports, FDI, licensing and patent applications by non-residents. Policies aimed at improving infrastructure for communication and transport and maintaining macroeconomic stability along with open trade and investment policies can encourage such flows, allowing countries improved access to foreign technology.

The role of multilateral organizations

Multilateral organizations can assist developing countries in meeting the terms of the TRIPS Agreement by promoting capacity building in IPRs, to obtain the maximum net benefit from TRIPS. Capacity building in IPRs should focus less on the specification of protective laws and regulations and more on the technical, judicial and legal expertise underlying effective technology transfer.

Multilateral organizations can play a significant role in facilitating research on the economic effects of IPR protection and in encouraging the dissemination of its findings to all interested parties. More generally, multilateral organizations have a role to play in fulfilling information needs by encouraging collaboration and information sharing among governments and by serving as a distributor of knowledge about successful technology acquisition programmes that have been undertaken in the past. Technical standards play an important role in diffusing production and certification technologies, and learning technical standards is often tantamount to learning technology. Here multilateral organizations could create a pool of experts to aid standard setting bodies in developing countries.

Given the importance of the presence of innovative capacity for successful international technology diffusion, multilateral organizations could play a role in encouraging the development of a research culture in developing countries. This could include the development of training programmes in how technology is transferred, as well as the financing of education programmes more generally, particularly those that can aid the diffusion of technology. Donor countries and multilateral organizations could consider establishing specific trust funds to finance the training of scientific and technical personnel to facilitate the transfer of technologies and to encourage R&D in developing countries.

Multilateral organizations, the WTO and UNIDO in particular, could increase the scope of monitoring developed country efforts in the transfer of technology and could add an evaluative mechanism for the effectiveness and extent of technology transferred. Finally, some researchers have asserted that the most powerful indirect incentive for technology transfer would be for developed countries to grant significant market access for products in which poor countries have a comparative advantage. They argue that a link exists between technology transfer and market access due to the role that market size and growth play in attracting trade and FDI, and the associated incentives to invest in new technologies if export markets were more assured. Multilateral organizations, particularly the WTO, have an obvious role to play here.

1. Introduction

The argument underlying public policy intervention to protect IPRs is that, without such protection, competitive market systems fail to provide private agents with sufficient incentives to undertake the costly and risky investments that generate the new ideas and technologies (knowledge) now widely recognized as the main source of sustained economic growth. This is because knowledge has "public good" attributes. Knowledge is typically non-excludable, in that it is not possible to prevent others from applying new knowledge even without the authorization of its creator. If a new technology is valuable, it is therefore likely to be copied or imitated, reducing the potential profits of the original inventor and potentially removing the incentive to engage in innovative activities. Where "imitation" has lower costs than "innovation", imitators have the advantage over innovators unless the latter can restrict access to their innovation. This characteristic provides the argument for strong IPR protection. IPRs create ownership of intellectual property by giving innovators the legally enforceable power to prevent others from using an intellectual creation or to set the terms on which it can be used. That is, IPRs encourage innovation by granting successful inventors temporary monopoly power over their innovations. The consequent monopoly profits provide the return on successful investment in R&D.

The other public good aspect of knowledge compounds the costs of granting this monopoly power. Knowledge tends to be non-rival, in that the marginal cost for an additional firm or individual to use the knowledge is often negligible. Once an innovation has been created, its non-rival character suggests that benefits will be maximized if its use is free to all at marginal cost. Although a policy of free access will yield benefits in the short run, it will severely damage the incentive for further innovation. IPRs allow successful innovators to appropriate some of the consumer surplus their innovation generates, both as a reward for their innovative efforts and to provide an incentive to future investors. Because research is a risky activity, returns on successful R&D (which produces intellectual property) must be large enough to compensate for the high proportion of R&D that is unsuccessful, generating in this way a normal return on R&D as a whole.[2]

[2]Evidence suggests that IPR protection stimulates innovation and that the social rate of return to innovation appears to be considerably higher than the rate of return to the innovator (Mansfield et al., 1977).

Choice of IPR policy then reflects a balancing of these considerations. The awarding of a temporary monopoly, although second-best, is intended to restore the incentive to innovate, which in turn should encourage long-run growth and improved product quality. It is not an all or nothing decision, however. Even in the absence of IPR protection there may exist natural incentives to innovate depending upon market lead times, marketing strategies and the difficulties in copying and imitating (Maskus, 2000a), and these features are likely to be more important than IPR protection under certain circumstances. Excessive IPR protection is likely to lead to an inadequate dissemination of new knowledge, which in itself could slow growth to the extent that access to existing technology is necessary to induce further innovation.[3] Other costs to society of strong IPR protection include rent seeking behaviour, the wasteful duplication of investment in R&D (i.e. patent races) and the costs of judicial actions to enforce property rights (Maskus, 2000a). Giving innovators too much protection may also limit the spread of new ideas and lead to permanent monopoly. Entry by rivals may be impeded, and successful innovators may have reduced incentives for developing and exploiting subsequent innovations.[4]

If IPRs were set and enforced by a global authority then, in principle, this authority would be in a position to determine the appropriate strength of IPR protection for the world as a whole. But IPRs are conferred by national governments and valid only within the relevant jurisdiction. Consequently, national IPR systems have largely focussed on what was perceived to be in the best interests of the country concerned, and different countries perceived the trade-off between profits and innovation differently. Thus (developed) countries, with many potential innovators, have tended to opt for relatively strong IPR systems, with the aim of encouraging inventive and creative activities, which are seen as an important source of long-run economic growth.[5] With R&D spending concentrated in a handful of the world's richest countries however, genuinely innovative activities are limited in most developed and developing countries, and the majority have taken a different approach, providing only weak IPR protection, if any, as a way of allowing the rapid diffusion of knowledge. For many of these countries imitation can be a significant source of technological development, and providing stronger IPR protection is seen as shifting profits from domestic imitative firms to foreign firms and reducing output in the domestic economy, rather than encouraging domestic innovative activity (Deardoff, 1992). The counter-argument is that stronger IPR protection can help reward creativity and risk-taking even in developing economies, with those countries that retain weak IPR protection remaining dependent on dynamically inefficient firms that rely on counterfeiting and imitation (Maskus, 2000a).

With the globalization of markets and the resulting increases in trade and investment flows across borders, particularly flows of technology and technology-intensive products,[6]

[3]Hence the argument, discussed below, that in many countries weak IPR protection actually stimulated R&D activity by encouraging knowledge spillovers from transnational companies (TNCs) and other domestic firms (Cohen and Levinthal, 1989).

[4]Gilbert and Newey (1982) show that under certain conditions a monopolist may accumulate patents and allow them to "sleep", thus deterring entry into an industry.

[5]Indeed there has been a general strengthening and broadening of IPRs over time in developed countries (Mazzoleni and Nelson, 1998).

[6]The share of knowledge-intensive or high-tech products in total world goods trade doubled between 1980 and 1994 (Fink and Primo Braga, 2005).

this difference in national IPR standards has taken on additional significance. Firms have looked increasingly to foreign markets to sell their goods and to foreign destinations as platforms for production, making it easier for intellectual property to be accessed and copied in countries that provide weak IPR protection. This is one of the major reasons why firms investing heavily in R&D put pressure on national governments to strengthen the international IPR regime. The outcome was the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), a product of the Uruguay Round (1986-1994) of trade negotiations. The TRIPS Agreement is the first comprehensive and global set of rules covering IPR protection.[7] It sets minimum standards of protection to be provided by each World Trade Organization (WTO) member in each of the main areas of intellectual property covered, as well as requiring countries to develop mechanisms to enforce these rights. The TRIPS Agreement does allow countries to pursue different policies with respect to IPR protection, but does specify minimum standards that should be attained by a designated time. Box 1 highlights some of the major requirements of TRIPS. The areas covered are copyrights and related rights, trademarks, geographical indications, industrial designs, patents, the layout designs of integrated circuits and undisclosed information including trade secrets and test data. Table 1 provides more information on these forms of intellectual property and how they are covered by international agreements.

From the preceding discussion it might be difficult to see why developing countries agreed to TRIPS. One factor was pressure from advanced countries (the United States and the European Union (EU) in particular). Developing country governments also thought that agreeing to TRIPS would encourage negotiations allowing developing countries wider access to agricultural and textile markets in developed countries. In addition business interests within many developing countries encouraged their governments to adopt stronger IPR protection in order to protect their own innovative activities tailored to the domestic market (Sherwood, 1997; Maskus, 1998a). Stronger IPR protection can also encourage increased imports, inward foreign direct investment (FDI) and technology licensing, all of which can lead to increased technology transfer.[8] Indeed Article 7 of the Agreement states that "[T]he protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge in a manner conducive to social and economic welfare, and to a balance of rights and obligations". The various areas of IPR protection covered by TRIPS are likely themselves to have differing impacts on innovation and technology diffusion, and some of these differences are discussed in box 2.

Following the TRIPS Agreement, a body of research has developed focussing on the potential impact of TRIPS, and of IPRs more generally, on various aspects of economic activity. Here we review the existing literature linking IPR protection to both economic

[7]There have been international agreements on IPRs since the nineteenth century. Until recently the main instruments of international law regarding the substantive protection of IPRs were the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886). The TRIPS Agreement has been analyzed extensively by Primo Braga (1996), UNCTAD (1996) and Maskus (1997).

[8]It is now widely accepted, for example, that the assimilation of foreign technology was a critical component of the Asian Miracle (see, for example, Nelson and Pack, 1999).

Box 1. Substantive requirements of TRIPS in the WTO

General obligations	Comments
1. National treatment	Applied for persons
2. Most favoured nation	Reciprocity exemptions for copyright; prior regionals/bilaterals allowed
3. Transparency	
Copyright and related rights	
4. Observes Berne Convention	Does not require moral rights
5. Minimum 50-year term	Clarifies corporate copyrights
6. Programmes protected as literary works	A significant change in global norms
7. Data compilations protected similarly	
8. Neighbouring rights protection for phonogram producers, performers	
9. Rental rights	A significant change in global norms
Trademarks and related marks	
10. Confirms and clarifies Paris Convention	
11. Strengthens protection of well known marks	Deters use of confusing marks and speculative registration
12. Clarifies non-use	Deters use of collateral restrictions to invalidate marks
13. Prohibits compulsory licensing	
14. Geographical indications	Additional protection for wines and spirits
Patents	
15. Subject matter coverage	Patents provided for products and processes in all fields of technology
16. Biotechnology	Must be covered but exceptions allowed for plants and animals developed by traditional methods
17. Plant breeder's rights	Patents or effective sui generis system required
18. Exclusive rights of importation	
19. Severe restrictions on compulsory licensing	Domestic protection can no longer be required; non-exclusive licences with adequate compensation
20. Minimum 20-year patent length from filing date	
21. Reversal of burden of proof in process patents	
22. Industrial designs	Minimum term of protection: 10 years
Integrated circuits designs	
23. Protection extended to articles incorporating infringed design	A significant change in global norms
24. Minimum 10 year protection	

Undisclosed information	
25. Trade secrets protected against unfair methods of disclosure	New in many developing countries
Abuse of IPRs	
26. Wide latitude for competition policy to control competitive abuses	Cannot contradict remainder of WTO agreement
Enforcement measures	
27. Requires civil, criminal measures and border enforcement	Will be costly for developing countries
Transitional arrangements	
28. Transition periods	Five years for developing and transition economies; 11 years for poorest countries
29. Pipeline protection for pharmaceuticals	Not required but a provision for maintaining novelty and exclusive marketing rights
Institutional arrangements	
30. TRIPS Council	Agreement to be monitored and reviewed
31. Dispute settlement	Standard approach with five-year moratorium in some cases

Source: Maskus (2000a)

growth and international technology diffusion.[9] The paper is structured as follows. In section 2 we discuss the existing literature on IPR protection and growth. Section 3 considers the importance of IPR protection in encouraging domestic innovation, while section 4 considers its importance for the international diffusion of technology. Here a number of specific channels for diffusion are emphasized, including trade, FDI, licensing and patenting. Section 5 considers some country studies of the role of IPR protection in development. The inferences one can draw from this empirical literature are summarized in section 6. Section 7 then offers some policy conclusions. Section 8 provides some overall conclusions.

[9]The details of this literature are discussed under the appropriate subheadings below, but it is worth noting here that Maskus (2000a) and Fink and Maskus (2005) provide book-length treatments on the impact of IPR protection on economic performance, and that the website www.iprsonline.org provides links to a large number of research papers, including papers covering such important topics as patenting in biotechnology and the access and pricing of drugs in developing countries. Space restrictions preclude discussions of some of the more controversial aspects of IPR protection. Finger and Schuler (2005) consider how IPR protection can protect knowledge that exists or might be created in developing countries.

Table 1. Instruments and agreements for protecting IPRs

Type of intellectual property	*Instruments of protection*	*Protected subject matter*	*Primary fields of application*	*International agreements*
Industrial property	Patents and utility models	New, non-obvious inventions with industrial utility	Manufacturing, agriculture	Paris Convention Patent Cooperation Treaty Budapest Treaty Strasbourg Agreement TRIPS
	Industrial designs	Ornamental designs of products	Manufacturing, clothing, automobiles, electronics, etc.	Hague Agreement Locarno Agreement
	Trademarks	Identifying signs and symbols	All industries	TRIPS Madrid Agreement Nice Agreement Vienna Agreement
	Geographical indications	Identifying place names	Wines, spirits	Lisbon Agreement
Artistic and literary property	Copyrights and neighbouring rights	Original expressions of authorship	Publishing, electronic entertainment, software, broadcasting	TRIPS Berne Convention Rome Convention Geneva Convention Brussels Convention WIPR Copyright Treaty WIPO Performance and Phonograms Treaty Universal Copyright Convention
Sui generis protection	Integrated circuits	Original designs	Computer chip industry	TRIPS
	Database protection	Databases	Information processing	Washington Treaty
	Plant breeders' rights	New, stable, distinct varieties	Agriculture, food	TRIPS
Trade secrets	Laws against unfair competition	Business information held in secret	All industries	EC Directive 96/9/EC UNOV TRIPS TRIPS

Source: Primo Braga, Fink and Sepulveda (2000)

Box 2. Aspects of TRIPS and their impact on innovation and technology diffusion

Included in the TRIPS Agreement are the following aspects of intellectual property protection:

- Patents—give their owners the right to exclude all others from making, selling, importing, or using the product or process named in the patent without authorization for a fixed period of time. Three forms of patents may be applied for; *(a)* invention patents require significant non-obviousness and as such a discrete advance in technology; *(b)* utility models tend to be awarded for incremental improvements of existing products and technologies; *(c)* industrial designs protect the aesthetic or ornamental aspects of a commercial article.
- Copyrights—protect the rights of creators of literary and artistic works to communicate, display, or perform those works in some medium, plus the rights to make and sell copies.
- Trademarks and service marks—protect the rights to use a particular distinctive mark or name to identify a product, service or company.
- Geographical indications—are related to trademarks and certify that a consumer product was made in a particular place and that it embodies the physical characteristics of that location.
- Trade secrets—are proprietary information about production processes, including items such as customer lists and organizational methods. Standard liability laws guard against unauthorized disclosure through commercially unfair means.
- Layout designs of integrated circuits—covers the layout design of integrated circuits, the chips on which they are masked, and products that incorporate the chip. TRIPS specifically permits reverse engineering of integrated circuits.

The importance of these different aspects of IPR protection for innovation and technology diffusion are likely to vary. Here we discuss some of these differences.

Patents are expected to increase both innovation and technology diffusion. By providing an incentive to undertake R&D and the associated costs of inventing a new technology or product, patents should encourage innovation. The empirical evidence linking patent rights to innovation is mixed however (see section 3). Through the publication of claims, patents add to the stock of public knowledge and can encourage technology diffusion. The evidence in favour of such diffusion is stronger (see section 4).

Literary and artistic ideas protected by copyrights are without industrial applicability. While not encouraging industrial innovation, copyright protection is aimed at encouraging creative works that provide social, cultural and economic benefits to society. On the other hand, copyright protection limits the dissemination of literary works and raises the static costs of education, research and education.

Trademarks and geographical indications do not protect the creation of additional knowledge, nor in theory do they restrict imitation or copying of protected goods as long as they are sold under a different mark. Like copyrights therefore they are unlikely to directly raise innovation or encourage technology transfer. Similar arguments can be made for the protection of integrated circuit designs, though TRIPS specifically allows for the reverse engineering of such designs. Trademarks are however likely to lower research costs, protect consumers from fraud regarding the origin of a product and safeguard commercial reputations for quality. Since trademarks and geographical indications are used as a signal of quality, they may also encourage firms to maintain or improve quality over time, as well as generating further product differentiation. There is also some anecdotal evidence that under the right circumstances trademarks can contribute to business development among low- and middle-income producers in the developing world (see for example Maskus et al., 2000c; Maskus, 2005).

Trade secrets are rationalized as a mechanism to foster innovations that do not comply with the strict requirements for the patentability of products and processes. Firms may choose not to patent an innovation for a number of reasons; *(a)* the innovator may judge their creation to be unpatentable in legal terms, but hard to imitate; *(b)* a firm may prefer not to disclose its processes, as required by patents, because disclosure could reduce expected profits; *(c)* firms may wish to avoid the costs of patenting. Trade secrets do not incur costs in the form of application and grant procedures, yet they also do not add to the base of knowledge available to the public. As such, trade secrets would not be expected to raise the diffusion of technology significantly, though the potential exists for trade secrets to be reverse-engineered. Trade secrets may however encourage innovation, especially of the small, incremental type.

Source: Based on Maskus (2000a, pp. 20-23 and 36-50).

2. Intellectual property rights and economic growth

In the modern literature on economic growth, technological progress is viewed as the prime determinant of long-run growth. This technological progress arises from the activities of economic agents carried out in order to profit from the introduction of new products (Romer, 1990; Grossman and Helpman, 1991, Ch. 3) or the improvement of existing ones (Grossman and Helpman, 1991, Ch. 4; Aghion and Howitt, 1992). Agents invest in R&D in the expectation of profiting from the resulting inventions. But besides creating new products, innovative activity adds to society's stock of knowledge, upon which subsequent innovations are based. This process is assisted where the information that IPRs protect is made available to other potential inventors as in patent claims.[10] The global rate of growth then depends upon the rate of innovation and the stock of knowledge, and IPR protection can increase growth by encouraging both.

When it comes to exploring these issues in a multi-jurisdiction context, the most relevant analyses are those that examine a world composed of two types of countries: a developed, innovating "North" and a developing, imitating "South". The main concerns have been whether increased IPR protection in the South would increase *(a)* the rate of (global) growth, *(b)* the rate of technology transfer from the North to the South, and, *(c)* welfare levels in both locations. A straightforward partial equilibrium analysis reveals that while the North always benefits from stronger IPR protection in the South, the South itself is found to benefit only when R&D is highly productive, such that the R&D induced by stronger IPR protection in the South results in significant cost reductions, and when the South comprises a large share of the overall market for the good (Chin and Grossman, 1990). In these circumstances the additional monopoly profits available in the South provide a significant additional incentive for northern investment in R&D, and the welfare of the South increases due to the increased benefits in consumption resulting from northern R&D. But as Deardoff (1992) shows, the benefits of increased innovation through stronger IPR protection become weaker as more and more countries strengthen their IPR regimes, since the extra market covered and the extra innovation that can be stimulated by such protection diminishes. Since IPR holders engage in monopoly pricing that distorts consumer choice,

[10] Mansfield (1985) provides evidence suggesting that the learning process from patent claims is relatively rapid, taking 10-12 months in the United States. These benefits should not be overstated however since patents do not necessarily disclose sufficient information for the invention to be manufactured and many developing countries lack the capacity to adopt and adapt new techniques.

strengthening IPR protection can lead to welfare reductions, particularly in a country that undertakes little or no R&D and would otherwise be able to free ride on foreign innovations.[11] Countering this is the notion that the North and the South may have different requirements and priorities when it comes to technology (Diwan and Rodrik, 1991). The South may then have an incentive to provide IPR protection in order to facilitate the invention of the particular technologies that meet its needs, which might otherwise be neglected.

More recent work has considered dynamic general equilibrium models of innovation and growth. Several aspects are then shown as potentially important. One is the competition for scarce resources between R&D (investments in innovation) and the production of the new and improved goods that arise from the innovation. The channels through which technology can be transferred from one country to another then become significant. In the simplest case, where only goods are traded, successful southern imitation results in the competitive advantage for the production of imitated products shifting to the South. Stronger IPR protection in the South then decreases southern imitation and increases northern innovation in the short run, as innovation becomes more profitable. But, as Helpman (1993) notes, in the long run innovation in the North may fall, because if new products are produced for a longer time span in the North, fewer resources are available for innovation there. Stronger IPR protection in the South may then reduce global growth. But weak IPR protection in the South may have effects besides reducing the incentive for innovation in the North. Northern exporters may be able to mask their production technologies, thereby limiting the extent to which it can be imitated through traded goods (Taylor, 1993). The potential gains from technology transfer through weak IPR protection in the South might then be offset by increases in northern masking.

Where FDI is an option, the resource competition effect noted by Helpman is moderated (Lai, 1998). The innovator can now shift production of new goods to the South, reducing the competition for resources in the North. Stronger IPR protection in the South may further increase the speed of foreign investment and the return to innovation. This analysis becomes more complicated, however, if one assumes, as seems reasonable, that southern firms can more easily imitate the products of transnational corporations (TNCs) when they are produced in the South than products produced in the North. Stronger IPR protection in the South then makes imitation more costly, and southern firms find themselves devoting greater resources to imitation, but with a lower rate of success. The additional resources drawn into imitation in the South leave less available for production, causing FDI to contract. In response production is shifted back towards the North leaving fewer resources in the North available for innovation, which lowers the rate of innovation overall (Glass and Saggi, 2002).

---

[11]Results such as these have led many commentators to argue that the main impact of TRIPS will be to shift wealth from developing countries to firms in developed countries. Rodrik (1994) for example states that "irrespective of assumptions made with respect to market structure and dynamic response, the impact effect of enhanced IPR in LDCs will be a transfer of wealth from LDC consumers and firms to foreign mostly industrial-country firms" (p. 449).

Extending the options further, the impact of stronger IPR protection in the South on incentives for firms in the North to innovate and to license advanced technologies to firms in the South has also been examined (Yang and Maskus, 2001a). Licensing has the advantage of higher profits due to lower production costs in the South, but involves other costs in terms of contract negotiations, transferring the necessary technology and in the rents that the innovator must give to the licensee to discourage imitation. By reducing the risk of imitation, stronger IPR protection in the South reduces the costs of licensing (and its policing), thus encouraging licensing to the South and freeing up resources for innovation in the North.

Perhaps the most important conclusion that follows from this brief review of the relevant theoretical literature is that the implications of stronger IPR protection in the South on either the incentives for innovation in the North or the rate of technology transfer from the North to the South are not clear cut. Much depends on the channels of transmission available and the ability of the South to take advantage of the technology to which it is exposed. For individual countries the impact of IPR protection on growth is likely to depend upon country characteristics, most notably factor endowments. This leads to a further consideration. Many models of endogenous growth have one dynamic sector that exhibits learning-by-doing externalities or spillover effects and another traditional sector that does not. Then, depending on whether opening up to trade shifts resources toward or away from the dynamic sector, a country's rate of economic growth may increase or decrease with globalization. The reallocation of resources will depend upon a country's initial factor endowments, amongst other things. While IPR protection would be expected to enhance growth in countries that move toward free trade and have a comparative advantage in the dynamic sector, its impact on countries with a disadvantage in this sector is less clear.

There is a small literature that directly tests whether stronger IPR protection is likely to result in higher growth. The results from this literature are summarized in table 2. This literature is not generally concerned with testing for the specific channels through which technology is being transferred among countries, or for the mechanisms through which growth might be enhanced, but simply whether, where and when a positive effect is discernable. The approach adopted is to include a measure of the strength of IPR protection in a standard cross-country empirical growth framework. Two indices of IPR protection are commonly used in the literature, and both are based on the perceived strength of a country's patent law. The index of Rapp and Rozek (1990) [RRI] is based on the adherence of each country's patent laws in 1984 to the minimum standards proposed by the United States Chamber of Commerce (1987). These standards include guidelines for patent examination procedures, term of protection, compulsory licensing, coverage of inventions, transferability of patent rights and effective enforcement against infringement. The index is on a six-point scale with higher numbers indicating stronger IPR protection. The index of Ginarte and Park (1997)[12] [GPI] is also on a six-point scale and is constructed using similar criteria to the RRI. Their scoring method differs however, with five categories of the national patent law considered: the extent of coverage,

[12]Annex I provides more information on the construction of the Ginarte and Park index.

membership of international patent agreements, provisions for loss of protection, enforcement mechanisms and duration of protection. While the two indices are highly correlated (Rafiquzzaman, 2002), for empirical purposes the GPI has the advantage over the RRI in that it is constructed quinquennially from 1960 to 1990.[13]

Table 2. Summary of research on IPRs and growth

Study	*Sample and method*	*Dependent variable(s)*	*IPR index*	*Results*
Gould and Gruben (1996)	95 countries; cross section with data averaged over the period 1960-1988	Growth of real GDP per capita	Rapp and Rozek Index	IPR protection has a positive impact on growth, which is slightly stronger in more open economies
Thompson and Rushing (1996)	112 countries; cross section with data averaged over the period 1970-1985	Growth of real GDP per capita	Rapp and Rozek index	IPR protection has a positive impact on growth only in countries that have reached a certain initial level of GDP per capita
Thompson and Rushing (1999)	55 countries; seemingly unrelated regression techniques on a cross-section of data over the period 1971-1990	Growth of real GDP per capita; ratio of total factor productivity (TFP)[a] in 1971 to that in 1990; the Rapp and Rozek Index of IPRs	Rapp and Rozek index	IPR protection has a positive impact on TFP in relatively rich countries, which in turn impacts positively upon output growth
Park (1999)	60 countries; seemingly unrelated regression techniques on a cross-section of data over the period 1960-1990	Growth of real GDP, fraction of GDP invested in physical capital, fraction of GDP invested in human capital, fraction of GDP invested in R&D	Ginarte and Park index	IPR protection has no direct impact on growth. IPR protection has an indirect positive impact on growth through physical capital investment and R&D in the most advanced countries

[a]Total Factor Productivity (TFP) is a derived measure of technology change.

While issues remain over the direction of causality[14] the results of the various studies lead to fairly consistent conclusions. Gould and Gruben (1996) employ the RRI to examine the importance of stronger IPR protection for growth in a sample of up to 95 countries with data averaged over the period 1960-1988. They also examine whether the impact of IPR protection on growth depends upon the degree of openness to trade, the underlying argument being that in closed economies stronger IPR protection may not have the desired effect of encouraging innovation and higher growth, as firms may not have the incentive to innovate if their market is guaranteed.[15] The model of Rivera-Batiz and Romer (1991) provides a theoretical rationale for this hypothesis, with firms in closed economies finding it more profitable to copy foreign technology than develop new technology.

[13]Both of these indices are based primarily on the statutes themselves, but not on their enforcement or implementation. Consequently these indices will overestimate the level of protection in a country where strong anti-infringement laws exist, but are not enforced as may be the case in many developing countries that inherited IPR laws from their colonial powers, but do not have the administrative capacity or inclination to enforce them (Gould and Gruben, 1996).

[14]The level of IPR protection is highly correlated with a country's level of economic development. Ginarte and Park (1997) examine the determinants of their index and find that higher levels of GDP per capita, shares of R&D in GDP, openness and levels of human capital are positively related to the strength of IPR protection.

[15]Their hypothesis is based on firm-level evidence from Brazil by Braga and Willmore (1991) who found a negative relationship between the degree of trade protection and a firm's propensity to develop new technology or purchase it abroad.

Gould and Gruben regress the average growth of real GDP per capita on the RRI and a number of standard explanatory variables, including initial GDP per capita, the investment to GDP ratio, the secondary school enrolment ratio and initial levels of literacy. They find that stronger IPR protection has a positive impact on growth, which is marginally statistically significant. Gould and Gruben then go on to examine the relationship between IPR protection and growth in open versus closed economies. Openness is measured using three variables. The first two are the Black Market Premium (BMP) and distortions in real exchange rates. Countries with high BMPs and high real exchange rate distortions tend to be highly distorted and inward orientated (De Long and Summers (1991) and Dollar (1992) respectively). The third measure is a composite index of a country's trade regime developed by Gould and Ruffin (1993) comprising a number of existing trade orientation indices as well as a country's BMP, real exchange rate distortions and the ratio of import taxes to imports. Each of these are interacted with the RRI and included in the growth regression. From their results, Gould and Gruben conclude that IPR protection has a slightly larger effect on growth in more open economies. These last conclusions are tentative, however, since, as Gould and Gruben acknowledge, openness is multifaceted, which makes using a single measure problematic, particularly since the measures of openness that have been employed in the empirical literature tend not to be highly correlated (Pritchett, 1996).[16]

Thompson and Rushing (1996) conduct a similar exercise, regressing the average growth of real GDP per capita between 1970 and 1985 on the ratio of investment to GDP, the secondary school enrolment ratio, population growth, initial GDP per capita and the RRI for 112 countries. While they find a positive relationship between the RRI and growth, it is not statistically significant. They then go on to consider whether IPR protection may have an impact upon a country's growth rate, but only once a country has reached a certain (but unknown) level of development, as measured by initial GDP per capita. For this they employ threshold regression techniques finding a threshold at an initial level of GDP of $3,400 (in 1980 dollars). For countries below this value there is no significant relationship between IPR protection and growth, but above, the relationship is positive and significant.

In a later paper (Thompson and Rushing, 1999), they extend their analysis to a system of three equations. The three dependent variables are: the growth rate of real GDP per capita, the ratio of total factor productivity (TFP) in 1971 to that in 1990 and the RRI. The system is estimated using Seemingly Unrelated Regression (SUR) techniques for 55 developed and developing countries. They once again split their sample in two depending on the initial level of GDP per capita. It is found that increases in TFP have a positive and significant impact on GDP growth. The IPR index is found to have an insignificant impact on TFP for the full sample of countries, but a positive and significant impact for the richest subsample. The results suggest that in the most developed countries stronger IPR protection impacts upon growth by enhancing TFP.

[16]Rodriguez and Rodrik (2000) provide a critique of the most popular measures of openness.

Recently, Falvey, Foster and Greenaway (2004a) extend and update the single equation analysis by employing the recently developed threshold techniques of Hansen (1996, 1999 and 2000). These allow the positioning and significance of a threshold (i.e. a structural break)[17] to be identified, as well as the possibility of having more than one threshold. They use the GPI and a panel of up to 80 countries with data averaged over four five-year periods between 1975 and 1994. They follow the approach of Thompson and Rushing, arguing that the impact of IPR protection is likely to depend upon the level of development of a country as well as the structure of its economy. They use initial GDP per capita and manufacturing value added (since manufacturing tends to be the most R&D intensive sector) as alternative indicators of imitative/innovative ability. Columns 2 and 3 of table 3 reproduce a selection of their results.[18] Column 4 extends these results by considering thresholds on a commonly used measure of openness, namely the trade to GDP ratio. This allows us to examine the results of Gould and Gruben in more detail.

The two measures of imitative/innovative ability yield consistent results, indicating a three-regime, model (i.e. two structural breaks). For countries in either the low or the high regimes a positive and significant impact of IPR protection is found. But for countries in the middle regime no significant relationship between IPR protection and growth appears to exist. These results suggest that it is the least and most developed countries in the sample that benefit in terms of growth from stronger IPR protection.[19] It is argued that the most developed countries benefit because stronger IPR protection encourages innovation and technology transfer. The least developed have little capacity to innovate or imitate, and benefit because stronger IPRs encourage technology transfer through other channels.[20] Those countries in the middle of the distribution are likely to have some capacity to imitate, and there stronger IPR protection can have two offsetting effects, encouraging domestic innovation and technology transfer through increased imports and FDI, on the one hand, but reducing technology transfer by limiting the extent of imitation on the other. In no case, however, do the authors find evidence of stronger IPR protection having a negative impact on growth.

The results for thresholds based on the trade to GDP ratio (column 4) are consistent with those of Gould and Gruben (1996). There is a positive relationship between the strength of IPR protection and growth in all regimes, but only in the high regime

[17]The current paper makes extensive use of the threshold techniques of Hansen. Threshold regression models are particularly useful when we expect a relationship between two variables to be contingent upon the value of a third variable. As such they are particularly useful for the study of IPRs where available theory suggests that the relationship between IPR protection and a number of variables including growth, innovation, imitation, trade and FDI are all likely to depend upon third variables. Annex II describes the threshold regression model in more detail.

[18]Annex III describes the data used for this analysis along with the sample of countries considered and provides more information on the specification for the growth model estimated. Following Falvey, Foster and Greenaway (2004a) we include the inflation rate, as an indicator of macroeconomic stability, in the growth regressions reported in table 3 alongside other standard explanatory variables.

[19]The authors note that this is reflected in the levels of IPR protection chosen, with lower average values found for countries in the middle regime than in the low and high regimes. Maskus and Penubarti (1995) similarly show that patent protection tends to decline as countries move beyond the poorest stage into the middle-income stage in which they have greater imitative ability.

[20]The available evidence is not clear on the exact channels through which the least developed countries benefit from stronger IPRs, since there exists little evidence of a positive relationship between trade and IPR protection for the poorest countries, while FDI flows into the least developed countries tend to be relatively small.

Table 3. IPR protection and economic growth

GROWTH	*INITGDP*	*MANVAL*	*TRADEGDP*
INITGDP	-0.10 (-6.54)***	-0.11 (-6.18)***	-0.10 (-6.10)***
GDI	0.04 (6.05)***	0.05 (5.49)***	0.03 6.54)***
POPGROW	1.01 (1.42)	1.47 (1.89)*	0.93 (1.43)
SYR15	0.008 (1.47)	0.003 (0.45)	0.007 (1.21)
TRADEPGDP	0.06 (3.54)***	0.04 (2.39)**	0.05 (3.05)***
INFLATION	-0.001 (-3.74)***	-0.001 (-3.61)***	-0.001 (-5.11)***
IPR TH ≤ λ_1	0.02 (2.05)**	0.02 (2.10)**	0.005 (0.60)
IPR λ_1 ≤ TH ≤ λ_2	0.003 (0.40)	0.01 (1.59)	0.01 (1.38)
IPR TH > λ_2	0.01 (1.83)*	0.02 (2.21)**	0.02 (2.10)**
OBSERVATIONS	293	233	293
TH1 (percentile)	6.51 (25^{th})	9.83 (15^{th})	0.34 ($18t^{h}$)
TH2 (percentile)	9.29 (77^{th})	21.91 (71^{st})	0.77 (84^{th})
p-value	0.01**	0.07*	0.04**
F-Stat	7.10***	6.17***	6.57***
ADJUSTED R^2	0.66	0.65	0.63

Notes: For ease of presentation the thresholds are listed by value, with λ_1 being the smallest estimated threshold, regardless of whether it was the first estimated threshold. All equations include a full set of unreported country and time dummies. *t*-values are reported in brackets. All models estimated using robust standard errors. *, **, *** indicate significance at the 10, 5 and 1 per cent level respectively. The *p*-value indicating the significance of the estimated threshold is computed using the bootstrap procedure of Hansen (2000) with 1,000 replications.

(i.e. for the most open countries) is the relationship statistically significant. Bearing in mind the caveats over measuring openness, this result provides a further indication that increased exposure to international trade can enhance the benefits of IPR protection.

Finally, there has been at least one attempt to explore the way in which IPR protection can influence the factors that directly contribute to the growth of GDP per worker. Park (1999) uses SUR methods to estimate a system of four equations. The four dependent variables are output growth, the fraction of GDP invested in the capital stock, the fraction of GDP invested in human capital and the fraction of GDP invested in R&D. The latter three variables are included as explanatory variables in the output growth equation, while the GPI is included as an explanatory variable in all four equations. The model was estimated for 60 countries with data averaged over the period 1960-1990. The results suggest that, while IPR protection has an insignificant direct impact on output growth, it does have a significant indirect effect through its impact on physical capital and R&D investment. Splitting the sample in two based on the average level of

GDP per worker, Park finds that IPR protection affects growth indirectly through these inputs in the richest half of the sample only, with no significant impact found for the poorest half.

In summary, the results reviewed in this section provide evidence that strengthening an IPR regime can be growth-enhancing, depending on country characteristics. IPR protection seems to lead to higher growth in more open economies, other things equal. It also seems to lead to higher growth in the richest and poorest countries, but has no significant effect on growth in middle-income countries, all other things being equal.

3. Intellectual property rights and innovation

The main benefit claimed for strong IPR protection is that by allowing innovators to appropriate a share of the benefits of their creative activities, R&D is encouraged which leads to innovation and higher long-run growth. In this section we examine the cross-country evidence linking IPRs to domestic innovation. The results are summarized in the upper part of table 4, which summarizes the literature linking IPR protection to innovation, technology diffusion and growth. At the aggregate level Kanwar and Evenson (2003) examine directly whether stronger IPR protection (measured by the GPI) results in increased R&D expenditure.[21] They estimate a panel model for up to 32 countries for the period 1981-1995, and find that stronger IPR protection has a positive and significant impact on the share of R&D investment in GDP. Given that it has been shown elsewhere that R&D spending impacts positively upon TFP and output growth (see, for example, Coe and Helpman, 1995), these results provide indirect evidence of the importance of IPR protection in growth and are consistent with the results of Park (1999) considered above.

R&D expenditure is a measure of the input into innovative activity. Patent applications are a measure of the output, and patents are recognized as the most important form in which industrial innovation is protected. Such protection is more important for some industries than others, however. The evidence suggests that firms in most industries in advanced countries do not find patents to be a particularly effective means of appropriating the returns to R&D (see Cohen (1995) for a review). Mansfield (1986) for example showed that although 65 per cent of pharmaceutical and 30 per cent of chemical inventions would not have taken place without patent protection, in most industries patent protection was unimportant.[22] One reason put forward for its limited role is that patent protection often does not affect the rate of entry significantly (Mansfield et al., 1981). Mazzoleni and Nelson (1998) pick up this latter point and argue that much of this survey evidence showing IPRs to be relatively unimportant can be faulted for focusing almost exclusively on large, established firms operating within particular industries. The studies tend to ignore the role of stronger IPRs on new entrants, small

[21]Note the potential for reverse causality in the relationship between R&D spending and IPR protection. Not only may IPR protection stimulate R&D and innovative activities, but we may also expect that the demand for IPR protection is stronger in countries that are more innovative.

[22]Mansfield et al. (1981) found that about a half of innovations considered in their study would not have been introduced without patent protection. Once again the bulk of these were in the drug industry, with less than a quarter of non-drug innovations being affected by patent protection. Other studies reaching similar conclusions include Scherer et al. (1959), Taylor and Silberston (1973), Arundel and van de Paal (1995) and Cohen et al. (1997).

firms, organizations outside of any particular industry (e.g. universities) and for the development of new industries (e.g. biotechnology). Cohen and Levinthal (1989) argue further that in some cases, overly strong IPR protection has been found to restrict the innovation process, with researchers finding it difficult to further develop a technology without infringing the rights of existing patent holders. Little evidence on the importance of IPR protection for innovation in developing countries is available, though Primo Braga et al. (2000) note that the criteria of novelty in patent grants is unlikely to be apt for promoting the small, incremental and adaptive innovations that are typical in developing countries.

Table 4. Summary of effects of stronger intellectual property rights on innovation, technology diffusion and growth

	Domestic intellectual property rights	*Technology spillovers*
Domestic Innovation		
Domestic R&D	Stronger IPRs increase domestic R&D spending	Evidence that higher R&D spending facilitates technology transfer and raises growth
Domestic patenting	Evidence mixed in general. But threshold analysis shows stronger IPRs (a) increase domestic patenting in countries with innovative/imitative capacity; (b) reduce domestic patenting in more open economies	Evidence relating domestic patenting to growth is mixed. In developing countries there is little evidence of a positive impact of domestic patenting on growth
Channels of international technology diffusion		
Foreign direct investment	Evidence mixed in general, but strong IPRs seem to be important for some TNC activities (production and R&D) and in industries where products can be imitated (chemicals, pharmaceuticals). Some evidence that TNCs more willing to transfer technology to countries with stronger IPRs	Evidence generally mixed on whether inward FDI provides technology spillovers, although some evidence of spillovers to host country firms with absorptive capacity. Some evidence of spillovers from outward FDI
Technology licensing	Limited evidence, but what evidence there is suggests stronger IPRs increase licensing, particularly in countries with innovative/imitative capacity	Little evidence
Foreign patenting	Positive effect stronger in more open economies and in countries with higher innovative/imitative capacity	Evidence of positive (negative) spillovers from foreign patenting for developing countries with strong (weak) IPRs, high (low) innovative/imitative capacity and large, open (small, closed) markets
Trade	Impact of IPRs on trade flows depends upon market size and the imitative ability of the importing country. Positive effect of IPRs on trade in manufacturing goods (except goods difficult to imitate) in countries that have imitative capacity. Possible negative effects in small markets with weak imitative ability	Trade has been found to promote technology spillovers both between developed countries and from developed to developing countries
Domestic growth	Evidence that stronger IPRs increase growth in developed countries and developing countries with low innovative/imitative capacity. No effect evident for developing countries with high innovative/imitative capacity	

There are a small number of econometric studies using data on domestic patent applications to examine the role of IPRs in promoting innovation. Many such studies suggest that stronger IPR protection results in little or no measured increase in domestic innovation, at least as measured by patent applications (Lerner, 2001, 2002; Branstetter et al., 2004).[23]

A recent paper by Chen and Puttitanun (2005) however shows that stronger IPR protection has a positive impact upon innovation in developing countries. Chen and Puttitanun develop a model that has both an import and a local sector, with a local and a foreign firm in the import sector and two local firms in the local sector. In the import sector the foreign firm has a patented technology, while one of the local firms has the ability to develop patentable technology in the local sector. Stronger IPR protection by reducing the ability to imitate can lead to lower competition and higher prices in the import sector, but may encourage innovation in the local sector. The theoretical model suggests that domestic innovation in a country increases in its protection of IPRs and its level of development, and that a country's level of IPR protection may at first increase and then decrease in its level of development. The model is tested empirically on a sample of 64 developing countries using panel data over the period 1975-2000. The empirical model is a system of two equations, one for IPRs and one for innovation. IPRs are measured using the GPI index, while innovation is measured using patent applications filed at the United States patent office by developing country residents. Empirical results confirm the U-shaped relationship between IPRs and a country's level of development and that stronger IPR protection encourages innovation. Including interaction terms between IPRs and the level of development suggests that IPR protection has a stronger impact on innovation in countries with higher levels of development. In a related paper, Schneider (2005) examines the importance of IPR protection, high-tech imports and FDI on innovation and on per capita GDP growth. Once again innovation is measured using the number of United States patent applications made by residents of a given country. The model is estimated on panel data for 47 developed and developing countries over the period 1970-1990. The results again suggest that innovation responds positively to IPR protection. Splitting the sample into developed and developing countries, Schneider finds that while IPRs have a positive impact on innovation in developed countries, the impact in developing countries is negative, and often significant.

While both R&D expenditure and patent applications have advantages and disadvantages as measures of innovative activity, patent application data has the advantages of being relatively reliable, available over a relatively long time period and for a relatively large number of developing countries. To examine whether the strength of IPR protection encourages domestic innovation we regress the ratio of the number of domestic patent applications to the labour force (DOMPAT) on the GPI measure of IPR protection (IPR) and control variables.[24] The latter include initial GDP per capita (INITGDP)

[23]Whilst finding that domestic innovation does not respond significantly to IPR protection, both Lerner (2001, 2002) and Branstetter et al. (2004) find that foreign patent applications respond to IPR reforms suggesting that one benefit of increased IPR protection is through technology transfer. This channel is discussed in section 4 below.

[24]Once again information on data sources and construction is provided in annex III.

and the average years of secondary schooling in the population over 15 (SYR15) as measures of the level of development and to account for the ability of a country to innovate and to absorb foreign technology, respectively, and the ratio of total trade to GDP (TRADE) to capture the impact of openness to trade on domestic innovation. The model is estimated for up to 47 countries with data averaged over four five-year periods between 1975 and 1994.[25]

To give some indication of the relationship between domestic patent applications and both a country's level of development and its protection of intellectual property, figures 1 and 2 plot the domestic patenting variable against initial GDP per capita and the GPI respectively. While a strong positive relationship between initial GDP and patenting is clearly observed, any relationship between IPR protection and patenting is not easily discernable. Table 5 reports the results from the regression analysis for the full sample of 47 countries.[26] The second column reports results when the IPR variable is included linearly. The results suggest that domestic patenting is higher in countries with higher levels of initial GDP per capita (as is consistent with figure 1), but that higher levels of secondary education or openness to trade have no significant impact on the level of domestic patenting. Most importantly, we do find that domestic patenting responds positively to stronger IPR protection.

The importance of domestic innovation is likely to vary with a country's level of development and its factor endowments. We may expect IPRs to impact on innovation differently in countries with significant innovative capacity as opposed to those with few resources available for domestic innovation. Similarly, as discussed above, we may expect the importance of IPR protection in stimulating innovation to be dependent upon the level of openness of the country. To explore the possibility of non-linearities in the relationship between IPR protection and domestic innovation, we employ the threshold regression techniques discussed in annex II allowing for thresholds on the level of development (as measured by INITGDP), education (as measured by SYR15) and openness (as measured by TRADE). These results are reported in the final three columns of table 5.

In column 3 a single threshold on IPR is found depending on the value of initial GDP per capita, indicating that there are two regimes with respect to a country's level of development. At low levels of development (i.e. below the threshold) increased IPR protection has no significant impact on the level of domestic patenting. But above the threshold an increase in IPR protection does have a statistically significant positive impact on the level of domestic patenting. Column 4 reports the results for thresholds

---

[25]The estimated regression model also includes a full set of country and time dummies to account for unobservable heterogeneity over time and across countries. Estimating the linear model using either random effects or pooled data does not affect the coefficient on the IPR variable a great deal.

[26]In a number of specifications we also include the square of the IPR variable to account for any non linearities in the relationship between IPR protection and domestic patenting. Measures of "economic freedom" and the interaction between the IPR index and a dummy for France, Germany, Japan and the United States were also considered, the latter variable because R&D is highly concentrated within advanced countries. Eaton and Kortum (1999) note that in the late 1980s, 80 per cent of OECD research scientists and engineers were employed in these four economies and the United Kingdom (which is not in our sample). These variables tended to be insignificant, however, and are not reported in the final tables.

based on SYR15, which are consistent with those based on initial GDP per capita. A single threshold on the IPR variable is found with an insignificant coefficient found in the low regime and a positive and significant coefficient found in the high regime. The results for the first two threshold variables support the view that stronger IPR protection can encourage domestic innovation in countries that have significant domestic capacity for innovation, as measured either by initial GDP per capita or the stock of human capital, but that it has little impact on innovation in countries with few such resources.

Column 5 reveals that there are three regimes for the TRADE variable. While the estimated coefficients are positive in all cases, they decline in magnitude as we move up the regimes. Only for countries whose openness to trade lies below the higher threshold will stronger IPR protection generate increased domestic patenting. This sense of a negative relationship between openness and domestic patenting is reinforced when we observe that the estimated coefficient on the variable TRADE is negative when significant.[27]

Table 5. Domestic patenting decision

DOMPAT	*LINEAR*	*INITGDP*	*SYR15*	*TRADE*
INITGDP	0.21	0.12	0.15	0.20
	(2.43)**	(2.67)***	(2.04)**	(2.76)***
SYR15	0.02	0.003	-0.01	0.03
	(0.67)	(0.07)	(-0.32)	(0.85)
TRADE	-0.04	-0.05	-0.04	0.006
	(-0.99)	(-1.75)*	(-0.91)	(0.21)
IPR	0.08			
	(1.77)*			
IPR		-0.05	0.04	0.14
$TH \leq \lambda_1$		(-1.25)	(0.91)	(2.94)***
IPR		0.10	0.10	
$TH > \lambda_1$		(2.56)**	(2.24)**	
IPR				0.09
$\lambda_1 \leq TH \leq \lambda_2$				(1.93)*
IPR				0.05
$TH > \lambda_2$				(1.12)
λ_1		8.59	2.68	0.24
(percentile)		(53^{rd})	(76^{th})	(11^{th})
λ_2				0.67
(percentile)				(74^{th})
p-value		0.00***	0.00***	0.00***
Observations	188	188	188	188
F-Statistic	199.0***	154.3***	149.4***	7037.2***
R^2	0.97	0.98	0.98	0.98

[27]The evidence considered in section 4.4 below indicates that what occurs is a substitution of domestic by foreign patenting in more open economies.

Figure 1. Domestic patent applications per 1,000 of workforce against initial GDP per capita

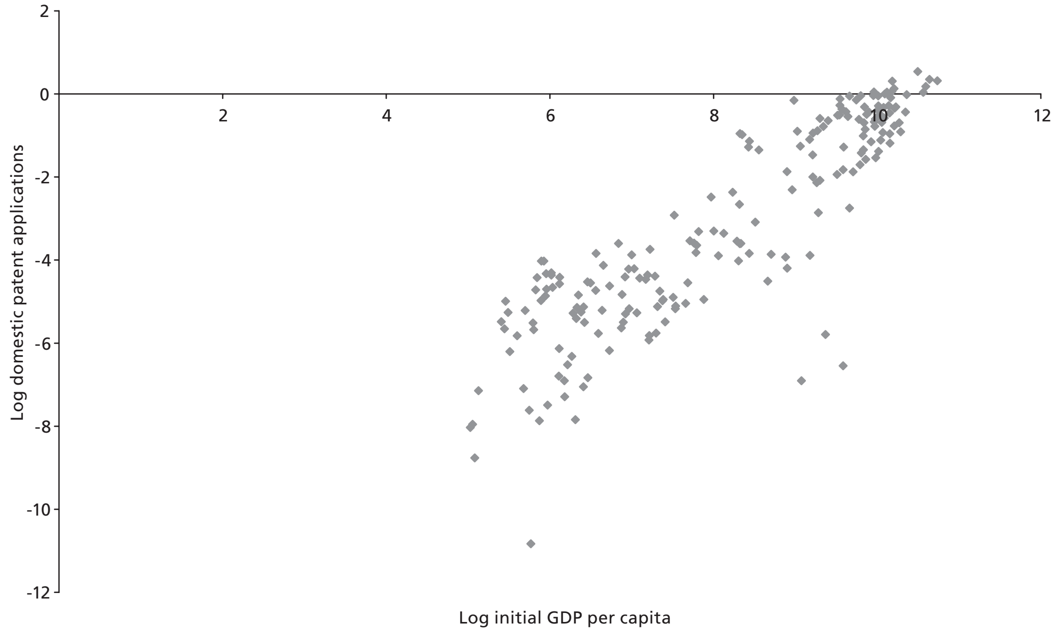
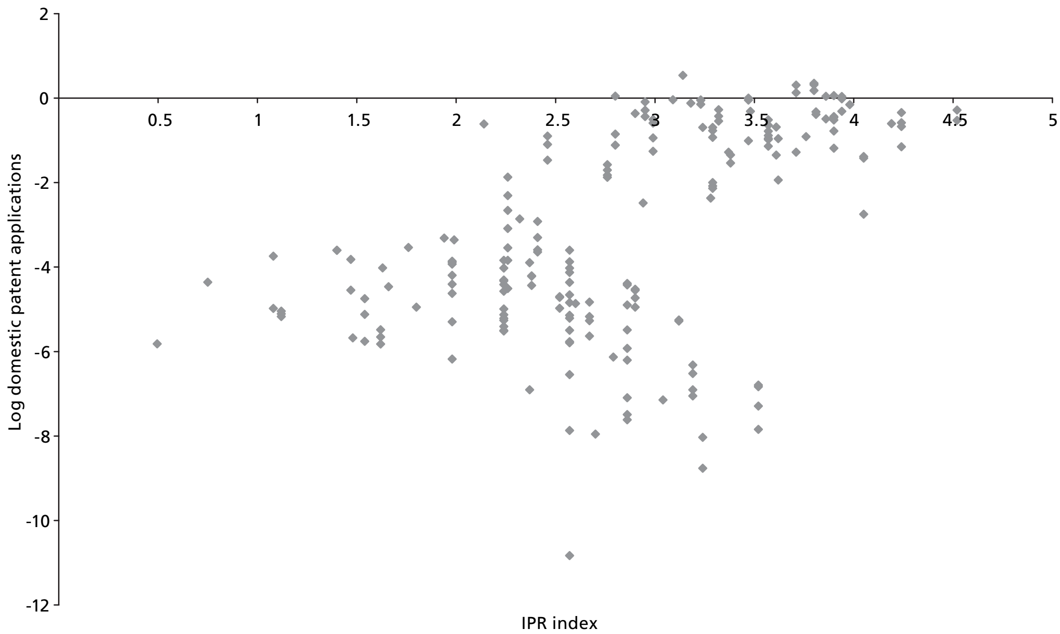


Figure 2. Domestic patent applications per 1,000 of workforce against the Ginarte and Park IPR index



4. Intellectual property rights and international technology diffusion

The importance of technology for raising productivity and living standards has long been recognized. Innovation and technological progress can raise productivity through the introduction of new goods (capital and intermediate inputs in particular), the improvement of existing goods and by reducing the costs of production. More broadly, technological progress encompasses changes in production processes, organizational structures, management techniques and the like that raise productivity. Resources for such innovations tend to be highly concentrated in a small number of advanced OECD countries,[28] which have the requisite skills and institutions in place to undertake innovation and invest heavily in R&D. As a result firms in these countries register the bulk of patents. For countries whose firms are not at the technological frontier, the diffusion of technology from the frontier is likely to be an important source of productivity growth, through both imitation and also through follow-on innovation and adaptation (Evenson and Westphal, 1995).

As we saw above, the impact of stronger IPR protection on technology diffusion is ambiguous in theory and will depend on a country's circumstances. On the one hand, stronger IPR protection can restrict the diffusion of technology, with patents preventing others from using proprietary knowledge and the increased market power of IPR holders potentially reducing the dissemination of knowledge due to lower output and higher prices. On the other hand, IPRs can play a positive role in knowledge diffusion, since the information available in patent claims is available to other potential inventors. Moreover, strong IPR protection may encourage technology transfer through increased trade, FDI, technology licensing and joint ventures. Despite this theoretical ambiguity, the diffusion of technology from countries at the technological frontier is considered to be one of the main potential benefits of the TRIPS Agreement, particularly for developing countries that tend not to innovate significantly.

International technology transfer or diffusion refers to the process by which a firm in one country gains access to and employs technology developed in another country. Some transfers occur between willing partners in voluntary transactions, but much comes through non-market transactions or spillovers. Technology flows across borders via a

[28]The share of R&D financed by enterprises in advanced countries was 98 per cent in the 1980s and 94 per cent in the 1990s (UNIDO, 2002).

number of formal and informal channels, making measurement difficult. One such channel is trade in goods and services, with imports of goods having the potential to transfer knowledge through reverse engineering, but also through the cross-border learning of production methods, product design, organizational structure and market conditions.[29] Trade in capital and intermediate goods in particular is likely to be an important source of technology diffusion in this way. A second channel is FDI, inward FDI in particular, with TNCs expected to deploy advanced technology to their subsidiaries that may be diffused to host-country firms. Licensing, which involves the purchase of production and distribution rights for a product and the knowledge required to make effective use of these rights, is a further channel for technology diffusion. Joint ventures combine many of the properties of FDI and licensing and hence will also involve technology transfer. The movement of skilled workers across borders can also act as a channel for international technology diffusion. These formal channels of technology diffusion are likely to be interdependent, with firms making their decision on which channel(s) to serve foreign markets based on the expected return to their technological assets.

Informal channels of technology diffusion include imitation; the movement of personnel from one firm to another taking with them specific knowledge of their original firm's technologies; data in patent applications and the temporary migration of people, such as scientists and students to universities and research institutes in advanced countries. What is specific to the informal channels, and is part of their attraction, is that there is no formal compensation to the original owner of the technology transferred. But there will still be costs. Imitation for example requires resources that may be drawn from local innovation.[30] The formal and informal channels are also related. It is likely that, in order to be able to reverse engineer and imitate advanced technology, some level of trade or temporary migration is required for example. The interdependence among formal channels and between formal and informal channels raises difficult issues for empirical studies.

The fact that technology or knowledge is typically intangible means that its measurement is not straightforward. Several measures have been employed in the empirical literature (see Keller, 2004), each with their own strengths and weaknesses. R&D expenditure data are often used, since R&D expenditures are the main input towards innovative activity. But such a measure fails to take into account that innovation is risky, so that a significant portion of R&D projects are unsuccessful, and there is the possibility of discovering new technology by chance. Patent counts, which are a measure of the output of innovative activity, have also been used. The weaknesses of patent count data include the substantial variation in the value of patents, with the majority worth very little, as well as the fact that many innovations are not patented. On a broader scale, measures of the changes in a country's or firm's TFP can be used as an

[29]Exports are also likely to be an important channel for technology diffusion. Grossman and Helpman (1991), for example, argue that sellers gain from the knowledge base of their buyers, especially where buyers suggest ways to improve the product or the process of manufacture. Firm-based evidence relating productivity to exporting supports this hypothesis (e.g. Bernard and Jensen, 1999). At the aggregate level Funk (2001) and Falvey, Foster and Greenaway (2004b) provide evidence suggesting that exports may act as a channel for technology spillovers.

[30]Mansfield et al. (1981) show that the costs of imitation, while lower than the cost of innovation, are significant. Patenting innovations was found to raise the costs of imitation further, though even for products that were patented, 60 per cent were imitated within four years.

indicator of technology change. This indicator is constructed by subtracting the contribution of changes in major factor (and material) inputs to changes in output with the remainder being assigned to changes in technology. Thus TFP is a derived measure of technology.[31]

Since technology itself is difficult to measure, we also tend to find that measures of technology diffusion are imperfect. Several approaches have been employed.[32] One approach, following the seminal contribution of Coe and Helpman (1995), has been to examine whether R&D conducted in a country impacts upon TFP in other countries. The starting point for this kind of analysis is to construct a stock of knowledge for each country using past R&D expenditures and then to weight these stocks by some variable indicating the access that other countries have to this knowledge. Weights used in the literature include imports (Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997), capital goods imports (Xu and Wang, 1999), inward and outward FDI (Xu and Wang, 2000) and exports (Funk, 2001; Falvey, Foster and Greenaway, 2004b).

A second approach has been to use patent count data. In addition to the decision to patent results in the publishing of the technical information relevant to the patent, as discussed above, Eaton and Kortum (1996) also argue that the decision of where to patent affords further information regarding where innovators see their ideas being used. Since patent laws are national in scope and since obtaining patent protection is costly, inventions are typically only patented in a small number of countries. Eaton and Kortum argue that this choice of where to patent is determined by market size and by where the invention is likely to be useful. They use a cross-section of 19 OECD countries to explain the number of patents taken out in one country (destination) by inventors in another country (source). The results suggest that technology diffusion is larger, the smaller the distance between two countries, the larger the ability of the destination to absorb technology (as measured by the level of human capital), and the higher the relative productivity of the destination. A higher ratio of imports to GDP is not always found to facilitate the diffusion of knowledge.

A third approach that has proved popular in the growth literature more broadly, has been to follow Nelson and Phelps (1966) who argue that the rate of technology absorption depends upon the "technology gap", usually measured by the ratio of GDP per capita of a country to that of the technological leader (usually the United States). Benhabib and Spiegel (1994), for example, regress the growth rate of GDP on standard variables including the interaction between the technology gap and a measure of human capital. They find a positive and significant coefficient on this interaction term and conclude that human capital speeds the adoption of foreign technology.

But most studies considering the impact of IPR protection on technology diffusion tend to take one of the channels through which technology might be diffused and to examine whether IPR protection impacts upon the volume of activity in this channel. If it does, then it is inferred that IPR protection affects technology flows. This is the literature

[31]See Keller (2004) for a discussion of the issues involved in the construction of TFP

[32]See Keller (2004) for a review of the evidence on international technology diffusion.

reviewed below. We examine research linking IPR protection to trade, FDI, licensing and patenting (section 4). A final subsection discusses other related literature. The general conclusions from these studies are summarized in the lower part of table 4, while table 6 (annex IV) summarizes the findings of several studies relating IPRs to the various channels of technology diffusion.

Intellectual property rights and international trade

Coe, Helpman and Hoffmaister (1997) identify four channels through which knowledge produced in one country and transmitted through imports can affect productivity and growth in others. Firstly, through the importation of intermediate and capital goods, which may enhance the productivity of domestic resources. Secondly, through the cross-border learning of production methods, product design, organizational structures and market conditions that can result in a more efficient allocation of domestic resources. Thirdly, through the imitation of new products. Finally, through the development of new technologies or the imitation of foreign technology.

Coe and Helpman (1995) examine the impact of international R&D spillovers and the importance of imports in facilitating these spillovers for 22 OECD countries. They construct a stock of R&D for each country as described above. A measure of the stock of foreign knowledge that is available to each destination country is then constructed by weighting the R&D stocks of its source (exporting) trade partners by the bilateral import shares.[33] TFP is then regressed on both the foreign and domestic stocks of knowledge.[34] The results suggest that both domestic and foreign knowledge stocks are important sources of productivity growth, although the former has a much larger impact in the larger countries. Smaller countries, it is argued, tend to be more open and benefit to a greater extent from foreign knowledge spillovers.[35] This type of analysis has been extended to consider North-South foreign knowledge spillovers by Coe, Helpman and Hoffmaister (1997) who find evidence that spillovers from the advanced North to the developing South are also an important source of productivity growth, with imports again being an important channel for such diffusion.

Simply providing access to foreign technology through imports may not be sufficient in itself for technology diffusion. Other conditions may be necessary before a country is able to absorb and implement such technology in its domestic production. Using the Coe and Helpman framework, Crespo-Cuaresma, Foster and Scharler (2004) find that the benefits of foreign R&D spillovers are stronger in OECD countries that conduct significant R&D and that have relatively high levels of absorptive capacity as measured by education variables.

[33]This literature is not without controversy, particularly over the appropriate weighting of the spillover variable and whether the volume or indeed the composition of imports is important in facilitating spillovers (Keller, 2004). See Falvey, Foster and Greenaway (2002) for a discussion of the interpretation and testing of alternative weighting schemes.

[34]In their preferred specification the stock of foreign knowledge is interacted with the overall import share to take account of the level as well as the distribution of imports.

[35]This outcome is not replicated when patent count data is employed, however. Eaton and Kortum (1996) find only limited evidence of a role for imports in facilitating technology diffusion among OECD countries as mentioned above.

While the available evidence suggests that trade is an important channel for technology diffusion, the question that remains is to what extent are trade flows influenced by IPRs. Maskus (2000a) discusses the problems faced in trying to identify the effects of IPR protection on international trade. Firstly, the effects of patent strength are partly embedded in the prices at which goods are traded, and these effects cannot be separated from other components of pricing behaviour. Secondly, as noted above, the decision to export may be but one of the options available. The effects of stronger IPRs on exports will also depend on whether FDI and licensing are viable alternatives and how stronger IPRs affect the choice among them (Ferrantino, 1993). Thirdly, IPR protection creates market power in the distribution and sale of new goods and technologies, implying that market structure also matters.

Bearing these problems in mind, there are two direct impacts of IPR protection on international trade that are likely to be of particular importance. On the one hand, firms should be encouraged to export their patented goods into foreign markets with strong IPR protection, since such protection reduces the risk of piracy that can diminish the profitability of the firm's activity in that country. In this respect, stronger IPR protection would be expected to raise imports into a country. On the other hand, because it reduces the ability of domestic firms to imitate, stronger IPR protection increases the market power of the importing firm, which may encourage this firm to act in a monopolistic manner by lowering sales. Maskus and Penubarti (1995) thus argue that there is a "trade-off between the enhanced market power for the firm created by stronger patents and the larger effective market size generated by the reduced abilities of local firms to imitate the product." (p. 229). They argue that of the two countervailing effects, the market expansion effect is likely to dominate in larger countries with strong imitative abilities, while the market power effect would dominate in smaller countries with weak imitative abilities. As Maskus (2000a) notes however, the market power and market size effects may be moderated by other circumstances. Weak IPR protection need not remove an innovative firm's market power since imitation in the local market is likely to be costly and take time. Similarly strong IPR protection need not create a monopoly because legitimate substitutes are likely to be available in the domestic economy. Taylor (1993) argues that a third factor may be important for larger markets with significant imitative abilities at least, with stronger IPR protection encouraging exports by reducing the need for firms to try and deter local imitation, thus reducing costs for exporting firms.

The above discussion suggests that the impact of IPR protection on trade is likely to depend importantly upon the level of development and upon the imitative ability of the importing country. In countries with little capacity to imitate advanced goods, stronger IPR protection may lead to market power effects, whereas in countries with the ability to imitate advanced goods strong IPR protection may be important for exporters in advanced countries, with such protection reducing the risk of imitation and encouraging trade.

Given the theoretical ambiguity of the IPR-Trade relationship, a number of studies have examined the question empirically. Maskus and Penubarti (1995) use an augmented version of the Helpman-Krugman model of monopolistic competition to estimate the effects of patent protection on 1984 bilateral trade for 28 manufacturing sectors. They examined trade from 22 OECD countries to a sample of 71 countries at all stages of development. Their explanatory variables include the importing country's per capita gross national product (GNP) and trade restrictions (BMP and tariff revenue as a percentage of dutiable imports) alongside the RRI of IPR protection. They also include the interaction between the IPR index and dummies indicating whether the importing developing country has a small or a large market to account for market size effects and technological capacity. Their results indicate that higher levels of IPR protection have a positive impact on bilateral manufacturing imports into both small and large developing economies, though the impacts were statistically weaker in the smaller economies. Whilst suggestive of the importance of technological capacity or imitative ability for the relationship between IPR protection and trade, their results find little support for a positive impact of IPR protection in the most patent sensitive industries.

Adding a measure of IPR protection to a standard equation explaining trade flows is a clear first step to determine if this channel is important for technology diffusion. Fink and Primo Braga (2005) add the GPI measure of IPR protection to a standard gravity equation[36] explaining either total non-fuel or high-tech trade flows for a large cross-section of countries for the year 1989. The rationale for using high-tech trade in addition to total non-fuel trade is based on the a priori expectation that the effects of IPR protection are stronger for knowledge-intensive trade. To deal with the econometric problem of zero trade flows, their model consists of one equation explaining the probability of zero observations and a second equation explaining the magnitude of positive trade flows. They find that stronger IPR protection has a small but significantly positive impact on the probability that countries trade with each other and a significantly positive impact on bilateral trade flows for both total non-fuel imports and exports. For high-tech trade however, stronger IPR protection is found to have a significantly negative impact on the probability that two countries trade with one another and a negative and insignificant impact on bilateral trade flows. This latter result is contrary to what one might have expected, and Fink and Primo Braga suggest several possible explanations, based on the considerations noted above. Firstly, strong market power effects, in the case of high-tech goods, may offset positive market expansion effects caused by stronger IPR protection. Secondly, stronger IPR regimes may cause high-tech firms to serve foreign markets by FDI, partly substituting for trade. Thirdly, the high-tech aggregate may include many goods that are not sensitive to the destination country's patent regime, as other means of appropriating the benefits of the investment in R&D may be more important. Fourthly, they were unable to include tariff and non-tariff barriers, which may be important determinants of trade flows for some industries.

In a similar gravity equation exercise, Smith (1999) examines the impact of IPR protection on exports from the 50 United States plus the District of Columbia to 96 countries.

[36]Including the GDP and populations of both trade partners, distance between trade partners and dummies for common border, common language and various Preferential Trading Arrangements (PTAs) as standard explanatory variables.

Smith splits her sample of importing countries into four groups depending on their imitative ability defined according to their strength of patent rights[37] and R&D spending as a percentage of GNP.[38] Dummies for these four groups were then interacted with the IPR measure. She finds a negative relationship between IPR protection and exports from the United States to those countries with the weakest threat of imitation. For those countries with the strongest threat of imitation however a positive relationship between IPR protection and trade exists. Overall, she concludes that United States exports depend upon IPR protection in importing countries, but that the direction of the relationship depends on the threat of imitation. Weak IPRs are a barrier to United States exports, but only for countries that pose a strong threat of imitation.

The results of these studies suggest that stronger IPR protection can lead to significantly higher trade flows, though not necessarily in goods and industries considered high-tech or patent sensitive. Fink and Maskus (2005) draw the following conclusions from this empirical literature. Firstly, they argue that transnational trading firms do not base their export decisions on IPRs in the poorest countries, where the local threats of imitation and reverse engineering are weakest. Secondly, patent rights matter importantly in middle-income, large developing countries, where such imitation is more likely. Stronger IPR protection in these countries encourages foreign firms to expand their trade volumes by reducing the threat of imitation. Thirdly, the products of many high-tech industries are difficult to imitate, so trade flows in these industries are in fact less sensitive to IPR protection than in other medium-technology industries.[39] Fourthly, high-tech firms may decide to serve foreign markets through FDI and licensing, so that exports in such industries may be little affected by variations in the degree of IPR protection. Moreover, while stronger IPR protection may increase imports of high-tech goods, it also increases imports of low-tech consumer goods and may lead to the decline of indigenous industries relying on imitation.

Intellectual property rights and FDI

Foreign direct investment occurs when a TNC has a sufficient cost or technological advantage over firms in the host country to offset the higher costs of operating internationally.[40] FDI can be vertical, in which case the subsidiary produces inputs or undertakes assembly from components that are likely to be exported within the TNC, or horizontal, in which case the subsidiary produces products and services similar to those

[37]Both the Rapp and Rozek and the Ginarte and Park indices are used with similar outcomes.

[38]The four groups are defined (in increasing order of imitative ability) as: *(a)* Countries with weak imitative abilities and strong IPR protection: *(b)* Poor countries that have low technological capabilities and thus a low threat of imitation, but that also have low levels of IPR protection: *(c)* Industrial countries that tend to have strong technological capabilities leading to a strong imitation threat, but that at the same time tend to have high IPR protection, which dampens this threat, and: *(d)* Industrializing countries that have an effective threat of imitation and that also have low levels of IPR protection. Maskus (2000a) suggests caution is warranted in interpreting Smith's results since, "in the developing economies R&D data are highly suspect and not comparable to those in developed countries" (p. 118). In addition, the division of countries into four groups is somewhat subjective, with a number of anomalous designations.

[39]Cohen (1995) argues that in many high-tech industries, such as aerospace and robotics, the complexity of the technology makes imitation via reverse engineering extremely difficult, rendering IPR protection unnecessary.

[40]See Maskus (2000a) for a detailed discussion of the determinants of FDI, and the role of IPR protection in the decision to invest abroad.

produced by the parent firm. Increasingly, FDI is undertaken in industries in which knowledge and technology are important. This is because technology advantages can be transferred relatively easily across borders, and because technology acts as a public good within the firm, where it can be employed in several locations without reducing its availability for others. The decision on where to invest will depend on locational considerations that include local market size, resource availability, distance from markets and production costs. Where technology is relevant to the FDI decision an adequate supply of labour with the appropriate skills will also be important.

While FDI can be an important channel for technology diffusion when firm-specific technology is transferred across borders, one important advantage of FDI relative to licensing or joint ventures from the TNC's perspective is that FDI keeps the technology internal to the firm. This may limit the diffusion of technology within the host country. Even so a number of considerations suggest that the presence of TNCs in a country will provide spillover benefits to domestic firms.[41] Fosfuri, Motta and Ronde (2001) for example argue that such benefits may appear through labour training and turnover, while Rodríguez-Clare (1996) suggests that the provision of high quality intermediate inputs may provide an important externality when they also become available to domestic firms. Imitation through reverse engineering may also be facilitated when the product is produced locally (Das, 1987). Domestic firms may find it easier to export once foreign TNCs establish distribution networks, a transport infrastructure and satisfy the relevant regulatory arrangements (Aitken, Hanson and Harrison, 1997).

Empirical evidence linking FDI to technology diffusion is mixed. In general, there is little evidence of substantial FDI spillovers for developed or developing countries.[42] Xu and Wang (2000) extend the approach of Coe and Helpman (1995) for a sample of up to 21 OECD countries over the period 1971-1990, by adding both inward and outward FDI flows as weights on foreign knowledge stocks. They find little evidence of spillovers through inward FDI, but some evidence of spillovers through outward FDI. Globermann, Kokko and Sjöholm (2000) using data on patent applications by Swedish TNCs and non-TNCs also find evidence that outward FDI is the more important source of technology transfer. An alternative approach has been to consider patent citations as an indicator of the extent of spillovers. Using data on Japanese FDI into the United States, Branstetter (2001) finds evidence that FDI encourages technology spillovers through subsidiaries bringing technology from their countries of origin and through TNCs facilitating learning of foreign technologies.

Görg and Greenaway (2004) summarize the results from several studies of FDI spillovers at the firm or industry level. Here firm or industry productivity is regressed on control variables plus a variable which proxies the presence of foreign firms in the sector, usually the share of employment in TNCs or the share of total sales by TNCs. The results are mixed with positive, negative and insignificant impacts of foreign

[41]See Blomstrom and Kokko (1998) and Saggi (2002) for a detailed discussion of the potential benefits of FDI
[42]See the review by Görg and Greenaway (2004).

investment all being found. One explanation put forward for the negative impact is that increased competition in product and factor markets can have a negative impact on a domestic firm's productivity (Aitken and Harrison, 1999). Görg and Greenaway do note that there is some evidence of spillovers for firms that have a certain level of absorptive capacity. Dougherty (1997), for example, using data on Chinese enterprises, finds that technology diffusion is positively related to the presence of domestic enterprise-level R&D programmes.

Like the other channels, economic theory is unable to draw unambiguous conclusions on the impact of IPR protection on FDI. TNCs are more likely to undertake FDI rather than licensing or joint ventures when they have a complex technology and highly differentiated products and when the costs of transferring technology through licensing are high (Davidson and McFetridge, 1984; Teece, 1986; Horstmann and Markusen, 1987). In such circumstances stronger IPRs, by reducing the risks of technology leakage through arm's length trade, may increase the extent of licensing and joint ventures, thus reducing the need for FDI (Yang and Maskus, 2001a). On the other hand, it has been argued that weak IPR protection tends to affect the general investment climate adversely, hence discouraging FDI (Smith, 2001). The importance of IPR protection is also likely to vary across sectors, being of secondary importance for FDI in low-tech industries, or where the product or technology is difficult to imitate. For TNCs with technology that is easy to copy however we would expect more attention to be paid to the strength of IPR protection. Regardless of these arguments, it is clear that strong IPR protection is not a necessary condition for firms to invest in particular countries. If it were, then large countries with high growth rates but weak IPR regimes, such as Brazil and China, would not have received the large foreign investment inflows that they have. While flows of FDI into these countries have been large, some evidence indicates that TNCs are unwilling to locate R&D facilities in such countries and that they may transfer older technology (see for example Maskus et al., 2005).

The empirical evidence linking IPR protection to inward FDI is mixed. Mansfield (1994) used survey evidence for 100 major United States firms in six industries, and asked whether IPR protection was a concern in the location of various facilities. He found that while IPR protection was of little concern in the location of sales and distribution outlets, it became more important at higher stages of production. Many firms were concerned about IPR protection when deciding on the location of components manufactures, while the majority were concerned about IPR protection in the location of complete product manufactures. The greatest concern about IPR protection was in deciding the location of R&D facilities, which were less likely to be located in countries with weak IPR protection.[43] Across industries IPR protection was found to be very important for chemicals and pharmaceuticals, but was of secondary importance in other industries. This it has been argued is because FDI in many low-tech goods is likely to depend more on input costs and market opportunities, rather than IPR protection (Maskus, 2000d). IPRs are also likely to be of secondary importance for FDI in products that are difficult to imitate.

[43]Mansfield (1995) conducted a similar exercise for German and Japanese firms, reaching similar conclusions.

The early empirical research found little evidence of links between IPR protection and the volume of FDI. Ferrantino (1993) found no statistically significant relationship between a country's membership of international patent or copyright conventions (or the length of its patent grant) and the extent of United States affiliate sales in that country; Mansfield (1993) found that there was no significant correlation between the extent of FDI by United States firms in a country and the perceived strength of its intellectual property protection; and Maskus and Eby-Konan (1994) found an insignificant impact of the RRI on FDI by United States TNCs. More recently, Primo Braga and Fink (1998) found no evidence of a relationship between either FDI flows or stocks and the GPI in a gravity model of FDI.[44] But Maskus (2000b) cautions that these studies should be discounted somewhat, since they were "limited in specification and plagued by poor measurement" (p. 10).

There is stronger evidence that the strength of IPRs affects the type of activities TNCs are willing to conduct in host countries. Lee and Mansfield (1996) consider the relationship between a country's protection of IPR and the volume and composition of United States FDI in that country. Using the same survey of 100 United States firms as Mansfield (1994), they explain the volume of United States FDI into each of 14 countries using control variables and a variable which measures the average percentage of firms who considered patent protection in this country to be too weak to either transfer their newest technology to a wholly owned subsidiary there or to invest in a joint venture with a local partner. The results suggest that FDI is lower in countries with weaker perceived IPR protection, and that the percentage of FDI that was devoted to final production and to R&D facilities was significantly lower in countries with perceived weak IPR protection, suggesting that not only the volume but also the quality of investment is affected by the strength of IPR protection. Kumar (2002) argues that these results should be treated with caution due to the small sample size, the subjective measure of IPR protection and the low *t*-values on coefficients. He goes on however to discuss evidence by Seyoum (1996) who found that IPR protection is significant in explaining inward FDI, particularly in emerging markets and Maskus (1998b) who found that the strength of IPR protection was positively related to affiliate sales and assets in developing countries.

The question of whether the strength of local IPRs is important for the location of overseas R&D activity of TNCs is taken up by Kumar (2001). Economies of scale in innovation, agglomeration economies and the need to protect firm-specific technology all discourage undertaking R&D abroad. But this may be partly countered by the need to adapt goods to local market conditions, to take advantage of cheap inputs, and to benefit from trained R&D personnel and localized knowledge. While investment in R&D overseas is the least globalized of TNCs activities, Kumar shows that it has grown over time, especially since the 1980s. He then relates the ratio of R&D expenditure to affiliate sales by United States and Japanese TNCs to control variables and the GPI in a sample of up to 77 countries, but finds that R&D spending overseas is not affected by the strength of IPR protection in the destination country.

[44] The results discussed and reported here are based on those of Fink (2005).

Smarzynska (2004) examines whether stronger IPR protection affects the composition of FDI flows for 24 transition economies. She estimates a Probit model of the decision to invest in a country and in the decision to invest in production facilities abroad. She finds that weak IPR regimes deter FDI in high-tech sectors (i.e. drugs, cosmetics and health-care products, chemicals, machinery and equipment and electrical equipment) with some evidence suggesting that FDI is deterred in other industries too. She also finds evidence to suggest that stronger IPR protection encourages firms to set up local production facilities rather than focusing solely on distribution networks, with this latter effect not restricted to high-tech sectors.

Branstetter et al. (2004) use affiliate level data on United States TNCs and aggregate patent data to test whether legal reforms that strengthen IPRs increase the transfer of technology by TNCs to reforming countries. The results suggest that technology transfer is higher following IPR reforms, with an increase in technology transfer, as measured by intra-firm royalty payments from parent firms to affiliates located in IPR reforming countries. They also distinguish affiliates between those whose parent companies patent in the United States above and below the median. They find that technology transfer is concentrated among affiliates of parents that use patents extensively (i.e. those that patent above the median).

In conclusion, while there are many reasons to expect inward FDI to be an important channel for technology diffusion, the evidence of this to date at both the aggregate and firm level is mixed. If anything at all, the evidence indicates that FDI is an important source of diffusion in countries that have reached a certain level of absorptive capacity. To the extent that FDI is an important source of diffusion, IPR protection can affect the extent of technology diffusion through its impact on FDI flows. Again however, the evidence linking IPRs to FDI is mixed. Stronger IPR protection has been found to encourage FDI in certain industries, most notably chemicals and pharmaceuticals. As with trade, IPRs may play less of a role in high-tech industries due to the difficulty in imitating these industries' products, while in low-tech industries other factors may be more important in determining FDI flows. Stronger IPR protection has also been found to affect FDI flows at certain production stages. In particular, IPRs can affect FDI flows in component manufactures, final production and R&D facilities, reflecting the fact that patenting is more important at some stages of production than at others.

Intellectual property rights and licensing

The relationship between licensing, technology diffusion and the strength of IPRs is likely to be even more complex than the other channels. Maskus (2004) argues that the reasons for this relate to the large variety of licensing agreements that may exist. Licences may exist within a firm, a joint venture or between unaffiliated firms. They may cover technical assistance, codified knowledge, know-how and IPRs. They may be offered for a fixed fee, a franchise fee, a royalty schedule or a share of profits, and they may offer the rights either to produce or distribute the product of the licensee for a given period of time within a geographical territory.

Economic theory suggests that firms that own a complex technology, produce highly differentiated products and face high licensing costs are more likely to undertake FDI than licensing (Horstmann and Markusen, 1987). FDI is more efficient in these circumstances as it allows the costs of technology transfer to be internalized. The reasons that technology and product licensing should be particularly sensitive to IPR protection are evident, however. Stronger IPR protection should reduce the costs of licensing by reducing the licensor's expense of deterring defection from contracts. They should expand security over the protection of proprietary information in licensing deals. Stronger IPR protection gives the licensor greater ability to set and monitor terms under which licensees operate. A stronger IPR regime is also likely to increase the rents accruing to the licensor, since it does not need to offer the licensee a higher share of the rents to deter imitation. At the same time stronger IPR protection provides the licensor with greater monopoly power, which as discussed above can reduce innovation, which in turn may lead to reduced licensing.

Little empirical literature on licensing and on the importance of IPRs exists, though Mansfield (1994) in his study of IPR protection and FDI found that United States TNCs were less likely to transfer advanced technologies to unaffiliated firms in countries with weak patent rights. More recently, Yang and Maskus (2001b) estimate the impact of international variations in IPR protection on the volume of unaffiliated royalties and licensing fees (a measure of arm's length technology transfer) paid to United States firms in a panel of 23 largely developed countries in 1985, 1990 and 1995. Included alongside the GPI (and its square) are measures of human capital (representing imitative ability), real GDP, the labour force and a measure of openness. The results often indicate a non-linear relationship between licensing and IPR protection, with stronger IPR protection reducing licensing at low levels and increasing licensing at higher levels. This it is argued is because countries with the lowest levels of IPR protection also have the weakest imitative ability. As such, an increase in IPR strength in these countries, while reducing the risk of imitation slightly, would also increase the monopoly power of the licensor. This latter effect is likely to dominate and lead to lower licensing. Most observations in the sample however are above the turning point, suggesting that IPR protection has a positive impact upon licensing.

Intellectual property rights and patenting

Given the costs involved in registering patents, if inventors in one country register a patent in another, it indicates that the technology could usefully be deployed in that second country. Eaton and Kortum (1996) include the RRI measure of IPR protection in their regression explaining the decision to patent abroad in OECD countries. They find that countries providing stronger IPR protection are more attractive destinations for foreign patents. They further show that productivity growth was significantly related to foreign patents, and that except for the major innovators (France, Germany, Japan, United Kingdom and the United States), countries in the sample obtained over 90 per cent of their productivity growth from foreign patenting.

Recent studies also consider developing countries. Park (1999) conducts a similar exercise to that above relating the decision to patent inventions abroad for 16 source countries and 40 destination countries for four periods between 1975 and 1990. He regresses the fraction of inventions in each source country that are patented in each destination on the market size of the destination (i.e. GDP per capita), the number of scientists and engineers per 10,000 of the workforce, the cost of filing patents and the GPI. The results indicate a strong positive impact of IPR protection on the decision to patent, suggesting that a 1 per cent increase in IPR protection leads to a greater than 1 per cent increase in the rate of foreign patenting.

Xu and Chiang (2005) consider three channels of technology diffusion. These are: international trade, following the approach of Coe and Helpman (1995); foreign patenting, following Eaton and Kortum (1996); and disembodied spillovers, following the approach of Benhabib and Spiegel (1994). Using data over the period 1980-2000, they split their sample of 48 countries into developed and developing countries and also into three groups based on real GDP per capita (low, middle and high-income countries). They show that, with few exceptions, TFP growth is positively and significantly related to all three channels of technology diffusion. They go on to examine the determinants of the patenting decision, finding that the level of IPR protection is positively and significantly related to foreign patenting across country groupings, suggesting that strengthening IPR protection may have a positive indirect upon TFP growth by increasing foreign patent applications.

We extend this work by first considering the determinants of foreign patenting. The approach is analogous to that used in section 3 to explain the determinants of domestic patenting. Here the variable we seek to explain is FORPAT, which is the number of foreign patent applications (also scaled by the domestic labour force) in a country. The explanatory variables are as before. Figures 3 and 4 plot the relationship between foreign patent applications and initial GDP per capita and the GPI index of IPRs respectively to give a visual indication of the relationship between patenting by non-residents and the level of development and of IPR protection in the recipient economy. As with domestic patenting, a strong positive relationship between foreign patent applications and initial GDP per capita is observed. The relationship between foreign patenting and the IPR index also appears positive, though not as strong. The regression results are presented in table 7. The results from the linear model suggest that the level of foreign patenting is higher the more developed the country is (as measured by INITGDP) and the stronger its IPR regime. The large and highly significant coefficient on the IPR index is consistent with the results of Park (1999) and is suggestive of the importance of IPR protection in facilitating technology diffusion through foreign patenting. The coefficients on the level of schooling and openness to trade are not significant.

As we did with the domestic patenting results we now allow for thresholds on INITGDP, SYR15 and TRADE, and find both interesting similarities and differences with the domestic patenting results. Considering thresholds on INITGDP and SYR15 we find evidence of a single and a double threshold respectively. Stronger IPR protection is found to have a consistently positive and significant impact upon foreign patenting,

Figure 3. Non-resident patent applications per 1,000 of workforce against initial GDP per capita

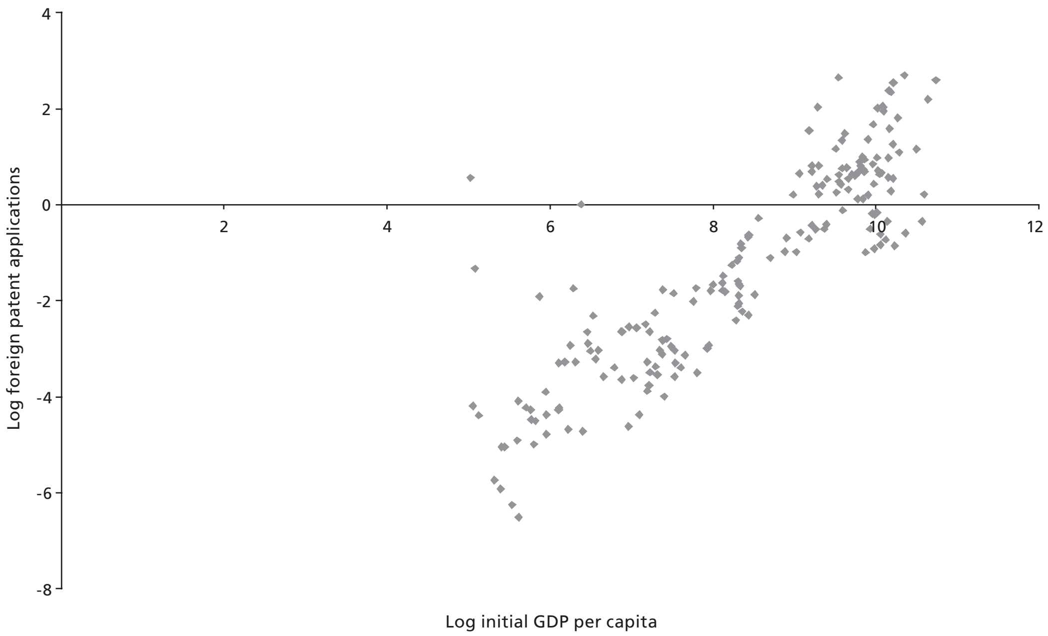
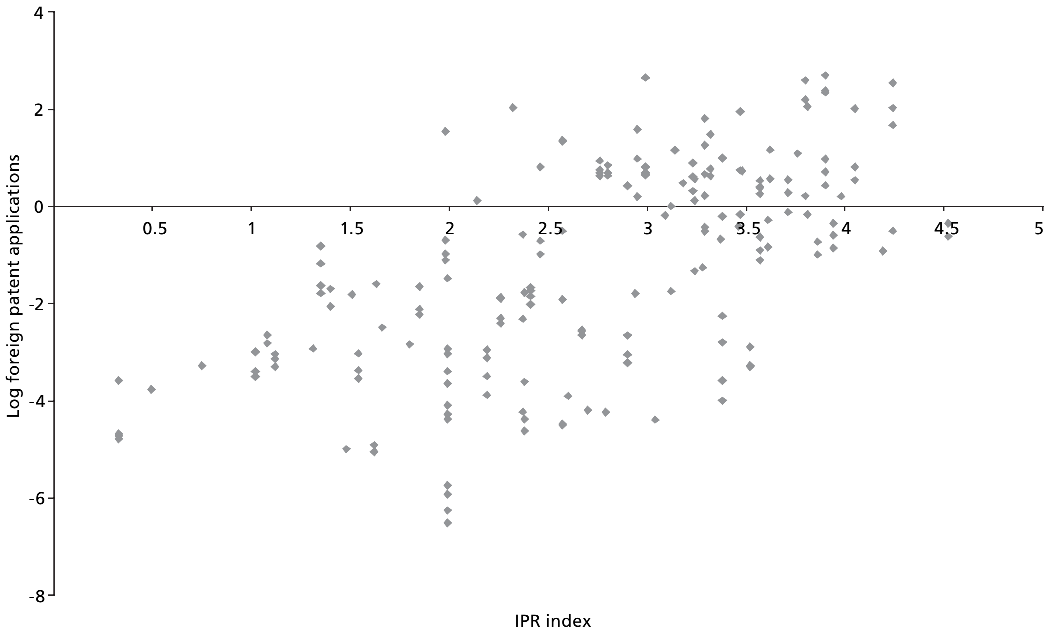


Figure 4. Non-resident patent applications per 1,000 of workforce against the Ginarte and Park IPR index



except in the low regime for thresholds based on education, where the coefficient is positive, but insignificant. The size of the coefficients indicates that the impact of stronger IPR protection on foreign patenting is greater in countries at higher levels of development and with higher levels of education. This is consistent with the view that stronger IPR protection enhances technology diffusion through foreign patenting in countries with significant levels of imitative ability. Considering the threshold results on TRADE we find evidence of a single threshold, with the impact of IPR protection on foreign patenting being positive and significant in both regimes. The coefficient is

Table 7. Foreign patenting decision

FORPAT	*LINEAR*	*INITGDP*	*SYR15*	*TRADE*
INITGDP	2.04	1.37	1.33	1.97
	(1.79)*	(1.49)	(1.16)	(1.91)*
SYR15	-0.04	-0.12	-1.47	-0.17
	(-0.06)	(-0.16)	(-2.17)**	(-0.24)
TRADE	0.13	-0.40	0.37	-0.52
	(0.13)	(-0.99)	(0.83)	(-1.27)
IPR	2.46			
	(2.67)**			
IPR		1.96	0.56	2.09
TH ≤ λ_1		(2.09)**	(0.67)	(2.47)**
IPR		3.28		2.58
TH > λ_1		(3.66)***		(2.79)***
IPR			1.21	
λ_1 ≤ TH ≤ λ_2			(1.68)*	
IPR			2.44	
TH > λ_2			(2.73)***	
λ_1		9.26	2.13	0.66
(percentile)		(59th)	(65th)	(73rd)
λ_2			3.35	
(percentile)			(86th)	
p-value		0.00***	0.01**	0.02**
Observations	188	188	188	188
F-Statistic	10.20***	8.66***	14.8***	10.88***
R^2	0.74	0.77	0.78	0.75

Notes: For ease of presentation the thresholds are listed by value, with λ_1 being the smallest estimated threshold, regardless of whether it was the first estimated threshold. All equations include a full set of unreported country and time dummies. *t*-values are reported in brackets. All models estimated using robust standard errors. *, **, *** indicate significance at the 10, 5 and 1 per cent level respectively. The *p*-value indicating the significance of the estimated threshold is computed using the bootstrap procedure of Hansen (2000) with 1,000 replications.

significantly larger for more open countries however. This result is the opposite of that for domestic patenting, where increased openness lowered the impact of stronger IPRs on patenting. In combination these results suggest that in relatively open economies stronger IPRs may encourage foreign patenting at the expense of domestic patenting. This result is consistent with the theoretical model of Rivera-Batiz and Romer (1991) discussed in section 2 above.

Having found that IPR protection can influence both domestic and foreign patenting, we examine whether these measures of innovation and technology diffusion influence economic growth, by adding them to a standard growth equation similar to that considered in section 2 for the sample of 47 countries for which we have data on domestic and foreign patenting.[45] Our primary concern is to examine the extent to which any growth promoting spillovers associated with foreign patenting are dependent on the characteristics of the recipient economy. Once again we employ threshold analysis for this purpose. The results are presented in table 8, where the second column presents the results for the linear model, including in the regression the GPI index of IPRs, DOMPAT and FORPAT as well as standard control variables. The coefficients on the

[45]Details concerning the construction and the definitions of the variables, country coverage and the model specification are provided in annex III.

Table 8. Foreign patenting and growth: full sample

FORPAT	*LINEAR*	*IPR*	*INITGDP*	*TRADE*	*GDP*
INITGDP	-0.10	-0.12	-0.11	-0.11	-0.11
	(-5.01)***	(-6.10)***	(-6.05)***	(-5.67)***	(-6.37)***
GDI	0.05	0.06	0.05	0.05	0.05
	(5.42)***	(6.09)***	(5.89)***	(5.74)***	(6.04)***
POPGROW	0.05	0.26	0.34	0.21	0.29
	(0.10)	(0.58)	(0.71)	(0.47)	(0.64)
SYR15	-0.001	0.004	0.006	0.006	0.006
	(-0.19)	(1.0)	(1.34)	(1.37)	(1.20)
TRADE	0.01	0.01	0.01	0.01	0.01
	(1.28)	(1.45)	(1.45)	(1.18)	(1.41)
IPR	0.015	0.02	0.02	0.01	0.02
	(2.33)**	(3.26)***	(3.24)***	(2.41)**	(3.35)***
DOMPAT	0.008	0.009	0.007	0.004	0.006
	(0.85)	(0.89)	(0.69)	(0.50)	(0.74)
FORPAT	0.0003				
	(0.37)				
FORPAT		0.003	-0.0003	-0.001	-0.005
TH ≤ λ_1		(2.59)**	(-0.23)	(-1.08)	(-1.76)*
FORPAT		-0.001		0.002	
TH > λ_1		(-1.02)		(1.67)*	
FORPAT			0.003		0.004
λ_1 ≤ TH ≤ λ_2			(4.88)***		(5.54)***
FORPAT			-0.0006		-0.001
TH > λ_2			(-0.92)		(-1.26)
λ_1		3.35	9.29	0.79	24.51
(percentile)		(69^{th})	(61^{st})	(89^{th})	(33^{rd})
λ_2			9.96		25.41
(percentile)			(81^{st})		(56^{th})
p-value		0.01**	0.07*	0.02**	0.02**
Observations	187	187	187	187	187
F-Statistic	29.19***	35.69***	30.97***	30.11***	41.85***
R^2	0.81	0.83	0.83	0.82	0.84

Notes: For ease of presentation the thresholds are listed by value, with λ_l being the smallest estimated threshold, regardless of whether it was the first estimated threshold. All equations include a full set of unreported country and time dummies. *t*-values are reported in brackets. All models estimated using robust standard errors. *, **, *** indicate significance at the 10, 5 and 1 per cent level respectively. The *p*-value indicating the significance of the estimated threshold is computed using the bootstrap procedure of Hansen (2000) with 1,000 replications.

control variables are of the expected sign and are significant for initial GDP per capita and investment only. The coefficients on the other control variables are not out of line with the previous literature, however. The coefficient on the IPR index is positive and significant, as was the case for the broader sample of countries considered by Falvey, Foster and Greenaway (2004a). The coefficients on the two patenting variables, while of the expected sign, are statistically insignificant, which may be attributable to their collinearity with the other variables. Alternatively, it may be that patenting is an important source of growth for subsamples of countries only. The threshold analysis examines this hypothesis for our measure of technology diffusion (FORPAT), which is the main variable of interest.

The threshold analysis reveals several interesting results. Thresholds based on the level of IPRs indicate that while foreign patenting has a significant positive impact on growth at lower levels of IPR protection, there is no significant impact of foreign patenting on

Table 9. Foreign patenting and growth: developing countries

FORPAT	*LINEAR*	*IPR*	*INITGDP*	*TRADE*	*GDP*
INITGDP	-0.12	-0.12	-0.12	-0.12	-0.13
	(-6.13)***	(-7.36)***	(-7.01)***	(-6.92)***	(-7.20)***
GDI	0.06	0.05	0.05	0.05	0.06
	(5.37)***	(5.31)***	(5.39)***	(4.98)***	(5.46)***
POPGROW	1.15	2.40	1.49	1.37	1.29
	(1.62)	(3.99)***	(2.09)**	(1.83)*	(1.79)*
SYR15	-0.007	-0.001	0.003	-0.0004	-0.002
	(-0.80)	(-0.06)	(0.27)	(-0.04)	(-0.17)
TRADE	0.008	-0.008	0.005	0.001	0.006
	(1.19)	(-1.63)	(0.73)	(0.13)	(0.92)
IPR	0.03	0.015	0.03	0.03	0.03
	(2.06)**	(1.27)	(2.27)**	(2.47)**	(2.44)**
DOMPAT	0.01	-0.11	-0.007	0.05	-0.008
	(0.54)	(-3.37)***	(-0.26)	(1.64)*	(-0.31)
FORPAT	-0.0002				
	(-0.05)				
FORPAT		-0.08	-0.02	-0.09	-0.02
TH ≤ λ_1		(-2.53)**	(-2.82)***	(-4.49)***	(-2.77)***
FORPAT			0.01		
TH > λ_1			(1.64)*		
FORPAT		-0.001		-0.02	0.004
λ_1 ≤ TH ≤ λ_2		(-0.15)		(-2.90)***	(1.05)
FORPAT		0.10		0.01	0.014
TH > λ_2		(4.17)***		(1.70)*	(3.62)***
λ_1		2.49	6.29	0.51	22.93
(percentile)		(63rd)	(26th)	(54th)	(21st)
λ_2		3.33		0.67	24.56
(percentile)		(83rd)	0.02**	(80th)	(56th)
p-value		0.03**	107	0.02**	0.06*
Observations	107	107	19.86***	107	107
F-Statistic	23.96***	33.8***	0.84	9.29***	29.20***
R^2	0.83	0.86		0.84	0.85

Notes: For ease of presentation the thresholds are listed by value, with λ_1 being the smallest estimated threshold, regardless of whether it was the first estimated threshold. All equations include a full set of unreported country and time dummies. *t*-values are reported in brackets. All models estimated using robust standard errors. *, **, *** indicate significance at the 10, 5 and 1 per cent level respectively. The *p*-value indicating the significance of the estimated threshold is computed using the bootstrap procedure of Hansen (2000) with 1,000 replications.

growth in countries with high levels of IPRs. This result suggests that overly strong IPR protection can limit the spread of knowledge through foreign patenting. The results for thresholds based on initial GDP per capita indicate that only countries in the middle regime benefit from diffusion through foreign patenting. Countries with little imitative ability and countries with significant innovative capacity do not appear to benefit from diffusion through patenting. Countries that are more open to international trade are found to benefit to a greater extent in terms of growth from foreign patenting than may be expected. Finally, we also allow for thresholds based on a measure of country market size (i.e. the level of GDP). The results suggest that for small countries increased foreign patenting has a negative effect on growth, a result suggestive of the importance of market power effects in small markets. In the middle regime increased foreign patenting has a positive and significant effect on growth, suggesting that market power effects are diminished in larger countries, while for the largest countries there is no statistically significant effect of foreign patenting on growth.

The analysis above includes both developed and developing countries in a single regression equation. One important debate concerning the impact of TRIPS is whether stronger IPR protection is likely to affect developing countries differently, depending upon their level of development, market size and imitative/innovative ability. To consider these issues, we repeat the above analysis for the 27 developing countries in our sample. The results are reported in table 9. Once again the only control variables that are consistently of the expected sign and significant are initial GDP per capita and investment. In the linear model we again find insignificant coefficients on both the domestic and foreign patenting variables.

Considering the threshold results, we find that for thresholds based on the level of IPR protection there is a positive relationship between foreign patenting and growth for developing countries with the highest levels of IPR protection. This suggests that stronger IPR protection in developing countries can encourage international technology transfer. For countries with the lowest levels of IPR protection a negative relationship between foreign patenting and growth is found. For the remaining three threshold variables we find a negative and significant relationship between foreign patenting and growth in the low regime. These results suggest that foreign patenting can have a deleterious impact on growth for developing countries with low levels of imitative ability, low levels of openness and small markets. This is consistent with many of the arguments developed in the literature arguing that market power effects can be significant for countries that have small markets and who have few domestic competitors or are sheltered from foreign competition. In countries that are more open to trade, are larger in size and are more developed in terms of GDP per capita however, the results suggest that technology diffusion through foreign patenting can be a significant source of growth.

Related literature

While valuable and informative, the accumulation of studies of individual channels of technology diffusion is unlikely to provide full information on the effects of increased IPR protection on international technology transfer for several reasons. Firstly, the decisions to export, undertake FDI or license are made jointly, implying that studies considering a single channel may produce biased results. Secondly, there are some channels that are very difficult to measure—imitation and reverse engineering for example—and, consequently, analysis of the impact of these channels does not exist. Thirdly, as noted above, there are likely to be interactions between direct channels and indirect channels, such as imitation. In view of these considerations, some authors have looked either at multiple channels simultaneously or attempted to model the overall costs and benefits of stronger IPR protection.

There are a small number of studies that consider several channels of diffusion simultaneously. Maskus (1998b) considered the joint decision of TNCs, examining the impact of patent rights on patent applications, affiliate sales, exports and affiliate assets using a four-equation simultaneous equation model. The model was estimated with data on the foreign operations of United States majority-owned manufacturing affiliates in 46 destination countries over the period 1989-1992. As independent variables Maskus included the RRI, distance from the United States, investment incentives, market size, tariff protection and the level of local R&D. Also included was the interaction between the IPR index and a dummy for developing countries. The results suggest that patent applications are strongly affected by IPR protection, though less so in developing countries. Stronger IPR protection also impacts positively upon exports, affiliate assets and affiliate sales in developing countries.

In a similar vein, Smith (2001) considers the simultaneous impact of IPR protection on United States exports, affiliate sales and licences to unaffiliated foreign firms in a sample of 50 developed and developing countries using a variant of the gravity equation. As in her previous study, the IPR variable is interacted with dummies for weak and strong imitative ability. The results suggest that stronger IPR protection increases bilateral exchange across all countries. At the same time, stronger IPR protection increases the benefits of locating abroad and leads to increases in affiliate sales and licensing relative to exports, particularly in countries with strong imitative abilities. Strong IPR protection also reduces the need to internalize knowledge assets within the firm thus increasing United States licences relative to both affiliate sales and exports. The evidence in favour of stronger IPR protection increasing United States exports is weak once multiple channels of exchange are allowed.

McCalman (2005) seeks to quantify the impact of TRIPS, by estimating an endogenous growth model for 27, mostly developed, countries.[46] He finds that in the short run (i.e. when the level of technology is held constant) the majority of countries lose due to a redistribution of wealth to foreign owners of technology. But in the long run, when research efforts can respond to the enhanced incentives provided by TRIPS, all countries benefit. McCalman shows that the increase in income levels due to enhanced innovation are sufficient to offset the redistributive impact of TRIPS, though under certain plausible parameter values India was found to lose. Given this last result, one might conjecture that countries with lower technological capability than India, but which were not covered in this study, may also suffer under TRIPS.

In an interesting case study, McCalman (2002) examines the behaviour of Hollywood film studios with respect to IPR protection in different countries. Given the large fixed costs and relatively low duplication costs of new films, IPR protection is likely to be of great importance to film studios. McCalman studies the speed of diffusion of 60 Hollywood films to 37 countries. The results suggest that increasing IPR protection from a relatively low level to a moderate level increases the speed of diffusion, but further increases to a high level reduce the speed of diffusion. The release of a film is likely to be delayed in countries with weak IPR protection, because of the risk of piracy that will reduce returns on that film. In countries with relatively high IPR protection

[46] See also McCalman (2001) who estimates the value of income transfers between countries in response to TRIPS.

studios may be less worried about piracy, but more worried about competition with their existing products, and so may also delay the release of a film. Overall, the results suggest that while some IPR protection can speed the diffusion of new products (films in this case), very strong IPR protection may in fact reduce the speed of diffusion.

5. Country specific evidence

Cross-country studies of the type reviewed so far have the advantage that they can cover a wide range of experience and circumstances. Yet they are subject to several common econometric problems, including endogeneity and measurement issues, as well as the question of the applicability of results outside the sample. The alternative approach is to undertake case studies examining the importance of the IPR regime in an individual country's economic development. Case studies allow greater depth of analysis and an accumulation of case studies can provide a similar range of experience to a cross-country study. The obvious candidates for study are those countries that have made a successful transition from technology importers to innovators.

Maskus and McDaniel (1999) considered how the Japanese patent system affected technological progress in Japan in the post-war period. They found that the patent system in place in Japan encouraged incremental and adaptive innovation and the diffusion of knowledge into the economy. This resulted from a number of measures, but most notably the use of utility models, which are patents of a shorter duration awarded to incremental inventions that build upon more fundamental discoveries. Such utility models were found to have a large positive impact on Japanese TFP growth.[47] While the direct impact of patent applications on TFP growth was smaller it was still positive, and patent applications were found to have an indirect impact on TFP growth through stimulating later utility models.

Kumar (2002) extends the discussion of the role of IPR protection in development from Japan to Taiwan Province and the Republic of Korea. He argues that the Republic of Korea also encouraged learning and diffusion through the utility model system, and claims that there was a deliberate policy of softening IPR protection to facilitate imitation by domestic enterprises. Kim (2002) argues further that in the early stages of development the Republic of Korea acquired and assimilated mature technologies in order to undertake duplicative imitation of existing foreign products with cheap skilled labour. Relatively few foreign firms patented technologies in the Republic of Korea because of its small market size and limited imitative threat. In addition to maintaining weak IPR standards, he argues that the role of government was to promote exports and to encourage the development of technical and engineering skills. In Taiwan Province, Kumar (2002) argues that

[47]Further case study evidence of the benefits of utility models includes Dahab (1986) who finds that utility models were important in allowing domestic producers to capture a significant share of the farm machinery industry by adapting foreign technology to local market conditions in Brazil, and Mikkelsen (1984) who describes how such utility models allowed the successful adaptive innovation of rice threshers in the Philippines.

IPR protection was also weak to encourage the diffusion of knowledge, with the government openly encouraging counterfeiting as a means of developing local industries.

While there was considerable diffusion of knowledge at early stages of development along with much incremental innovation in these two cases, eventually pressure from abroad forced them to strengthen their IPR regimes. Based on the experience of the Republic of Korea, Kim (2002) argues that strong IPR protection will hinder rather than facilitate technology transfer and indigenous learning activities in the early stages of industrialization when learning takes place through reverse engineering and duplicative imitation of mature foreign products. It is only after countries have accumulated sufficient indigenous capabilities and an extensive science and technology infrastructure capable of undertaking creative imitation that IPR protection becomes an important element in technology transfer and industrial activities.

Kumar (2002) goes on to document the experience of India. While inheriting a relatively strong IPR regime from colonial times that provided protection for most industries, considerable pressure built up from Indian firms in the 1960s that were unable to develop their own technology due to foreign patent holders who were restricting entry. This was particularly the case in the chemicals and pharmaceuticals industries and led to a new patent act that reduced the scope of patentability in food, chemicals and pharmaceuticals to processes and not products. It is widely accepted that these changes helped facilitate the development of local technological capability in chemicals and pharmaceuticals.[48] Kumar argues that the experience of India indicates the importance of weak IPR protection in building up local capabilities, even in countries at very low levels of development.

Maskus (2000c) examines the likely effects of introducing stronger IPR protection in the Lebanon, using survey data on 117 manufacturing and services firms. IPRs are seen as unimportant in many industries, and where patents are applied for they tend to be for minor improvements and disclosure does not provide for effective technology transfer. Whilst acknowledging their shortcomings, Maskus uses partial equilibrium models to calculate the impact of stronger IPR protection in different industries. For most industries he finds that the static effects of stronger IPR protection on prices, employment and output are likely to be negative. He goes on to suggest that dynamic gains from stronger IPR protection are possible, however, through increased FDI, increased product development by local firms (particularly in cosmetics, food products, software applications, publishing and film production), and the increased ability to enter into joint ventures or product licensing. Further, to the extent that these lead to additional technology transfer and local product development, the average quality of local products should rise.

Survey evidence from China reveals that managers of foreign enterprises are reluctant to locate R&D facilities in China for fear of misappropriation and patent infringement (Maskus et al., 2005). Enforcement problems and weak penalties were also a concern. These factors led firms that transferred technology to China not to use the latest technology, but technologies that were at least five years behind the frontier. Chinese firms were also found to suffer from trademark infringement, which in the long run is likely to be particularly damaging to enterprise development.

[48] Fink (2001) simulates the effects of the introduction of IPR protection on two therapeutic drugs in India. The results suggest that the impact of offering IPR protection can be higher prices and significant welfare losses, but that non-patented therapeutic substitutes to a patented drug can limit the extent of price increases and reduce welfare losses.

6. Summary of empirical results

The literature reviewed above has tended to use cross-country or panel data techniques to detect the role that stronger IPR protection might play in encouraging economic growth and international technology transfer. As noted in the Introduction, there are a range of channels through which growth-enhancing technology transfer might occur. Formal channels include foreign patenting, FDI and technology licensing. All of these channels may also generate informal technology transfer (technology spillovers), as can other forms of international contact, including trade in goods and services and the movement of workers. Whether growth-enhancing effects occur at all, and their magnitude if they do, also depends on the characteristics of the recipient country—such as its levels of development and human capital, openness to trade and FDI and its market size.

Because this is a relatively recent research topic the literature is still relatively small. There are also weaknesses in both the data and the econometric methodology employed. The results are far from definitive as a consequence. But while it would be premature to make strong claims on the basis of the limited evidence to date, the overall pattern of results justifies certain inferences.

It seems clear that the implications of stronger IPRs depend, inter alia, on a country's level of development (measured by GDP per capita or human capital). Three distinct groups emerged from our threshold analysis—advanced countries with innovative capability; middle-income countries with imitative capability and innovative potential; and poor countries with neither. The membership of these groups can be expected to change over time and also depends on the activity under consideration.

For the advanced countries, the evidence from section 2 suggests that strengthening IPRs raises growth, and later sections indicate that this at least partly comes about through increased innovation, as shown by increases in domestic patenting, and technology diffusion, as shown by increases in foreign patenting. These are the countries whose IPR regimes already meet or exceed the TRIPS standards, leaving them free to strengthen them further if they wish.

For middle-income countries, the evidence suggests that strengthening IPRs has no overall effect on growth. Despite this the evidence suggests that a stronger IPR regime encourages both domestic innovation and technology diffusion through foreign patenting and international trade in these countries, with evidence also indicating that both domestic innovation and technology diffusion can impact positively upon growth. For such countries therefore the potential for gains from stronger IPRs exists. The available evidence indicates however that the beneficial impact of stronger IPR protection on domestic innovation and technology diffusion in these countries is to a certain extent offsetting the growth-enhancing benefits otherwise obtained from the imitation now precluded by the stronger IPR regime. These are countries whose IPR regimes will need to be strengthened in order to meet the TRIPS standards. Their policy focus should be to encourage domestic firms to shift from imitation to innovation and to facilitate other activities with growth-enhancing technology spillovers.

For poor countries, the evidence from section 2 suggests that strengthening IPRs encourages growth. Unfortunately research so far is less than enlightening on the exact channels through which this occurs. Stronger IPRs appear to have no effect on innovation in these countries and the evidence reviewed suggests that the impact on international trade of stronger IPR protection in these countries is negative. Moreover, while stronger IPR protection is found to encourage foreign patenting, this has no significant effect on growth in the lowest-income countries. These are countries whose IPR regimes will also need to be strengthened to meet the TRIPS standards. It may be that most will not have significant imitative or innovative capability in the near future. Those which do must be concerned that TRIPS will inhibit their firms from passing through the imitative stage that seems to be the precursor to gaining innovative capability in relatively high-tech industries. The TRIPS obligations may make WTO membership less attractive for those countries with imitative aspirations.

A country's openness to international trade also seems important in determining the impact of IPR protection on growth, innovation and technology diffusion. The evidence from section 2 suggests that, other things equal, stronger IPRs have a significant and positive effect on growth in more open economies. The exact mechanism through which this occurs is yet to be revealed, but it appears to involve the substitution of domestic innovation for technology produced abroad, since stronger IPRs seem to lead to less domestic patenting and more foreign patenting in more open economies. And it is not just that more open economies receive more foreign patents. The evidence suggests that the growth-enhancing effects of foreign patenting also appear to be stronger in more open economies

In addition to the role of trade in the relationship between IPRs and growth, IPRs are also found to influence trade, with evidence suggesting that stronger IPR protection leads to larger trade flows, albeit mainly for countries with imitative capability and not necessarily in goods and industries considered high-tech or patent sensitive.

Since most innovation occurs in a few advanced countries, FDI and technology licensing are often perceived as the major formal channels for international technology transfer. But while there is some evidence that stronger IPRs encourage licensing, the evidence on whether stronger IPRs encourage FDI is largely inconclusive. IPRs do appear to be important for some TNC activities (R&D and local production) and in some sectors (chemicals and pharmaceuticals), however. Most host countries anticipate that FDI or licensing will yield further benefits from technology spillovers to domestic firms. By their nature such spillovers are difficult to measure, so perhaps it is not surprising that there is little conclusive evidence of growth-enhancing spillovers through inward FDI, either at the economy-wide, industry or firm level.

The above suggests that for some countries foreign patenting may be an important source of technology transfer. In addition to the effects discussed so far, the evidence indicates that a country's market size may be important in determining whether increased foreign patenting encourages or inhibits growth. When the full sample of countries was considered the evidence suggests that increased foreign patenting has a negative effect on growth in small countries, a positive effect in middle sized countries and no effect in larger countries. Results for developing countries reported in the paper suggest that foreign patenting has a positive impact on growth in countries with relatively high levels of IPR protection, for relatively open economies and for countries with relatively large markets. Combined with the result that stronger IPR protection encourages foreign patenting in developing countries, these results are consistent with the broad conclusions of the literature that stronger IPR protection should encourage technology diffusion and that the benefits of technology diffusion should be greater in more open economies, countries that are more developed and in larger markets where foreign firms have less market.

7. Policy responses to TRIPS

Few developing countries agreed to TRIPS in the hope or expectation that it would encourage domestic innovation and international technology diffusion. Indeed, since the adoption of the Agreement, the North-South technological gap has continued to grow (Correa, 2001). In response an international commission on IPRs established by the British Government has questioned whether the TRIPS Agreement is likely to provide any benefits to the world's poorest countries.[49] The Commission argues that stronger IPR protection is unlikely to make the poorest countries attractive locations for innovation and recommends that for such countries the deadline for adopting TRIPS standards should be extended until at least 2016.[50] This recommendation has to an extent been taken up by the WTO's TRIPS council which recently decided to extend the transition period for the least-developed countries by seven and half years from the 1 January, 2006 until the 1 July, 2013. Despite this concession the trend for developed countries is not towards a relaxation of the TRIPS Agreement, but towards a strengthening of IPR protection (Correa, 2001). Moreover as acknowledged in the Commission's report, for many developing countries at a certain level of development and with a certain innovative capacity, stronger IPR protection may be beneficial, supporting innovation and technology diffusion and in turn enhancing growth. These conclusions are consistent with those drawn from the literature reviewed above.

In the past, countries have been able to adapt their IPR regimes to facilitate technological transfer and to promote their own industrial policy objectives. Both anecdotal evidence and the case study evidence reviewed above, indicates that many current innovators operated lax IPR systems in the past, designed to encourage technology diffusion through imitation, as well as incremental innovation through utility models. While TRIPS removes a large part of this flexibility, it does allow countries to undertake different policies with respect to IPR protection. In this section we discuss policies consistent with TRIPS that can help countries maximize the benefits (or minimize any losses) from TRIPS. The potential policy responses to TRIPS have been considered quite

[49] The Commission on Intellectual Property Rights (2002).

[50] Article 66 allows those least developed countries that are experiencing difficulties in implementing TRIPS to seek time extensions.

extensively elsewhere,[51] and we draw upon this work to examine policies that can affect the relationship between IPRs and both innovation and technology diffusion.[52]

From our summary of the empirical evidence it is clear that policy recommendations should vary according to a country's level of development and its level of imitative or innovative capacity. The policy priority in poor countries, with weak institutions and limited R&D capacity for example, should be to improve the investment environment, with liberal trade policies to encourage imports of technology embodied in goods. Such countries should not be required to apply and enforce strong IPR obligations and they should have access to mechanisms that reduce the cost of importing IPR protected goods. Hoekman et al (2004) argue that this could be achieved through a direct subsidy or more likely a differential pricing scheme that lowers the consumption cost of technology intensive imports. For other developing countries, with relatively high levels of innovative potential, the stronger IPR protection required by TRIPS can encourage domestic firms to switch from imitation to innovative activities. Stronger IPR protection in these countries by encouraging technology diffusion through international trade and foreign patenting will also help offset any adverse growth effects from lost imitative opportunities. We begin by looking at policy responses at the national level, and then turn to the role of multilateral organizations.

Intellectual property rights related policies

In order for countries to benefit in terms of growth, TRIPS should encourage domestic innovation and international technology diffusion, while limiting the market power of foreign patent holders. While TRIPS sets minimum standards for IPR protection, it does leave some room for discretion and this can be used to achieve these goals. Maskus (2004) sets out policies with respect to patent fees, the scope of patentability and standards for the inventive step, or novelty requirement of patents, that may contribute to the development of a domestic innovative sector and to the international diffusion of technology.

The fees for patent applications and for the renewal of patents and trademarks can be set to promote both innovation and diffusion. It is possible, for example, to set lower patent application fees for small and medium-sized enterprises than for large firms, thus encouraging innovation by local firms. Patent renewal fees may also rise over time to encourage firms to let patents on mature technologies lapse early, thus allowing domestic firms to imitate older technology, which as discussed above was one factor in the development of countries such as the Republic of Korea and Taiwan Province for example.

Developing countries can also limit the scope of the subject matter that can be patented. TRIPS does not define "invention" nor specify the three criteria for patentability

[51]See Maskus (2000a, 2004), Kumar (2002) and Hoekman et al. (2004) in particular.

[52]In this paper we concentrate specifically on those policies that may affect innovation and international technology diffusion, and in turn long-run growth. Maskus (2000a, 2004) and Primo Braga et al. (2000) discuss the more general policy responses required following TRIPS, including those related to creating the enforcement processes and procedures and building up the capacity to process patent applications in developing countries.

(i.e. that it is "new", involves a "non-obvious inventive step" and is "capable of industrial application"). Allowable claims could therefore be made narrow and limited to single technologies or applications, which will not block others from inventing around the patent. Broad patents on the other hand could allow rights that go considerably beyond the claimed invention itself and could thereby discourage subsequent innovation.

Countries could also set high standards for the inventive step in order to prevent routine discoveries from being patented. This could be combined with a system of utility models to encourage local firms to invent around patents and to improve their manufacturing methods. As discussed above, utility models, which award patents to incremental innovations, have been shown to encourage local domestic innovation and these should be considered as a means of developing a domestic innovative sector. Introducing a second tier patent regime will be of little use, however, if there are too few national resources to create the user base.

Developing countries should also encourage the rapid publication of patent applications, with full disclosure of the technical processes involved in producing the inventions and how to put them to commercial use. This will maximize the spillovers to local firms, allowing them to build upon the disclosed knowledge and possibly to invent around the patent. This tactic will be constrained by the need to attract foreign patenting in the first place, however.

But whatever their post-TRIPS policy choices, developing countries have to be aware of the likely response from the developed countries that demanded the stronger IPR protection in the first place. Some will argue that any imitation unauthorized by the IPR holder is piracy and theft. The United States Congress for example has not renounced unilateral trade action and reserves the right of the United States Trade Representative to initiate bilateral negotiations with countries whose IPR standards may be TRIPS compatible but nevertheless lower than those of the United States. Indeed, several developing countries have already complained about the continuous use of unilateral pressure to raise IPR protection beyond the minimum levels of TRIPS (see Correa, 2001).

Competition policies

One potential outcome of TRIPS that is of particular concern to developing countries is that stronger IPR protection strengthens the market power of foreign TNCs, which may lead to reduced sales and higher prices,[53] and which can limit the extent of technology diffusion. In addition enhanced market power may restrict entry and can lower the rate of innovation. As our summary of the empirical literature in section 6 indicates, this may be of particular concern in countries that are relatively closed to trade and those with small markets. Moreover, as Correa (1999) notes, in most developing countries mechanisms aimed at controlling restrictive business practices, or the misuse of IPRs, are either weak or non-existent.

---

[53]Lanjouw (1997) and Maskus (1998c) for example find that stronger patent protection increases the price of protected drugs considerably when compared with copied or generic drug prices.

Enhanced market power through stronger IPR protection may facilitate other forms of anti-competitive behaviour, including selling practices and licensing restrictions (Primo Braga et al., 2000).[54] These include: *(a)* the cartelization of potential competitors through cross licensing agreements that fix prices, limit output or divide markets; *(b)* the use of IPR-based licensing agreements to exclude competitors in particular markets by raising entry barriers through tie-in sales or restrictions on the use of related technology; *(c)* the use of IPR protection to predate competitors by threatening or initiating bad faith litigation and opposition proceedings, which may raise market entry barriers particularly for new and small enterprises. It has been argued elsewhere, however (Maskus, 2000a), that IPR protection alone rarely creates such power unless accompanied by restrictions on competitive entry by other firms.

TRIPS article 40 sets out a general right for countries to establish and enforce anti-monopoly policies for the purposes of combating abusive technology licensing practices. There exist a range of domestic policies that are consistent with TRIPS and which can offset such market power effects. Examples include price controls, compulsory licences, and parallel imports. To the extent that anti-competitive practices are reliant on restrictions on competitive entry, however, there is a rationale for using policy to minimize entry barriers, through limiting business regulation and through the further opening of the economy to international trade and investment, which allows greater competition from foreign sources.

One possibility for governments that wish to reduce the impact of IPR induced market power on prices would be to consider price controls through reference prices or administrative ceilings. A balance between the host country's and foreign firm's interests needs to be struck, allowing firms to generate "normal" profits on their underlying R&D investments (Primo Braga et al., 2000). Such practices are not uncommon in pharmaceuticals, particularly where health is publicly funded. But price controls are relatively inflexible and distort market signals. Their widespread use is to be avoided.

Compulsory licences are an alternative possibility for limiting market power. A compulsory licence is an involuntary contract between a patent holder and a third party authorized by the national authorities that entitles the licensee to exploit the patent for a fixed period of time during the patent life, upon the payment of reasonable remuneration to the right holder. Firms taking out a patent in a country which grants compulsory licences will know that any attempt to restrict supply to exploit its monopoly power could be undermined in this way. Governments may resort to compulsory licensing to promote public health, welfare, security, competition and other objectives. These would need to be transparent and well defined in order not to discourage the entry of foreign firms and the development of new technologies by domestic firms (Maskus, 2004). Moreover, the threat of compulsory licensing is only credible if a potential licensee capable of supplying the patented product economically at a lower price exists. While potentially useful as a means of limiting anti-competitive behaviour, there is little

[54]Article 40 of TRIPS lists specific anti-competitive practices that may be encouraged by strong IPR protection including exclusive grantback conditions, conditions preventing challenges to validity and coercive package licensing

evidence that countries have successfully used this tool to gain access to international technologies (Maskus, 2004). Indeed, some argue that the restrictions imposed on compulsory licences are so rigorous as to eliminate nearly all prospects for effective technology transfer (Correa, 2003). In particular, requirements for compensation, the need for non-exclusive licensing, and the inability to compel transfer of know-how significantly restrict the ability of local firms to benefit from this policy.

If patenting in different countries allows the patentee to price discriminate internationally, then the profits of the innovating firm will be maximized by setting higher prices in markets with lower price elasticities of demand. Such market segmentation may also promote collusive behaviour. If price differences exceed the costs of shipment between markets, however, then profitable arbitrage opportunities arise for third parties if they ship legally sold products in low priced markets for resale in high priced markets. This is known as parallel importing.[55] Whether parallel importing is legal or not depends upon the principal of exhaustion adopted by the importing country.[56] Under a system of national exhaustion, a title holder can prevent parallel importation of their product from a foreign country. If rights are exhausted internationally, the title holder loses their exclusive privilege after the first distribution of the product, thus allowing parallel imports from abroad.[57]

The claim that price discrimination across segmented markets is harmful and promotes collusion must be considered from the relevant perspective, however.[58] Firstly, the market power associated with IPR protection may be slight if there is extensive inter-brand competition in each location. Secondly, allowing unrestrained parallel trade would establish uniform pricing by the IPR holder, subject to differences in transport and marketing costs. Economies with large markets and inelastic demand would face lower prices under uniform pricing, benefiting consumers. In contrast, countries with small markets and elastic demand would face higher prices than under price discrimination. The standard view is that this latter situation is that which pertains in most developing countries, suggesting that a global regime that allowed parallel imports may not be beneficial to them. Thirdly, foreign right holders may choose not to sell in some countries, in the presence of parallel trade, because local demand would be insufficient under uniform pricing, which in turn may lower the extent of technology diffusion.[59] Fourthly, it may be that products that would command low prices in developing countries under a regime of national exhaustion would be exported to otherwise higher priced regions under a regime of parallel imports. Here the trade-off would be increased export revenue at the expense of higher prices to

[55]It should be stressed that parallel imports are trade in legitimate goods outside official channels of distribution, and not trade in counterfeit goods. Maskus (2000a, chapter 7) provides a more detailed analysis of the treatment of parallel imports.

[56]This is discussed in greater detail in Falvey, Martinez and Reed (2004). TRIPS allows members to decide for themselves the extent of exhaustion. Article 6 states that "[F]or the purposes of dispute settlement under this Agreement, subject to the provisions of Articles 3 and 4, nothing in this Agreement shall be used to address the issue of the exhaustion of intellectual property rights".

[57]A hybrid to these two extremes is a system of regional exhaustion whereby parallel trading is allowed within a particular group of countries, but parallel imports from countries outside the region are banned.

[58]Maskus (2000c) argues that if Lebanon were to adopt a policy banning parallel imports of IPR protected goods, the resulting segmentation of its market from world markets could support higher prices.

[59]Further arguments in favour of banning parallel imports relate to the possibility of parallel traders free riding on the investment, marketing and service costs of authorized distributors, and that exclusive rights make it easier to monitor marketing efforts and enforce product quality (see Maskus, 2000a, pp.208 215).

domestic consumers.[60] Finally, under certain conditions price discrimination can provide positive economic benefits at the global level.

Malueg and Schwartz (1994) show that a global ban on parallel importing could result in perfect price discrimination, in that each market has its own price, which would maximize firm profits and encourage further innovation.[61]

Recent research however suggests that the impact of banning parallel imports on innovation is theoretically ambiguous. Li and Maskus (in press) develop a model in which a manufacturer with the ability to engage in cost-reducing innovation competes for sales in its own market with parallel imports from a distributor in another market. They show that distortions associated with parallel imports reduce the incentive for the manufacturer to invest in innovation. The amount by which R&D is reduced is found to depend upon both transport costs and the legal treatment of parallel imports. Valletti (in press) develops a model in which a monopolist after conducting R&D to determine the quality of its product serves a number of different markets. In the model, price differences across markets can arise due to both differences in marginal costs and in consumer demand in different markets. Valletti shows that the impact on the level of investment in R&D of allowing parallel imports depends upon the reason for differential pricing. When differential pricing is due purely to consumer demand parallel imports reduce investment in R&D, but when differential pricing is due to cost differences parallel imports increase in R&D investment.

The role of parallel imports is therefore quite controversial. Some argue for banning parallel imports (Barfield and Groombridge, 1998), while others argue that such a ban amounts to a non-tariff barrier to trade (Abbott, 1998). A more moderate view is that they play a useful role in discouraging abusive price discrimination and collusive behaviour. The ambiguous impact of parallel imports on prices and technology diffusion leads Maskus (2000a) to conclude that the best advice seems to stick with the status quo, with each country selecting its own policy.[62] In many developing countries this would imply a presumption that a policy of international exhaustion allowing parallel imports should be followed.

Complementary policies

Much of the literature reviewed above indicates that the responsiveness of innovation and the channels for international technology diffusion to stronger IPR protection are likely to depend upon other characteristics that reflect a country's ability to innovate

[60]For developed countries therefore, there is an argument for banning parallel imports, particularly of patented drugs. This would allow patent holders to prevent pharmaceutical products priced and sold for poor people in developing countries from being arbitraged and resold in developed countries.

[61]Obviously the claim that global welfare could be higher does not mean that all countries benefit equally or even at all. Price discrimination redistributes consumer benefits from high-price countries to low-price countries.

[62]While the results discussed here hold for all forms of IPR protection, Primo Braga et al. (2000) note that in the area of trademark protection, parallel imports may undermine the efforts of the property right owners to guarantee consistent quality and to maintain pre-sales and after-sales services.

and take advantage of foreign knowledge. Here we consider complementary policies that may encourage domestic innovation and technology diffusion.

Encouraging local technology development can have both a direct effect on productivity and growth, especially as many of the benefits of R&D are likely to be local in nature, and an indirect effect by encouraging greater technology diffusion. But while encouraging local technology development should be a priority for the relatively more advanced developing countries, the benefits of such policies for the least developed countries are likely to be limited, particularly if they draw scarce resources away from other more pressing activities, such as education and health care. Evidence suggests that the ability of domestic firms to absorb foreign technology does depend upon the existence of an in-house R&D capacity.[63] Technology policies, capital market regulations and tax policies could therefore be adjusted to encourage more innovation and in turn technology diffusion. Developing domestic innovative capacity may also lead to increased inflows of FDI, which could further increase technology diffusion. Examples of policies to encourage domestic innovative activities include public assistance for basic R&D and public-private research partnerships.[64] Direct subsidies can be quite costly, however, by distorting resource allocation decisions, encouraging firms to behave strategically in order to win subsidies, and creating opportunities for corruption and rent seeking behaviour. Hoekman et al., (2004) argue that the biggest problem of implementing subsidy policies is that they are difficult to control and that governments need to be able to determine which efforts are successful and establish an effective and credible exit strategy from those that are unsuccessful.

Investment in education may also encourage domestic innovation and the international diffusion of technology. Although there is limited evidence on the subject, it is to be expected that stronger IPR protection would become more important in encouraging innovation in countries with high levels of education and training, particularly in science and technology. In addition to encouraging innovation, countries that invest in education are likely to encourage greater inflows of FDI in response to a strengthening of IPR protection. Moreover, by enhancing a country's absorptive capacity, education is likely to encourage the adaptation of foreign technology.[65] But in order to encourage domestic innovation and technology diffusion, skills other than basic literacy and mathematical skills are required. As such there is an argument for encouraging higher education in science and engineering, which will improve specialist skills. This could involve encouraging students to undertake training at foreign universities, which in itself could act as a form of technology diffusion. At the same time, such a policy is subject to the risk of a "brain drain", with trained graduates not returning to work in their country of origin.

---

[63] Aggregate evidence from developed countries also suggests that the presence of a domestic R&D sector can allow countries to benefit from foreign technology (see for example Crespo-Cuaresma et al., 2004; Griffith, Redding and van Reenen, 2004)

[64] Utility models as discussed earlier may also promote domestic adaptive innovation.

[65] Crespo-Cuaresma et al. (2004) also present evidence for OECD countries suggesting that the benefits from foreign technology spillovers are stronger in countries with higher levels of human capital.

Technology diffusion

To the extent that trade flows, FDI, technology licensing and foreign patenting lead to externalities in the form of technology spillovers, they should be encouraged. While the evidence in favour of these channels encouraging technology diffusion is mixed, in countries with significant imitative abilities the evidence reviewed above suggests that stronger IPR protection could increase such flows. Other factors are also likely to be important in increasing both the flows and the knowledge spillovers through these channels. These include sufficient levels of human capital (which can raise a country's imitative and innovative ability as discussed above), the local investment climate, market competition, governance policies and the degree of openness to trade and foreign investment.

Available evidence suggests that FDI and licensing are attracted to locations with an effective infrastructure, stable government, and open trade and investment regimes (Wheeler and Mody, 1992; Brainard, 1997; Carr et al., 2001). While government incentives to undertake FDI in a country may be important in some cases, in general they are ineffective in the absence of an adequate skilled labour force, market opportunities, infrastructure, macroeconomic stability and political and legal predictability (Wallace, 1992).

The empirical evidence reviewed above suggests that the impact of IPR protection on growth is stronger in more open economies. Moreover, stronger IPR protection creates market power that is more easily abused in closed economies. In addition to a liberal stance on inward trade and FDI improving a country's access to foreign technologies, intermediate inputs and producer services therefore, openness may reduce monopoly power and encourage innovation and growth. The problem that IPR protection in small and relatively closed economies can lead to market power effects that limit the diffusion of knowledge may be partly relaxed by membership of a Regional Trade Agreement if this increases the effective size of the market served by IPR holders.

The role of multilateral organizations

For most developing countries, achieving the benefits of access to developed country markets that membership of the WTO can provide comes at the perceived cost of strengthening their IPR regime in order to conform to the TRIPS Agreement. Ensuring that developing countries obtain the maximum net benefit from TRIPS is a task facing their governments, and one in which multilateral organizations can provide assistance. In this as in many other areas, the degree and type of assistance required will depend on the circumstances of the country concerned. The empirical literature reviewed above has highlighted the relevant country characteristics: levels of development, skill levels, market size and openness to trade and FDI. One major potential benefit to developing countries from strengthening their IPR regimes to comply with TRIPS is through the increased international transfer of technology this induces in some circumstances. Multilateral organizations can also have a role to play in facilitating this transfer.

One point that should be clear from the literature reviewed above is that there is still much to learn about the economic effects of IPR protection. Multilateral organizations can play a significant role in facilitating research in this area and in encouraging the dissemination of its findings to all interested parties. Primo Braga et al (2000) argue that such research should focus on specific types of intellectual property and should analyse the implications of IPRs under different country-specific and sector-specific circumstances. A combination of the broad multi-country studies of the type reviewed here, and specific country and sector case studies seems appropriate.

Each developing country will need to design an IPR regime that best fits its own circumstances, subject to being TRIPS compliant. Appropriate policies were discussed above. But this regime will also need to be modified as circumstances change and as the country develops. Individual countries stand to benefit from the knowledge and experience of those who have gone before them and multilateral organizations can encourage the accumulation of this knowledge and facilitate access to it.

Along the same lines, multilateral organizations may play a role in capacity building in this area more generally. Maskus (2004) argues that capacity building in IPRs should focus less on the specification of protective laws and regulations and more on the technical, judicial and legal expertise underlying effective technology transfer. One possibility is the development of a repository and the publication of best practices in foreign licensing contracts with subsidiaries, joint ventures and arm's length partners. Multilateral organizations have a role to play in reducing overall information problems by encouraging collaboration and information sharing among governments, possibly by serving as an intermediary for knowledge about successful technology acquisition programmes that have been undertaken in the past (Saggi, 2003). Technical standards play an important role in diffusing production and certification technologies, and learning technical standards is often tantamount to learning technology. Here multilateral organizations could create a pool of experts to aid standard setting bodies in developing countries (Maskus, 2004).

Given the importance of the presence of innovative capacity for successful international technology diffusion, multilateral organizations could play a role in encouraging the development of a research culture in developing countries. This could include the development of training programmes in how technology is transferred, as well as the financing of education programmes more generally, particularly those that can aid the diffusion of technology (Maskus, 2004). In this area the training of scientists and engineers would seem to be a priority, possibly in advanced country institutions.[66] A complementary approach would also exploit the use of the Internet for online training services (Maskus, 2004). The development of a domestic R&D sector could be encouraged through public-private R&D partnerships and supporting research institutions in developing countries. Donor countries and multilateral organizations could consider establishing specific trust funds to finance the training of scientific and technical personnel to facilitate the transfer of technologies that are particularly important in the provision of public services, and for encouraging research in developing countries (Roffe, 2002). Multilateral organizations may also have a role to play in supporting research

[66]Indeed, negotiations over the temporary cross-border movement of people have already been launched in the WTO with respect to the GATS agreement on trade in services. This could be extended to include people who move temporarily to increase their education levels. (Hoekman et al., 2004).

into technologies that would be productive in developing countries for social needs, such as water treatment, energy and the environment (Maskus, 2004).

Article 66.2 of the TRIPS Agreement provides an obligation on behalf of developed country governments to provide incentives to their enterprises and institutions to promote technology transfer to the least-developed countries.[67] Hoekman et al (2004) suggest that this benefit should be extended to other low-income developing countries that have little or no innovative capacity. There is, of course, no assurance that this encouragement will be successful. While there are clear constraints on imposing obligations on governments with respect to the disposal of private property, Maskus (2004) argues that multilateral organizations, and the WTO in particular, could increase the scope for monitoring developed country efforts in the transfer of technology and could add an evaluative mechanism for the effectiveness and extent of technology transferred. Over time this approach should build up useful information about problems and effective practices in transferring technologies. An agreement at the WTO to increase the size of the pool of technologies available in the public domain or widely accessible at affordable costs could also be considered. This should certainly be feasible for research that is largely publicly funded (Barton, 2003; Maskus, 2004). Developed country governments could also extend the fiscal benefits to firms transferring technologies to disadvantaged home regions to transfers to developing countries. Similarly they could offer the same tax advantages for R&D performed abroad as for R&D done at home (Maskus, 2004).

Many suggestions for developed country action involve a cost, which weakens the incentive to implement them. There is an argument therefore for coordinating commitments through the relevant multilateral organization. Hoekman et al (2004) argue that the most powerful indirect incentive for technology transfer is for developed countries to grant significant market access for products in which poor countries have a comparative advantage. They argue that a link between technology transfer and market access exists due to the role that market size and growth play in attracting trade and FDI, and the associated incentives to invest in new technologies if export markets were more assured. Multilateral organizations, particularly the WTO, have an obvious role to play here. Developed countries could also expand their programmes for the training and development of workers in developing countries, particularly in science and technology. Maskus (2004) argues that fiscal incentives could be introduced to encourage enterprises to employ on a temporary basis recent science, engineering and management graduates from developing countries. Similarly, he argues that universities could be encouraged to recruit and train students from developing countries in science, technology and management. Incentives for setting up degree programmes through distance learning or even foreign establishments of university campuses may be considered. One problem with the temporary movement of highly skilled individuals across borders is that it may become permanent, as they perceive the personal rewards of operating in developed markets. This can lead to a brain drain and have a detrimental impact on developing countries. Thus complementary programmes to establish a domestic entrepreneurial environment that attracts back skilled workers who reside in developed countries may be important.

[67]Article 66.2 states that "Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base".

8. Concluding remarks

While few would consider IPR protection to be a panacea for developing countries, views on the importance of IPR protection tend to be polarized. On one side, it is believed that stronger IPR protection can encourage innovation, technology diffusion and enhance growth. On the other it is thought that stronger IPR protection leads to monopoly power for patent holders, reduces the incentive to innovate and limits the diffusion of knowledge. The evidence reviewed and presented here supports neither claim.

The impact of IPR protection on growth, innovation and technology diffusion in developing countries is likely to depend upon a number of factors. While stronger IPR protection in the poorest countries is not likely to lead to substantial benefits in terms of innovation or technology diffusion, the administrative cost of developing a patent system and the enforcement of TRIPS, along with the potential abuses of market power in small closed markets suggests that such countries could lose out from TRIPS. Stronger IPR protection in the poorest countries may also inhibit or lengthen the imitative stage of development that seems to be necessary in order to develop innovative capacity in many industries. Policies aimed at improving the business environment and encouraging imports of technology embodied in goods could potentially reduce such costs, though their impact on other development-related goals needs to be carefully weighed.

In other developing countries the potential for benefits from TRIPS is stronger. Here existing firms engaging in imitation could be encouraged through stronger IPR protection to shift resources towards adaptive innovation, while stronger IPR protection is likely to increase trade and FDI flows into countries with existing imitative ability, thus enhancing technology transfer. Policies to enhance the benefits of TRIPS would help develop the domestic innovative sector through encouraging R&D and investment in education, along with policies aimed at opening markets to foreign imports and encouraging inward FDI.

References

Abbot, F. (1998), "First Report (Final) to the Committee on International Trade Law of the International Law Association on the Subject of Parallel Importation", *Journal of International Economic Law*, 1, pp. 607-636.

Aghion, P. and P. Howitt (1992), "A Model of Growth through Creative Destruction", *Econometrica*, 60, pp. 323-351.

Aitken, B., G. H. Hanson and A.E. Harrison (1997), "Spillovers, Foreign Investment, and Export Behavior", *Journal of International Economics*, 43, pp. 103-132.

Aitken, B. and A. E. Harrison (1999), "Do Domestic Firms Benefit from Direct Foreign Investment?" *American Economic Review*, 89, pp. 605-618.

Arundel, A. and G. van de Paal (1995), "Innovation Strategies of Europe's Largest Industrial Firms", *Unpublished Manuscript* (Maastricht: MERIT).

Bai, J. (1997), "Estimating Multiple Breaks One at a Time", *Econometric Theory*, 13, pp. 315-352.

Bai, J. and P. Perron (1998), "Estimating and Testing Linear Models with Multiple Structural Changes", *Econometrica*, 66, pp. 47-78.

Barfield, C. E. and M. A. Groombridge (1998), "The Economic Case for Copyright Owner Control over Parallel Imports", *The Journal of World Intellectual Property*, 1, pp. 903-939.

Barro, R. J. and J. W. Lee (2000), "International Data on Educational Attainment: Updates and Implications", *Working Paper no. 42*, Center for International Development (Cambridge, MA: Harvard University).

Barton, J. (2003), *Preserving the Global Scientific and Technological Commons* (Stanford: Stanford University).

Benhabib, J. and M. M. Spiegel (1994), "The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data", *Journal of Monetary Economics*, 34, pp. 143-173.

Bernard, A. and J. B. Jensen (1999), "Exceptional Exporters Performance: Cause, Effect or Both?", *Journal of International Economics*, 47, pp. 1-25.

Blomstrom, M. and A. Kokko (1998), "Multinational Corporations and Spillovers", *Journal of Economic Surveys*, 12, pp. 247-277.

Braga, H. C. and L. N. Willmore (1991), "Technological Imports and Technological Effort: An Analysis of their Determinants in Brazilian Firms", *The Journal of Industrial Economics*, 39, pp. 421-433.

Brainard, S. L. (1997), "An Empirical Assessment of the Proximity-Concentration Trade-off Between Multinational Sales and Trade", *American Economic Review*, 87, pp. 520-544.

Branstetter, L. G. (2001), "Are Knowledge Spillovers International or Intranational in Scope? Microeconometric Evidence from the US and Japan", *Journal of International Economics*, 53, pp. 53-79.

Branstetter, L. G., R. Fisman and C. F. Foley (2004), "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data", *World Bank Policy Research Working Paper no. 3305* (Washington, DC: The World Bank).

Carr, D. L., J. R. Markusen and K. E. Maskus (2001), "Estimating the Knowledge-Capital Model of the Multinational Enterprise", *American Economic Review*, 91, pp. 693-708.

Chan, K. (1993), "Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model", *The Annals of Statistics*, 21, pp. 520-533.

Chen, Y. and T. Puttitanun (2005), "Intellectual Property Rights and Innovation in Developing Countries", *Journal of Development Economics*, 78, pp. 474-493.

Chin, J. and G. M. Grossman (1990), "Intellectual Property Rights and North-South Trade", in R. W. Jones and A. O. Krueger (eds.), *The Political Economy of International Trade*, pp. 90-107 (Cambridge, MA: Basil Blackwell).

Chong, T. T-L. (1994), "Consistency of Change-Point Estimators when the Number of Change-Points in Structural Change Models is Underspecified", *Working Paper* (Shatin, Hong Kong Special Administrative Region of China: Chinese University of Hong Kong).

Coe, D. T. and E. Helpman (1995), "International R&D Spillovers", *European Economic Review*, 39, pp. 859-887.

Coe, D. T., E. Helpman and A. W. Hoffmaister (1997), "North-South R&D Spillovers", *The Economic Journal*, 107, pp. 134-149.

Cohen, W. M. (1995), "Empirical Studies of Innovative Activity", in P. Stoneman (ed.), *Handbook of the Economics of Innovation and Technical Change* (Oxford: Basil Blackwell).

Cohen, W. M. and D. A. Levinthal (1989), "Innovation and Learning: The Two Faces of R&D", *The Economic Journal*, 99, pp. 569-596.

Cohen, W. M., R. R. Nelson and J. Walsh (1997), "Appropriability Conditions and Why Firms Patent and Why They Do Not in the U.S. Manufacturing Sector", *Working Paper* (Pittsburgh: Carnegie Mellon University).

Commission on Intellectual Property Rights (2002), *Integrating Intellectual Property Rights and Development Policy*. (London: Commission on Intellectual Property Rights).

Correa, C. M. (1999), "Intellectual Property Rights and the Use of Compulsory Licenzes: Options for Developing Countries", *Working Paper* (Geneva: South Centre).

Correa, C. M. (2001), *Review of the TRIPS Agreement: Fostering the Transfer of Technology to Developing Countries* (Penang, Malaysia: Third World Network).

Correa, C. M. (2003), "Can the TRIPS Agreement Foster Technology Transfer to Developing Countries?", *Manuscript* (Durham, NC: Duke University).

Crespo-Cuaresma, J., N. Foster and J. Scharler (2004), "On the Determinants of Absorptive Capacity: Evidence from OECD Countries", *Current Issues in Economic Growth, Proceedings of OeNB Workshops* (Vienna: Austrian National Bank), pp. 58-81.

Dahab, S. (1986), "Technological Change in the Brazilian Agricultural Implements Industry", *Unpublished PhD dissertation* (New Haven, CT: Yale University).

Das, S. (1987), "Externalities and Technology Transfer Through Multinational Corporations: A Theoretical Analysis", *Journal of International Economics*, 22, pp. 171-182.

Davidson, W. H and D. G. McFetridge (1984), "International Technology Transactions and the Theory of the Firm", *Journal of Industrial Economics*, 32, pp. 253-64.

Deardoff, A. V. (1992), "Welfare Effects of Global Patent Protection", *Economica*, 59, pp. 33-51.

De Long, J. B. and L. H. Summers (1991), "Equipment Investment and Economic Growth", *Quarterly Journal of Economics*, 106, pp. 445-502.

Diwan, I. and D. Rodrik (1991), "Patents, Appropriate Technology, and North-South Trade", *Journal of International Economics*, 63, pp. 79-90.

Dollar, D. (1992), "Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs, 1976-1985", *Economic Development and Cultural Change*, 40, pp. 523-544.

Dougherty, S. M. (1997), *The Role of Foreign Technology in Improving Chinese Productivity*, MIT Science and Technology Initiative (Cambridge, MA: MIT)

Dufour, J. (1987), "Some Impossibility Theorems in Econometrics with Applications to Structural Variables and Dynamic Models", *Econometrica*, 65, pp. 365-384.

Eaton, J. and S. Kortum (1996), "Trade in Ideas: Patenting and Productivity in the OECD", *Journal of International Economics*, 40, pp. 79-90.

Eaton, J. and S. Kortum (1999), "International Technology Diffusion: Theory and Measurement", *International Economic Review*, 40, pp. 537-570.

Evenson, R. and L. Westphal (1995), "Technological Change and Technology Strategy", in J. Behrman and T. Srinivasan (eds.), *Handbook of Development Economics, Vol. 3A*, pp. 2209-2229 (Amsterdam: North Holland Publishing Company).

Falvey, R. E., N. Foster and D. Greenaway (2002), "North-South Trade, Knowledge Spillovers and Growth", *Journal of Economic Integration*, 17, pp. 650-670.

Falvey, R. E., N. Foster and D. Greenaway (2004a), "Intellectual Property Rights and Economic Growth", *GEP Research Paper no. 04/12*, Leverhulme Centre for Research on Globalisation and Economic Policy (Nottingham: The University of Nottingham) (forthcoming in the *Review of Development Economics*).

Falvey, R. E., N. Foster and D. Greenaway (2004b), "Imports, Exports, Knowledge Spillovers and Growth", *Economics Letters*, 85, pp. 209-213.

Falvey, R. E., F. Martinez and G. V. Reed (2004), "Trade and the Globalisation of Patent Rights", Chapter 14 in E. Kwan Choi and J. C. Hartigan (eds.), *Handbook of International Trade, Volume II* (Oxford: Blackwell).

Ferrantino, M. J. (1993), "The Effect of Intellectual Property Rights on International Trade and Investment", *Weltwirtschaftliches Archiv*, 129, pp. 300-331.

Finger, J. M. and P. Schuler (2005), *Poor People's Knowledge: Promoting Intellectual Property in Developing Countries* (Washington, DC: The World Bank/Oxford University Press).

Fink, C. (2001), "Patent Protection, Transnational Corporations, and Market Structure: A Simulation Study of the Indian Pharmaceutical Industry", *Journal of Industry, Competition and Trade*, 1, pp. 101-121.

Fink, C. (2005), "Intellectual Property Rights and U.S. and German International Transactions in Manufacturing Industries", in C. Fink and K. E. Maskus (eds.), *Intellectual Property and Development: Lessons from Recent Economic Research* (Washington, DC: The World Bank/Oxford University Press).

Fink, C. and K. E. Maskus (2005), *Intellectual Property and Development: Lessons from Economic Research* (Washington, DC: The World Bank/Oxford University Press).

Fink, C. and C. A. Primo Braga (2005), "How Stronger Protection of Intellectual Property Rights Affects International Trade Flows", in C. Fink and K. E. Maskus (eds.), *Intellectual Property and Development: Lessons from Recent Economic Research* (Washington, DC: The World Bank/Oxford University Press).

Fosfuri, A., M. Motta and T. Ronde (2001), "Foreign Direct Investment and Spillovers Through Worker's Mobility", *Journal of International Economics*, 53, pp. 205-222.

Funk, M. (2001), "Trade and International R&D Spillovers Among OECD Countries", *Southern Economic Journal*, 67, pp. 725-737.

Gilbert, R. J. and D. Newey (1982), "Preemptive Patenting and the Persistence of Monopoly", *American Economic Review*, 72, pp. 514-526.

Ginarte, J. C. and W. G. Park (1997), "Determinants of Patent Rights: A Cross-National Study", *Research Policy*, 26, pp. 283-301.

Glass, A. and K. Sagi (2002), "Intellectual Property Rights and Foreign Direct Investment", *Journal of International Economics*, 56, pp. 387-410.

Globbermann, S., A. Kokko and F. Sjöholm (2000), "International Technology Diffusion: Evidence from Swedish Patent Data", *Kyklos*, 53, pp. 17-38.

Gould, D. M. and W. C. Gruben (1996), "The Role of Intellectual Property Rights in Economic Growth", *Journal of Development Economics*, 48, pp. 323-350.

Gould, D. M. and R. J. Ruffin (1993), "Human Capital, Trade and Economic Growth", *Research Paper no. 9301* (Dallas, TX: Federal Reserve Bank of Dallas).

Görg, H. and D. Greenaway (2004), "Much Ado about Nothing: Do Domestic Firms Really Benefit from Foreign Direct Investment?", *World Bank Research Observer*, 19, pp. 171-197.

Griffith, R., S. Redding, and J. van Reenen (2004), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *Review of Economics and Statistics*, 86, pp. 883-895.

Grossman, G. M. and E. Helpman (1991), *Innovation and Growth in the Global Economy* (Cambridge, MA: The MIT Press).

Hansen, B. E. (1996), "Inference when a Nuisance Parameter is not Identified under the Null Hypothesis", *Econometrica*, 64, pp. 413-430.

Hansen, B. E. (1999), "Threshold Effects in Non-Dynamic Panels: Estimation, Testing and Inference", *Journal of Econometrics*, 93, pp. 345-368.

Hansen, B. E. (2000), "Sample Splitting and Threshold Estimation", *Econometrica*, 68, pp. 575-603.

Helpman, E. (1993), "Innovation, Imitation, and Intellectual Property Rights", *Econometrica*, 61, pp. 1247-1280.

Hoekman, B. M., K. E. Maskus and K. Saggi (2004), "Transfer of Technology to Developing Countries: Unilateral and Multilateral Policy Options", *Working Paper PEC2004-0003*, Institute of Behavioral Science (Boulder: University of Colorado).

Horstmann, I. and J. R. Markusen (1987), "Licensing versus Direct Investment: A Model of Internalization by the Multinational Enterprise", *Canadian Journal of Economics*, 20, pp. 464-481.

Kanwar, S. and R. E. Evenson (2003), "Does Intellectual Property Protection Spur Technological Change?", *Oxford Economic Papers*, 55, pp. 235-264.

Keller, W. (2004), "International Technology Diffusion", *Journal of Economic Literature*, 42, pp. 752-782.

Kim, L. (2002), "Technology Transfer and Intellectual Property Rights: Lessons from Korea's Experience", *UNCTAD/ICTSD Working Paper* (Geneva: UNCTAD/ICTSD).

Kumar, N. (2001), "Determinants of Location of Overseas R&D Activity of Multinational Enterprises: The Case of US and Japanese Corporations", *Research Policy*, 30, pp. 159-174.

Kumar, N. (2002), "Intellectual Property Rights, Technology and Economic Development: Experience of Asian Countries", *RIS Discussion Paper no. 25/2002* (New Delhi: Research and Information System for the Non-Aligned and Other Developing Countries (RIS))

Lai, E. L.-C. (1998), "International Intellectual Property Rights Protection and the Rate of Product Innovation", *Journal of Development Economics*, 55, pp. 115-130.

Lanjouw, J. O. (1997), "The Introduction of Pharmaceutical Product Patents in India: 'Heartless Exploitation of the Poor and Suffering'?", *Economic Growth Center Discussion Paper no. 775* (New Haven, CT: Yale University).

Lee, J. Y. and E. Mansfield (1996), "Intellectual Property Protection and U.S. Foreign Direct Investment", *The Review of Economics and Statistics*, 78, pp. 181-186.

Lerner, J. (2001), "150 Years of Patent Protection", *NBER Working Paper no. 7478* (Cambridge, MA: National Bureau of Economic Research).

Lerner, J. (2002), "Patent Protection and Innovation over 150 Years", *NBER Working Paper no. 8977* (Cambridge, MA: National Bureau of Economic Research).

Levine, R. and D. Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, 82, pp. 942-963.

Li, C. and K. E. Maskus (forthcoming), "The Impact of Parallel Imports on Investments in Cost-Reducing Research and Development", *Journal of International Economics*.

Malueg, D. A. and M. Schwartz (1994), "Parallel Imports, Demand Dispersion, and International Price Discrimination", *Journal of International Economics*, 37, pp. 167-196.

Mansfield, E. (1985), "How Rapidly Does Industrial Technology Leak Out?", *Journal of Industrial Economics*, 34, pp. 217-223.

Mansfield, E. (1986), "Patents and Innovation: An Empirical Study", *Management Science*, February, pp. 173-181.

Mansfield, E. (1993), "Unauthorized Use of Intellectual Property: Effects on Investment, Technology Transfer, and Innovation", in M. B. Wallerstein, M. E. Mogee, and R. A. Schoen (eds.), *Global Dimensions of Intellectual Property Rights in Science and Technology* (Washington: National Academy Press).

Mansfield, E. (1994), "Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer", *Discussion Paper no. 19* (Washington, DC: International Finance Corporation).

Mansfield, E. (1995), "Intellectual Property Protection, Direct Investment and Technology Transfer: Germany, Japan and the United States", *IFC Discussion Paper no. 27* (Washington, DC: The World Bank and International Finance Corporation).

Mansfield, E., J. Rapoport, A. Romeo, S. Wagner and G. Beardsley (1977), "Social and Private Rates of Return from Industrial Innovations", *Quarterly Journal of Economics*, 16, pp. 221-240.

Mansfield, E., M. Schwartz and S. Wagner (1981), "Imitation Costs and Patenting: An Empirical Study", *The Economic Journal*, 91, pp. 907-918.

Markusen, J. R. (1995), "The Boundaries of Multinational Enterprises and the Theory of International Trade", *Journal of Economic Perspectives*, 9, pp. 169-190.

Maskus, K. E. (1997), "Implications of Regional and Multilateral Agreements for Intellectual Property Rights", *The World Economy*, 20, pp. 681-694.

Maskus, K. E. (1998a), "The International Regulation of Intellectual Property", *Weltwirtschaftliches Archiv*, 134, pp. 186-208.

Maskus, K. E. (1998b), "The Role of Intellectual Property Rights in Encouraging Foreign Direct Investment and Technology Transfer", *Duke Journal of Comparative and International Law*, 9, pp. 109-161.

Maskus, K. E. (1998c), "Price Effects and Competition Aspects of Intellectual Property Rights in Developing Countries", *Background paper for the World Bank, World Development Report 1998/99* (Washington, DC: The World Bank).

Maskus, K. E. (2000a), *Intellectual Property Rights in the Global Economy* (Washington, DC: Institute for International Economics).

Maskus, K. E. (2000b), "Intellectual Property Rights and Foreign Direct Investment", *Policy Discussion Paper no. 0022*, Centre for International Economic Studies (Adelaide: University of Adelaide).

Maskus, K. E. (2000c), "Strengthening Intellectual Property Rights in Lebanon", in B. Hoekman and J. Zarrouk (eds.), *Catching Up with the Competition: Trade Opportunities and Challenges for Arab Countries*, Studies in International Economics (Ann Arbor: University of Michigan Press).

Maskus, K. E. (2000d), "Intellectual Property Rights and Economic Development", Paper prepared for the series *Beyond the Treaties: A Symposium on Compliance with International Intellectual Property Law*, Cox International Law Center (Cleveland, Ohio: Case Western Reserve University).

Maskus, K. E. (2004), "Encouraging International Technology Transfer", *UNCTAD/ICTSD Issue Paper no. 7* (Geneva: UNCTAD/ICTSD).

Maskus, K. E., S. M. Dougherty and A. Mertha (2005), "Intellectual Property Rights and Economic Development in China", in C. Fink and K. E. Maskus (eds.), *Intellectual Property and Development: Lessons from Recent Economic Research* (Washington, DC : The World Bank/Oxford University Press).

Maskus, K. E. and D. Eby-Konan (1994), "Trade Related Intellectual Property Rights: Issues and Exploratory Results", in A. V. Deardoff and R. M. Stern (eds.), *Analytical and Negotiating Issues in the Global Trading System* (Ann Arbor: University of Michigan Press).

Maskus, K. E. and C. McDaniel (1999), "Impacts of the Japanese Patent System on Productivity Growth", *Japan and the World Economy*, 11, pp. 557-574.

Maskus, K. E. and M. Penubarti (1995), "How Trade-Related are Intellectual Property Rights?", *Journal of International Economics*, 39, pp. 227-248.

Mazzoleni, R. and R. R. Nelson (1998), "The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate", *Research Policy*, 27, pp. 273-284.

McCalman, P. (2001), "Reaping What You Sow; An Empirical Analysis of International Patent Harmonization", *Journal of International Economics*, 55, pp. 161-186.

McCalman, P. (2002), "National Patents, Innovation and International Agreements", *Journal of International Trade and Development*, 11, pp. 1-14.

McCalman, P. (2005), "Who Enjoys 'TRIPs' Abroad? An Empirical Analysis of Intellectual Property Rights in the Uruguay Round", *Canadian Journal of Economics*, 38, pp. 574-603.

Mikkelsen, K. W. (1984), "Inventive Activity in Philippines Industry", *Unpublished PhD Dissertation* (New Haven, CT: Yale University).

Nelson, R. R. and H. Pack (1999), "The Asian Miracle and Modern Growth Theory", *The Economic Journal*, 109, pp. 416-436.

Nelson, R. R. and E. S. Phelps (1966), "Investment in Humans, Technological Diffusion, and Economic Growth", *American Economic Review, Papers and Proceedings*, pp. 69-75.

Park, W. G. (1999), "Impact of the International Patent System on Productivity and Technology Diffusion", in Lippert, O. (ed.), *Competitive Strategies for Intellectual Property Protection* (Vancouver, BC: Fraser Institute).

Primo Braga, C. A. (1996), "Trade-Related Intellectual Property Issues: The Uruguay Round Agreement and Its Economic Implications", in W. Martin and L. A. Winters (eds.), *The Uruguay Round and Developing Countries* (Cambridge: Cambridge University Press).

Primo Braga, C. A. and C. Fink (1998), "The Relationship between Intellectual Property Rights and Foreign Direct Investment", *Duke Journal of Comparative and International Law*, 9, pp. 163-188.

Primo Braga, C. A., C. Fink and C. P. Sepúlveda (2000), "Intellectual Property Rights and Economic Development", *World Bank Discussion Paper no. 412* (Washington, DC: The World Bank).

Pritchett, L. (1996), "Measuring Outward Orientation in LDCs: Can it be Done?", *Journal of Development Economics*, 49, pp. 307-335.

Rafiquzzaman, M. (2002), "The Impact of Patent Rights on International Trade: Evidence from Canada", *Canadian Journal of Economics*, 35, pp. 307-330.

Rapp, R. T. and R. P. Rozek (1990), "Benefits and Costs of Intellectual Property Protection in Developing Countries", *Journal of World Trade*, 24, pp. 75-102.

Rivera-Batiz, L. A. and P. M. Romer (1991), "International Trade with Endogenous Technological Change", *European Economic Review*, 35, pp. 971-1004.

Rodríguez, F. and D. Rodrik (2000), "Trade Policy and Growth: A Skeptic's Guide to the Cross-National Evidence", *NBER Macroeconomics Annual*, 15, pp. 261-325.

Rodríguez-Clare, A. (1996), "Multinationals, Linkages and Economic Development", *American Economic Review*, 86, pp. 852-873.

Rodrik, D. (1994), "Comments on Maskus and Eby-Konan", in A. V. Deardoff and R. M. Stern (eds.), *Analytical and Negotiating Issues in the Global Trading System*, pp. 447-450 (Ann Arbor, MI: University of Michigan Press).

Roffe, P. (2002), "Preliminary Note on the WTO Working Group on Trade and Transfer of Technology", *Manuscript* (Geneva: UNCTAD).

Romer, P. M. (1990), "Endogenous Growth and Technical Change", *Journal of Political Economy*, 99, pp. 807-827.

Saggi, K. (2002), "Trade, Foreign Direct Investment, and International Technology Transfer: A Survey", *World Bank Research Observer*, 17, pp. 191-235.

Saggi, K. (2003), *International Technology Transfer: National Policies, International Negotiations, and Multilateral Disciplines*, Report for the Commonwealth Secretariat (London: Commonwealth Secretariat).

Sala-i-Martin, X. (1997), "I Just Ran Two Million Regressions", *American Economic Association Papers and Proceedings*, 87, pp. 178-183.

Scherer, F. M., S. E. Herzstein, A. W. Dreyfoos, W. G. Whitney, O. J. Bachman, C. P. Pesek, C. J. Scott, T. G. Kelly and J. J. Galvin (1959), *Patents and the Corporation: A Report on Industrial Technology under Changing Public Policy* (Cambridge, MA: Harvard University).

Schneider, P. (2005), "International Trade, Economic Growth and Intellectual Property Rights: A Panel Data Study of Developed and Developing Countries", *Journal of Development Economics*, 78, pp. 529-547.

Seyoum, B. (1996), "The Impact of Intellectual Property Rights on Foreign Direct Investment", *Columbia Journal of World Business*, 31, pp. 50-59.

Sherwood, R. M. (1997), "The TRIPS Agreement: Implications for Developing Countries", *IDEA: The Journal of Law and Technology*, 37, pp. 491-544.

Smarzynska, B. (2004), "The Composition of Foreign Direct Investment and Protection of Intellectual Property Rights: Evidence from Transition Economies", *European Economic Review*, 48, pp. 39-62.

Smith, P. J. (1999), "Are Weak Patent Rights a Barrier to U.S. Exports?", *Journal of International Economics*, 48, pp. 151-177.

Smith, P. J. (2001), "How Do Foreign Patent Rights Affect U.S. Exports, Affiliate Sales, and Licenzes?", *Journal of International Economics*, 55, pp. 411-440.

Taylor, C. T. and Z. A. Silberston (1973), *The Economic Impact of the Patent System* (Cambridge: Cambridge University Press).

Taylor, M. S. (1993), "TRIPs, Trade, and Technology Transfer", *Canadian Journal of Economics*, 26, pp. 625-638.

Teece, D. J. (1986), *The Multinational Corporation and the Resource Cost of International Technology Transfer* (Cambridge: Ballinger Press).

Thompson, M. A. and F. W. Rushing (1996), "An Empirical Analysis of the Impact of Patent Protection on Economic Growth", *Journal of Economic Development*, 21, pp. 61-79.

Thompson, M. A. and F. W. Rushing (1999), "An Empirical Analysis of the Impact of Patent Protection on Economic Growth: An Extension", *Journal of Economic Development*, 24, pp. 67-76.

United Nations Conference on Trade and Development (1996), *The TRIPs Agreement and Developing Countries* (Geneva: UNCTAD).

United Nations Industrial Development Organization (2002), *Industrial Development Report 2002/2003* (Vienna: UNIDO).

United Nations Industrial Development Organization (2005), *Industrial Development Report 2005* (Vienna: UNIDO).

US Chamber of Commerce (1987), *Guidelines for Standards for the Protection and Enforcement of Intellectual Property Rights*, Report of the US Chamber of Commerce Intellectual Property Task Force (Washington, DC: US Chamber of Commerce).

Valletti, T. (forthcoming), "Differential Pricing, Parallel Trade, and the Incentive to Invest", *Journal of International Economics*.

Wallace, C. D. (1992), "Foreign Direct Investment in the Third World", in C. D. Wallace (ed.), *Foreign Direct Investment in the 1990s* (Washington, DC: Center for Strategic and International Studies).

Wheeler, D. and A. Mody (1992), "International Investment Location Decisions: The Case of U.S. Firms", *Journal of International Economics*, 33, pp.57-76.

WIPO (Various Years), *WIPO Industrial Property Statistics* (Geneva: World Intellectual Property Organization).

World Bank (2001), *World Development Indicators* (Washington, DC: World Bank).

Xu, B. and E. P. Chiang (2005), "Trade, Patents and International Technology Diffusion", *Journal of International Trade and Economic Development*, 14, pp. 115-135.

Xu, B. and J. Wang (1999), "Capital Goods Trade and R&D Spillovers in the OECD", *Canadian Journal of Economics*, 32, pp. 1258-1274.

Xu, B. and J. Wang (2000), "Trade, FDI and International Technology Diffusion", *Journal of Economic Integration*, 15, pp. 585-601.

Yang, G. and K. E. Maskus (2001a), "Intellectual Property Rights, Licensing, and Innovation in an Endogenous Product-Cycle Model", *Journal of International Economics*, 53, pp. 169-187.

Yang, G. and K. E. Maskus (2001b), "Intellectual Property Rights and Licensing: An Econometric Investigation", *Weltwirtschaftliches Archiv*, pp. 137, 58-79.

Annex I.
Construction of the Ginarte and Park IPR index

The following is an outline of how the strength of IPR protection was constructed and is taken from the appendix of Ginarte and Park (1997).

(1)	Coverage	YES	NO
	Patentability of pharmaceuticals	1	0
	Patentability of chemicals	1	0
	Patentability of food	1	0
	Patentability of plant and animal varieties	1	0
	Patentability of surgical products	1	0
	Patentability of microorganisms	1	0
	Patentability of utility models	1	0
(2)	Membership in international treaties	YES	NO
	Paris convention and revisions	1	0
	Patent cooperation treaty	1	0
	Protection of new varieties (UPOV)	1	0
(3)	Loss of protection measures against losses	YES	NO
	Working requirements	1	0
	Compulsory licensing	1	0
	Revocation of patents	1	0
(4)	Enforcement	YES	NO
	Preliminary injunctions	1	0
	Contributory infringement	1	0
	Burden-of-proof reversal	1	0
(5)	Duration	Value	
	Application-based standard		
	$x \geq 20$ years	1	
	$0 \leq x < 20$	$x/20$	
	Grant-based standard		
	$x' \geq 17$ years	1	
	$0 \leq x' < 17$	$x'/17$	

Notes: Where x = duration of protection in years under an application-based standard and x' = duration of protection under a grant-based standard.

The value of each category, other than duration, is j/k where j is the number of "1"s received (or number of conditions satisfied) and k the number of conditions to be satisfied.

Source: Ginarte and Park (1997).

Annex II. Threshold regression analysis

Threshold regression analysis is particularly useful when we expect the relationship between two variables to be contingent upon the value of a third variable. In the case of IPR protection such models can be particularly useful therefore, since IPR protection is expected to impact differently upon countries at different stages of development. In a series of papers, Hansen (1996, 1999 and 2000) develops a technique that allows the sample data to jointly determine both the regression coefficients and the threshold value. In addition the technique allows one to test the significance of the threshold value. In this Appendix we briefly describe this approach.

Estimation

We can write the threshold regression model for a single threshold as:

$$\gamma_i = \delta_1 x_i + \varepsilon_i \qquad q_i \leq \lambda_1 \qquad (1)$$
$$\gamma_i = \delta_2 x_i + \varepsilon_i \qquad q_i > \lambda_1 \qquad (2)$$

where q_i is the threshold variable. Here the observations are divided into two regimes depending on whether the threshold variable is smaller or larger than λ_1. The two regimes are distinguished by different regression slopes, δ_1 and δ_2. Chan (1993) and Hansen (1999) recommend estimation of λ_1 by least squares. This involves finding the value of λ_1 that minimizes the concentrated sum of squared errors. In practice this involves searching over distinct values of q_i for the value of λ_1 at which the sum of squared errors is smallest. This value of λ_1 is our estimate of the threshold, λ_1. Once we have a value for it, it is straightforward to estimate the coefficients of the regression model.

This approach can be extended to any number of thresholds. In the two-threshold model we would then have the following:

$$\gamma_i = \delta_1 x_i + \varepsilon_i \qquad q_i \leq \lambda_1 \qquad (1)$$
$$\gamma_i = \delta_2 x_i + \varepsilon_i \qquad \lambda_1 \leq q_i \leq \lambda_2 \qquad (2')$$
$$\gamma_i = \delta_3 x_i + \varepsilon_i \qquad q_i > \lambda_2 \qquad (3)$$

where λ_2 is the second threshold and the thresholds are ordered so that $\lambda_1 < \lambda_2$. It is a straightforward extension to search for the values of λ_1 and λ_2 that minimize the sum of squared errors. At the same time however this can be computationally demanding. Chong (1994), Bai (1997) and Bai and Perron (1998) have shown that sequential estimation is consistent, thus avoiding this computation problem. This involves fixing the first threshold at λ_1 and searching for a second threshold assuming that the first is fixed. It can be shown that the estimate of λ_2 is asymptotically efficient, but that λ_1 is not. This is because the estimate λ_1 was estimated from a sum of squared errors, a function that was contaminated by the presence of a neglected regime. Bai (1997) suggests a refinement estimator for λ_1, which involves fixing the second threshold at λ_2 and searching for the first threshold, λ_1, now including the second threshold. We denote this refined estimate by λ_1.

Testing for the significance of a threshold

Having found a threshold it is important to determine whether it is statistically significant or not, that is, to test the null hypothesis H_0: $\delta_1 = \delta_2$. Given that the threshold λ_1 is not identified under the null, this test has a non-standard distribution and critical values cannot be read off standard distribution tables. Hansen (1996) suggests bootstrapping to simulate the asymptotic distribution of the likelihood ratio test allowing us to obtain a *p* value for this test. Firstly, one estimates the model under the null (linearity) and alternative (threshold occurring at λ_1). This gives the actual value of the likelihood ratio test, (*F1*),

$$F_1 = \frac{S_0 - S_1(\lambda_1)}{\sigma^2} \qquad \text{where} \qquad \sigma^2 = \frac{1}{n(t-1)} S_1(\lambda_1)$$

Here S_0 and S_1 are the residual sum of squares from the linear and threshold models respectively. Then a bootstrap is created by drawing from the normal distribution of the residuals of the estimated threshold model. Hansen (2000) recommends fixing the regressors in repeated bootstrap samples. Using this generated sample, the model is estimated under the null and alternative and the likelihood ratio F_1 is obtained. This process is repeated a large number of times (in our case 1,000). The bootstrap estimate of the *p*-value for F_1 under the null is given by the percentage of draws for which the simulated statistic F_1 exceeds the actual one.

In the case of the two-threshold model we would like a test to discriminate between one and two thresholds. An approximate likelihood ratio test of one versus two thresholds is given by the following statistic,

$$F_1 = \frac{S_0 - S_1(\lambda_1)}{\sigma^2} \qquad \text{where} \qquad \sigma^2 = \frac{1}{n(t-1)} S_1(\lambda_1)$$

To obtain the p-value a bootstrap procedure is once again followed with the dependent variable being generated under the null hypothesis of a single threshold.

The threshold analysis in this paper begins by estimating a single threshold on each of the threshold variables considered. If the first threshold is found to be significant using the bootstrap procedure described above we search for a second threshold using the sequential estimation method described above. We continue this process until an insignificant threshold is found. To maintain a reasonable sample size in each regime we adopt the restriction that at least 10 per cent of observations must be in each regime.

Annex III. Empirical method, data sources and construction

Empirical methods

In the empirical analysis we relate both the level of IPR protection (section 2) and the level of international technology diffusion, as measured by patent applications from non-residents to economic growth in a relatively large sample of developed and developing countries. The starting point for this analysis is, by now, a standard empirical growth regression in a panel setting. Following the contributions of Levine and Renelt (1992) and Sala-i-Martin (1997) there has been some standardization of the variables included in empirical growth models. The core regression that we estimate is the following:

$$GROWTH_{it} = \beta_1 INITGDP_{it} + \beta_2 GDI_{it} + \beta_3 POPGROW_{it} + \beta_4 SYR15_{it} + \beta_5 TRADE_{it} + \mu + \upsilon + \varepsilon$$

where GROWTH is the average growth of GDP per capita over each five-year period, INITGDP is the log of initial GDP per capita in each five-year period, GDI is the log of the average level of investment in each five-year period, POPGROW is the average growth rate of population in each five-year period, SYR15 is the average years of secondary schooling in the population over 15 at the beginning of each five-year period and TRADE is the average ratio of total trade to GDP in each five-year period. We expect positive coefficients on GDI, SYR15 and TRADE and a negative coefficient on INITGDP and POPGROW.[68] We also estimate a fixed effects specification, including a full set of time and country dummies in all specifications.

In section 2 we add to these variables the measure of IPR protection developed by Ginarte and Park (1997). We extend the linear model considering the relationship between IPR protection and growth by conducting a threshold regression analysis, to address whether the impact of IPR protection on growth depends upon the value of variables measuring imitative ability (namely INITGDP and manufacturing value-added

[68]The coefficient on population growth is expected to be negative and significant. In the existing (mainly cross-section) literature however both positive and negative coefficients have been obtained, with Levine and Renelt (1992) finding the coefficient on this variable to be "fragile". We find that excluding the country-fixed effects and estimating a pooled or a random effects model give us the more usual negative coefficient on population growth, though the coefficient tends to be insignificant. One possibility therefore is that population growth is capturing some form of market size effect.

as a share of GDP, MANVAL) and upon openness, as measured by the ratio of trade to GDP. This follows from the arguments of Thompson and Rushing (1996) and Gould and Gruben (1996).

The second part of our empirical analysis considers the impact of patenting by domestic and foreign residents on growth and of the importance of IPR protection in influencing the extent of foreign technology diffusion through patents. On the one hand, this simply extends the above growth model to include the ratio of patent applications by domestic residents per 1,000 of the labour force (DOMPAT) and the ratio of patent applications by non-residents per 1,000 of the labour force (FORPAT). The variable on domestic patents is included to account for domestic innovation, while the variable on patenting by non-residents is included to account for international technology diffusion, as discussed in the main text. Once again we extend the linear model to consider threshold effects, allowing the coefficient on foreign patenting to depend upon third variables. We consider threshold effects based on the level of IPR protection to examine whether the strength of IPR protection affects the extent of technology diffusion through foreign patenting. We also consider thresholds on the level of initial GDP per capita, which allow us to examine whether the extent of technology diffusion through foreign patenting is affected by variables used to account for a country's ability to imitate existing products and to innovate. Finally, we consider thresholds based on the ratio of trade to GDP in order to examine whether the degree of openness affects the extent of diffusion, and the level of GDP to examine whether market size affects the extent of technology diffusion.

In addition to examining the importance of foreign patenting for growth, we also examine whether the level of IPR protection impacts upon domestic innovative activity, as measured by DOMPAT, and upon international technology diffusion, as measured by FORPAT. The basic specification for our empirical model is the following;

$$X_{it} = \beta_1 INITGDP_{it} + \beta_2 SYR15_{it} + \beta_3 TRADE_{it} + \beta_4 IPR_{it} + \mu_i + \upsilon_t + \varepsilon_{it}$$

where the dependent variable, X, is either the average ratio of patent applications by domestic residents per 1,000 of labour force or the average ratio of patent applications by non-residents per 1,000 of labour force and the independent variables INITGDP, SYR15, TRADE and IPR are as defined above. In various specifications we also include a measure of higher schooling, variables representing political and civil liberties (taken from Freedom House) and in the case of the foreign patenting equation we include DOMPAT. The inclusion of these variables does not alter either the sign or significance of the main variable of interest, namely the index of IPR protection. Moreover, the coefficients on the variables themselves tend not to be significant. Since we have no solid theory on which to draw for our empirical analysis we report the results from the above parsimonious specification. The equation as written above is once again a fixed effects model allowing for unobserved country and time heterogeneity. We also experimented with both a pooled and a random effects model. The sign and significance of the coefficient on the IPR variable tends not to differ greatly across specifications.

Country coverage, data sources and construction

Most of the data used in our analysis was taken from Falvey, Foster and Greenaway (2004a). This dataset considers up to 80 developed and developing countries over the period 1975-1994 using data on four five-year averages. The sample of countries considered in our analysis is listed below. Data on patent applications is only available for 47 of these 80 countries. The 47 countries used in our analysis of domestic and foreign patenting are indicated by an asterisk in the list below.

Developed Countries	Developing Countries	
Australia*	Algeria*	Republic of Korea*
Austria*	Argentina	Malawi*
Belgium*	Bangladesh*	Malaysia
Canada*	Benin	Mauritius
Denmark*	Bolivia	Mexico*
Finland*	Botswana	Mozambique
France*	Brazil*	Nepal
Germany*	Cameroon	Nicaragua
Greece*	Central African Republic	Niger
Ireland*	Chile*	Papua New Guinea
Italy*	Colombia*	Pakistan*
Japan*	Democratic Republic of the Congo	Panama
New Zealand*	Republic of the Congo	Paraguay
Netherlands*	Costa Rica	Peru*
Norway*	Dominican Republic	Philippines*
Portugal*	Ecuador*	Rwanda
Spain*	Egypt*	South Africa*
Sweden*	El Salvador*	Senegal
Switzerland*	Fiji	Singapore*
United States of America	Ghana	Sri Lanka*
	Guatemala*	Swaziland
	Haiti	Syrian Arab Republic
	Honduras	Thailand
	India*	Togo
	Indonesia*	Trinidad and Tobago
	Iran (Islamic Republic of)*	Uganda
	Israel*	Uruguay*
	Jamaica	Venezuela*
	Jordan	Zambia*
	Kenya*	Zimbabwe*

Data for both the empirical growth model and the determinants of domestic and foreign patenting are taken from a number of available sources. Variable names, definitions and sources are listed below.

Variable	***Definition***	***Source***
GROWTH	Average growth rate of GDP per capita in each five-year period	World Development Indicators (2001)
INITGDP	(log) of initial GDP per capita in each five-year period	World Development Indicators (2001)
GDI	Average of the (log) of gross domestic investment in each five-year period	World Development Indicators (2001)
POPGROW	Average growth rate of population in each five-year period	World Development Indicators (2001)
SYR15	Average years of secondary schooling in the population over 15 at the beginning of each five-year period	Barro and Lee (2000)
INFLATION	Average annual rate of increase of the CPI index in each five-year period	World Development Indicators (2001)
TRADE	Average of the ratio of total trade to GDP in each five-year period	World Development Indicators (2001)
IPR	Index of IPR protection	Ginarte and Park (1997)
MANVAL	Average of manufacturing value-added as a share of GDP in each five-year period	World Development Indicators (2001)
DOMPAT	Average number of patent applications by domestic residents per 1,000 of labour force in each five-year period	WIPO (various years) and World Development Indicators (2001)
FORPAT	Average number of patent applications by non-residents per 1,000 of labour force in each five-year period	WIPO (various years) and World Development Indicators (2001)
GDP	Average of the (log) of the level of GDP	World Development Indicators (2001)

Annex IV. Evidence on IPR protection

Selective summary of the evidence on IPR protection and the channels of technology diffusion

Study	*Sample and method*	*Diffusion channel*	*IPR index*	*Results*
Maskus and Penubarti (1995)	Helpman-Krugman model using export data for 28 manufacturing sectors from 22 OECD countries to 71 developed and developing countries for the year 1984.	International trade	Rapp and Rozek Index	Stronger IPR protection encourages imports from OECD countries, with the impact being larger in countries with large markets.
Fink and Primo Braga (2005)	Gravity model on total non-fuel and high technology trade on a cross-section of 89 by 88 countries in 1989.	International trade	Ginarte and Park Index	Stronger IPR protection encourages trade for the total non-fuel aggregate, but has no significant impact on trade for the high-tech aggregate.
Smith (1999)	Gravity model using exports from the 50 US states plus the District of Columbia to 96 countries in 1992. Aggregate manufactured exports plus industry level exports for nineteen two-digit industries considered.	International trade	Rapp and Rozek and Ginarte and Park IPR Indices	Stronger IPR protection encourages imports from the US in countries that pose a strong threat of imitation. In countries with weak imitative ability some evidence of a negative relationship between trade and IPR protection.
Maskus and Eby Konan (1994)	Relate several measures of US foreign presence in seven manufacturing industries in 44 countries in 1982 to national characteristics, including IPR strength.	FDI	Rapp and Rozek Index	In most cases a negative relationship between IPR protection and US FDI is found, though the coefficient is rarely significant.
Mansfield (1994)	Survey evidence from 100 US firms in six manufacturing industries in 1991.	FDI	Perceived strength of IPR protection by respondents	Strong IPR protection was found to influence FDI decisions only for certain investments, such as R&D facilities. IPR protection is relatively unimportant in the decision to undertake FDI except in a small number of industries, notably chemicals and pharmaceuticals.

Study	*Sample and method*	*Diffusion channel*	*IPR index*	*Results*
Mansfield (1995)	Survey evidence from major US, German and Japanese firms.	FDI	Perceived strength of IPR protection by respondents	Strong IPR protection was found to be more important for FDI in certain investments, such as R&D facilities. IPR protection was found to be more important in encouraging FDI in certain industries, such as chemicals, machinery and electrical equipment.
Lee and Mansfield (1996)	Relate the volume of US FDI in 14 countries to the strength of IPRs. Data is from a survey of 100 US firms in 1991 in six manufacturing industries assessing the importance of IPR protection for investment in 14 countries.	FDI and its composition	Perceived measure of IPR protection based on US firms' survey responses.	FDI is lower in countries with weaker perceived IPR protection. The percentage of FDI devoted to final production and to R&D facilities is lower in countries with weak perceived IPR protection.
Kumar (2001)	Examines the relationship between FDI in R&D activity by US and Japanese TNCs and IPRs. Model is estimated for up to 77 countries in the years 1982, 1989 and 1994.	FDI in R&D facilities	Ginarte and Park Index	The strength of IPR protection has no significant impact on the extent of R&D spending overseas by Japanese and US TNCs.
Smarzynska (2004)	Probit model examining the decision of a firm to invest in a country and to invest in production facilities in a country. Firm-level survey data for 1995 on FDI in 24 East European and FSU countries.	FDI and its composition	Ginarte and Park Index and an index also capturing the enforcement aspect of the IPR regime	Weak IPR protection discourages FDI, particularly in IPR sensitive industries. Weak IPR protection deters investors from undertaking local production and encourages them to focus on distribution.
Branstetter et al (2004)	Examine the relationship between intra-firm royalty payments of US TNCs (as a measure of technology diffusion through FDI) and patent reforms in 12 countries.	FDI	Dummy representing legal reforms that strengthen IPR protection	US TNCs respond positively to changes in IPR regimes abroad by increasing technology transfers to reforming countries. Increases in technology transfer are concentrated among TNCs that patent intensively.
Yang and Maskus (2001b)	Examine the impact of IPRs on the volume of unaffiliated royalties and licence fees paid to US firms from 23 countries in 1985, 1990 and 1995.	Technology licensing	Ginarte and Park Index	Stronger IPR protection has a positive impact on licensing.
Eaton and Kortum (1996)	Model simultaneously productivity growth and the propensity to patent abroad for 19 OECD countries.	Foreign patenting	Rapp and Rozek Index	Countries providing stronger patent protection are more attractive destinations for foreign patents. Foreign patenting is found to impact positively upon productivity growth.
Park (1999)	Relates the fraction of source country patents that are filed in the destination country to the strength of IPR protection for a panel of 16 source and 40 destination countries.	Foreign patenting	Ginarte and Park Index	An increase in the strength of IPR protection has a strong positive impact on the rate of foreign patenting.

Study	*Sample and method*	*Diffusion channel*	*IPR index*	*Results*
Xu and Chiang (2005)	Model technology diffusion from three sources including foreign patenting. Examines the importance of IPR protection as a determinant of foreign patenting. Data is for 48 countries over the period 1980-2000.	Foreign patenting	Ginarte and Park Index	IPR protection has a positive impact upon the foreign patenting decision. In turn foreign patenting is positively related to TFP growth in low- and middle-income countries, but not in high-income countries.
Ferrantino (1993)	Gravity model examining the impact of IPR protection on US exports, affiliate sales by US firms and royalty and licence receipts by US affiliates in up to 77 countries in 1982.	International trade (US exports), FDI (affiliate sales) and licensing (royalty and licence receipts)	Dummies representing membership in international patent agreements and length of patent in years	Membership in IPR agreements has no significant impact on US exports and overseas affiliate sales. Some evidence that royalty receipts and payments are higher in countries that are members of IPR agreements as long as patent length is sufficiently long.
Maskus (1998b)	Relates the strength of IPR protection to patent applications, affiliate sales, exports and affiliate assets using data on US majority-owned manufacturing affiliates in 46 countries over the period 1989-1992.	Multiple channels of technology diffusion (patent data, exports, FDI and licensing)	Rapp and Rozek Index	Stronger IPR protection positively influences all four channels of diffusion. Stronger IPR protection has a weak impact on patent applications in developing countries, but positive impacts on developing countries through the other three channels.
Smith (2001)	Gravity model using aggregate manufactures data on US exports, affiliate sales and licences to 50 developed and developing countries in 1989.	International Trade (exports from the US), FDI (affiliate sales) and Licensing (dollar value of royalties and licence fees)	Rapp and Rozek Index, Ginarte and Park Index, and the number of patent lawyers in a country	Bilateral exchange reacts positively to stronger IPR protection, particularly in countries with strong imitative abilities. Strong IPR protection increases licensing and FDI at the expense of exports, and licensing at the expense of FDI. Little evidence of a relationship between IPRs and exports.

Printed in Austria
V.05-91453—June 2006—600

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: http://www.unido.org