Appropriate Patent Scope for Developing Countries

A New Empirical Approach

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ABSTRACT

This study develops a novel approach for measuring technology imitation by the South through a new proxy of patent scope. It then attempts to quantify the significance of this measure as a potential determinant of FDI inflows into selected high-technology sectors. The empirical investigation --employing data for the 1992-2001 period covering 13 countries from Asia and Latin America-- demonstrates that neither this measure of patent infringement nor the more standard measures of intellectual property protection are significant, and that the most crucial determinant of high-tech investment flows appears to be the scientific and technical sophistication of the local personnel in the recipient countries. In this way, the study generates a different set of policy implications than those emphasized by the recent international patent agreements.

1. Introduction

Protection of intellectual property rights (IPRs) has been a prominent item on the international policy agenda, especially in the context of economic globalization. Proponents of stronger IPRs point to their positive impact on a country's international trading position, technological advancement, and investment inflows. One standard hypothesis has been that a weak IPR regime deters foreign direct investment (FDI), especially in high technology sectors where knowledge-based assets play an important role. In order to promote inward investment, developing countries have been advised to adopt stronger patent laws. Recently, this has been institutionalized in the WTO agreement on trade-related intellectual property rights (TRIPs).[1] However, the extent and coverage of protection remains largely an open question and one that raises a number of

1 Under the 1994 TRIPs agreement (one of the agreements resulting from the Uruguay round of international trade talks), WTO members must adopt and enforce strong and non-discriminatory minimum standards of protection for intellectual property. To be in compliance with international standards, this is often (voluntarily) extended to technologies in new and controversial areas such as biotechnology and electronic databases. Many developing countries have until January 1, 2005 to implement all aspects of TRIPs.

related questions. How wide or narrow should allowable patents be in less advanced countries? Will wider patents stimulate FDI? Will they stimulate local innovation? What, from a development perspective, are the appropriate criteria for innovativeness?

The main objective of this paper is to explore the possible role of patent scope in the technological progression of developing countries. Patent scope is defined as the effective coverage of a patent. Two dimensions are of particular relevance. The first is the doctrine of equivalents. This allows patent owners to litigate against competing products -or components of products- shown to be essentially equivalent to what is covered under their invention. One way to think about the doctrine of equivalents is to associate it with horizontal scope. The second dimension -of a more vertical nature- is the height of a patent. This refers to the sequential improvements that may be deemed infringing. In other words, it is concerned with the degree to which a follow-on invention must "improve" upon the original invention in order to pass the novelty test.[2]

Determining the possible impact of alternative patent scope practices on the technological prospects of countries may not be feasible at present. As said, the TRIPs agreement is recent and most countries are still struggling with some of its thornier issues. This study takes an indirect route to the questions at hand. In particular, an attempt is made to evaluate the hypothesis that countries with a history of patent violation (as presently defined) are *not* attractive locations for multinational corporations. A "patent infringement" proxy is used as a possible determinant of FDI in an econometric model where the latter is defined as direct investment by US firms in the high-technology sectors of each of the sample countries over a ten-year period. If the hypothesis that patent violation deprives countries of crucial foreign investment is true, then the influence of this proxy should be negative. Moreover, the proxy is defined in a way that also sheds light on the differential impact of alternative patent widths on technology acquisition. Hence, the objective of the study is two-fold. The first is to tell a story about the extent of creative imitation that countries have actually done. The second is to draw some conclusions of relevance to future patent scope policies.

2 See O'Donoghue (1998), O'Donoghue and Zweimuller (1998), and O'Donoghue et al (1998) for further details on these dimensions of patent scope.

The paper uses a panel dataset covering 13 countries from Asia and Latin America between 1992 and 2001. The results show that the main determinant of inflows of this type of FDI to these countries is their technical and scientific capabilities. None of the other variables -whether the traditional ones or the patent-infringement measure constructed for this study—come out significant. This leads to the conclusion that countries seeking to attract FDI into high-technology fields should focus mostly on augmenting the (pertinent) human capital of their manpower.

The rest of the paper is organized as follows. The next section provides the theoretical motivation for the study. Section three presents an overview of the literature on the relevant issues and the special contribution of this paper. Details on the methodology and data used to test a simple econometric model are described in section four. Section five discusses the model's empirical results. Finally, section six concludes with policy implications and recommendations.

2. A Theoretical Framework

The relationship between intellectual property rights and foreign investment is analytically complex. Under a weak or lax IPR regime, the provision and sharing of intellectual assets with subsidiaries can be risky (Markusen, 1998). *Ceteris paribus*, this tends to make a country less attractive for MNC projects. On the other hand, strong protection may shift the preference of interested corporations from FDI towards licensing. This contest between the *market-power* and *market-expansion* effects of stronger IPRs constitutes one level of complexity.[3] Another source of complexity lies in the multitude of factors involved in the MNC investment decision. Ultimately, what matters to the firm is the likelihood that an investment will raise its expected profits. The factors that influence profitability are numerous. From the viewpoint of a prospective MNC, the strength of IPR laws is one of many variables to consider as it weighs FDI against other market penetration options that may be feasible (exporting, technology licensing, joint ventures, etc.) To gain a clearer understanding of this concept, it is,

3 Another, perhaps more readily observable, example of the market-power effect would be the greater tendency of MNCs to engage in monopolistic and abusive practices under a system of stronger IPRs. This happens, for instance, when these firms use their patents to prevent domestic manufacturers from entering specific markets, even where no patent infringement would be involved.

perhaps, helpful to recall the three main motivations that lead a firm to establish foreign subsidiaries. Following Dunning's ownership-location-internalization paradigm (Dunning, 1981), the first is to support its operations by undertaking activities that are closer to the target markets yet under the MNC's direct control. The second is to rationalize activities according to cost by locating in sites with inexpensive resources. The third motivation is to avail from (and internalize) the knowledge spillovers that are made possible through closer interaction with other countries (specially advanced ones with skilled personnel). Among these motivations, only the first is directly related to the protection of intellectual assets.

Just as multinational companies view IPRs as one consideration among many, policy makers in developing countries may be advised that in implementing stronger standards, the appropriate balance must be struck between the requirements of technology acquisition and technology generation. Most nations will wish to adopt a set of policies that do not unfairly disadvantage domestic inventors and creators. They may succeed in achieving that thru interpreting TRIPs in a manner that allows sensible and appropriate exemptions, and thru carefully defining the scope of protection for different technologies and fields (Maskus, 2000).[4] More generally, countries must continually strive to develop an effective competition system in order to ensure that patents promote rather than stifle technological growth (UNCTAD, 2001). As a recent World Bank report states, since the bulk of the world's intellectual property is actually owned by the industrialized countries (with many developing countries holding no patents at all), the TRIPs agreement has in essence shifted the rules of the game in favor of those countries (World Bank, 2001). Given this, the overriding concern of the less developed nations should not be the protection of others' patents *per se*, but rather accommodating them in TRIPs-compliant but non-restrictive ways.

What about patent scope? The claims of each patent are specified in the application originally filed with the national patent office in the country in which

4 The case of Brazil provides an example of how domestic patent laws can be intelligently crafted to prioritize a country's needs. By producing generic HIV drugs, Brazil was utilizing the leeway allowed by TRIPs with regard to compulsory licensing of essential drugs. The Agreement does not limit the grounds upon which compulsory licenses are to be granted, but only requires a clear specification of those grounds and reasonable rates of licensing fees to the original inventor. Recently, the U.S. was forced to withdraw proceedings against Brazil's compulsory licensing provisions after that country managed to prove the provisions were within the bounds of TRIPs (see WTO Reporter, June 26, 2001).

protection is sought. As a matter of practice, after a national patent office receives an application it is scrutinized by the examiners to determine whether it constitutes a patentable invention and which of its claims to ratify. In advanced countries, this could be followed by protracted legal procedures to adjudicate infringement cases or competitor-instigated investigations. In the United States alone, thousands of cases are prosecuted every year as a result of contending interpretations of patent coverage (Merges and Nelson, 1994; Lanjouw and Schankerman, 2001).

The TRIPs agreement itself does not provide much guidance on this matter except to state that countries have the flexibility to determine the most appropriate coverage guidelines in accordance with their national interest. This is very vague. Further, it makes it possible for advanced nations to pressure less advanced ones to adopt patent scope policies that are harmonious with theirs. That means that developing countries -- eager to appeal to foreign investors-- may be compelled to extend unqualified protection to foreign patents that are wider in scope than what was customary under prior practices. Under the new system, a single broad filing may be made (say by a foreign firm) that encompasses discoveries previously spread out over several filings. Pressures aside, because developing nations have limited prior experience in patent administration, they are likely to face considerable challenges as they craft appropriate policy guidelines in this complex domain. It is hence expected that many national patent offices will choose the easy route and recognize awards registered in the US or in Europe without scope restrictions (or even due diligence). Will that be optimal from a development perspective? The previously cited World Bank report says it may not and explicitly cautions countries against blanket, non-selective recognition of foreign patents. The granting of narrow claims and the adoption of a narrow (or no) doctrine of equivalents are among the recommendations proposed for low- and middle-income developing countries. The report generally advises nations to weigh carefully any requests to grant protection that would reduce their access to information and technology in any shape or form (p. 148). Obviously, the most serious threat of wide patent scopes would be the inability of inventors from developing countries to conduct meaningful research in certain fields without purchasing licenses for the underlying technologies. In cases where patent owners charge hefty license fees, innovative activity will be slower.[5]

3. Exploring the Role of IPRs in Development

Little economic research has been done on the issue of appropriate patent scope policies for developing countries. Rather the available literature has explored the issues involved in two different tracks. There have been numerous theoretical studies on patent scope from a *developed* country perspective. On the other hand, the literature on intellectual property rights in developing countries has confined itself to the strength of the IPR regime from a general statutory standpoint. Any exploration of the nuances of different alternatives is practically non-existent. On an entirely different track, a good chunk of research has focused on the broader question of knowledge acquisition in developing countries. Much of this work is anecdotal. For the purpose of this paper, a digression into the insights generated by this literature is useful in as far as it describes the mechanisms thru which developing countries benefit from external technology. These insights may help us gain a deeper understanding of the role of intellectual property and, more importantly from the perspective of this paper, the role of patent scope policies in technological development. In what follows, the pertinent works are summarized in three modules according to the above taxonomy.

3.1 Narrow or Wide Patents

The literature strongly suggests that even in technologically advanced countries, the jury is still out on the optimal breadth of patents. Different OECD countries have had different experiences with this policy element, with practices ranging from wide to narrowly-defined patent claims. Furthermore, differential country performance in terms of innovative output has not strongly favored one set of practices over the other. The long-standing Japanese policy of allowing narrow, single-claim patents is a case in point (as will be explained below).

5 For instance, the biotechnology industry makes relatively intensive use of broad patents, such as the one currently held by Genentech on the use of gene expression techniques in bacteria to reproduce human proteins. Under the TRIPs agreement, developing countries may claim exemption from biotechnology patents, but pressures have been mounting on them to consider greater harmonization in that respect (World Bank, 2001). The effects of stronger protection on agricultural research are likely to be negative.

What economists seem to agree on is that considerable economic trade-offs are involved. For example, Gilbert and Shapiro (1990) suggest that narrow patents are better because broad patents create more deadweight loss. Klemperer (1990) finds that the optimal design depends on consumer preference for product variety. Broad protection results in a wider portion of a product space being covered by a patent, and this reduces variety. Taking a different route, Denicolo (1996) shows that greater competition in the race for new products is often socially wasteful. From this perspective, broad patents are probably better as they tend to reduce "over-fishing" within the same product space. However, a survey by Mazzoleni and Nelson (1998) shows that it may not be so much the quantity of patent races that creates the social waste, but the quality of those races. The broader the potential scope of the coveted patent, the higher are the stakes, and the more aggressively firms will compete. The prospects of winning one of many *narrow* patents may lead a lot of firms to jump into R&D contests, but the prospects of winning one *wide* patent (with a lucrative commercial value) is what generates most of the socially wasteful "over-fishing" phenomenon.

In exploring the matter of patent scope, one must bear in mind the two dimensions along which it operates: the horizontal dimension (diversification within the same product class) and the vertical dimension (sequencing of product qualities).[6] A crucial assumption behind the findings of the above papers is that the nature of the patent award does not affect the incentives of subsequent researchers. Merges and Nelson (1990, 1994) were among the earlier authors to analyze the impact of patent breadth on *cumulative* innovations, where the vertical sequencing of inventions is the issue of interest. They cite numerous anecdotes from recent industrial history that reveal how a wide breadth can hinder improvements on existing innovations. If wide patents are allowed, today's inventors will be ensured against encroachers but tomorrow's inventors might be deterred from venturing into certain fields because of the likelihood that their inventions will be challenged.[7] The general conclusion is that patent breadth should be

6 A good example of horizontal innovation would be different drug compositions for the treatment of the same disease via the same (or similar) mechanisms. To better understand sequential innovation, on the other hand, consider how the Lotus 123 spreadsheet program built on VisiCalc and how MS Excel built on Lotus, or how successive generations of computer chips build on one another.

kept narrow in situations where an invention opens up a relatively broad future prospect. Lerner and Merges (1997) reach the opposite conclusion. In this study, the authors present a rationale for why the scope of awards should actually be broad in an industry's formative years: a wide scope helps spread the essential building blocks of the underlying technology as far as possible through orderly and cheap licensing. As the industry structure evolves and further inventions accumulate, the allowable breadth should be narrowed down to make room for healthy competition. More recently, however, Bessen and Maskin (2000, 2002) demonstrate that a wide patent award could preclude other firms from pursuing a subsequent innovation, leading to a situation where -from a social welfare standpoint- strong protection is worse than no protection at all. Their conclusions do not seem to be contingent upon the stage of development of the industry concerned.

Several other studies have in fact emerged in the past few years on the issue of patenting sequential innovations.[8] The space does not allow for any delving into this research, but the following two comments will be made. First, the balance of the present theoretical work seems in favor of wider patents. Seen within the context of the general global thrust towards *stronger* patents, this is not a surprising concurrence. Secondly, as said, none of these papers deal with the possible role of patent scope from the perspective of a lower level of industrialization and technological sophistication.

3.2 IPRs in Developing Countries

Economists have long observed that the relationship between IPR protection and development is less than obvious. Countries have differed widely in the strength of protection provided to intellectual property, both in the laws and in practice. This has lent itself to a plethora of studies exploring the link between IPRs and various economic variables (growth, FDI inflows, technology licensing, etc.).

Two questions have received a lot of attention in the literature. The first asks whether stronger IPRs promote more research investment and, consequently, higher

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7 Lerner's (1995) empirical analysis of patenting behavior in the biotechnology industry provides one of the most compelling pieces of evidence in support of this argument. Lerner finds that firms that expect to incur high litigation costs (mostly smaller firms) are less likely to seek patents in fields where rivals with lower litigation costs (mostly larger, more established firms) already own significant claims.

8 The leading papers are by O'Donoghue (1998) and O'Donoghue *et al* (1998).

growth. The second looks at whether the strength of IPRs in a country is a significant determinant of foreign technology transfer. Many economists have attempted to explore these two issues empirically, and a thorough review of these studies is not feasible. The major strands can be highlighted, however. In a cross-sectional study of 99 nations, Maskus and Penubarti (1995) find the relationship between IPR protection and level of development to be non-linear. This suggests that patent protection tends to decline in strength as economies move from the poorest to the middle-income stage in which they have greater abilities to imitate new technologies. A somewhat related conclusion is reached by Ginarte and Park (1997). In this study covering 110 countries for the period 1960-90, it is proposed that either the level of economic development or factors correlated with it, such as the level of R&D activity, market environment, and international integration, explain the strength of patent protection provided by countries. In other words, economic development eventually leads to strong IPRs and not the other way around. Another leading study by Gould and Gruben (1996) finds a significant positive effect of the strength of patent protection (as measured by the so-called Rapp and Rozek index of 1990) on growth for 79 countries. Nevertheless, they propose that if the national R&D infrastructure is weak to start with, strengthened patent protection is unlikely by itself to lead to any general increase in the level of research investment. More recently, Kanwar and Evenson (2003) provide seemingly unqualified support for a positive relationship between the two. In this paper, R&D expenditure is regressed on the strength of patent protection (measured by the Park and Ginarte index) and other country-specific characteristics. The multi-country, 10-year dataset demonstrates that strong patent rights promote innovativeness. Unfortunately, no attempt to account for endogeneity is made in this study.

Theoretically, recent analyses of the effects of stronger patents on growth have also been mixed, with conclusions largely depending on model assumptions. In some North-South partial equilibrium models (Helpman, 1993; Glass and Saggi, 1995), technology is mostly transferred through imitation by lagging countries. When stronger IPR standards are adopted, imitation becomes harder so that its rate declines. Eventually, the reduced threat of profit loss enhances market power and may decrease the incentives for innovative firms in the North to engage in R&D. This could lead to a slower global rate of innovation. In Helpman (1995), it is demonstrated that while the technology exporting nations in the North may stand to benefit from stronger protection of IPRs, the long run effects on developing countries depend on their sizes and income levels. Small, low-income countries will mostly sustain negative welfare effects. Such skepticism on the value of patent protection is not shared by other authors. For example, Lai (1998) finds that product innovation and technology diffusion are expanded under stronger rights if foreign direct investment (FDI) is the means through which technology is transferred. Another study by Vishwasrao (1994) shows that the quality of technologies transferred by MNCs rises with stronger IPRs, and this promotes economic growth.

On the issue of IPRs and FDI, theory does not provide a clear-cut answer to how strengthening the former impacts the latter. On one hand, good IPRs decrease the probability of imitation, which improves a country's chances of attracting foreign investors. On the other hand, stronger laws may shift the preference of multinational corporations from FDI towards licensing. The anticipated effects of the TRIPs agreement in this regard are therefore ambiguous (Yang and Maskus, 1999). Generally, economists recognize that static costs are likely to be significant whenever the *market power effects* of tighter IPRs outweigh their *market expansion effects*. Another complication arises from the diverse nature of FDI. As surveys of multinationals have shown, the importance of IPR protection varies across industries and different corporate activities (Mansfield, 1994). For example, investment and technology transfer are relatively insensitive to IPRs in industries with standardized, labor-intensive technologies and products. FDI representing complex but easily copied technologies, such as chemicals, electronics, and software programs, is plausibly more attuned to the ability of the local legal systems to deter imitation. Therefore, such investment is likely to increase when IPRs are strengthened. As Mansfield (1994) also demonstrates, the concern with IPRs across all industries is reportedly highest in the case of R&D facilities and lowest for sales and distribution activities. Finally, and apart from protecting their intellectual assets, stronger IPRs may improve a country's chances of attracting FDI simply because interested firms see in them a commitment by the local government to move toward greater transparency and professionalism in their public management practices. This increases the challenge of disentangling the various determinants of FDI.[9]

On the empirical level, most of the studies performed on the IPR-FDI link have also been inconclusive. A thorough review of this literature is included in Maskus (2000). Here, a few of the more relevant papers are summarized. Ferrantino (1993) finds no statistically significant relationship between the extent of U.S. affiliate sales in a foreign country and that country's membership in an international patent or copyright convention. Similarly, Maskus and Konan (1994), as well as Primo Braga and Fink (2000), do not obtain statistically significant results.

In support of the hypothesis of a strong positive relationship, there is Mansfield (1994) and Lee and Mansfield (1996), where evidence is based on (subjective) surveys of American MNC executives who are asked to rate their investment behavior in countries according to their IPR laws. In these two papers, strong IPR protection is found to exert a positive influence on FDI inflows. Supportive evidence is also obtained in Maskus (1998) who checks for the sensitivity of U.S. investment to the strength of IPRs in 46 countries over a four-year period and finds it significant. Finally, Smarzynska (2000) observes that a weak protection of intellectual property rights has a significant impact on the composition of FDI inflows into Eastern Europe. This research is done on 22 countries from that region and concludes that investors in sectors relying heavily on intellectual property are deterred by a weak IPR regime in a potential host country.

A different tack would be to investigate the relationship between IPRs and the R&D activities of MNCs. Since IPRs are most pertinent to the type of intellectual assets produced in research laboratories, one would expect multinationals to be particularly concerned with the strength of patent laws whenever they decide to perform some of their R&D activities overseas. However, Kumar (2002) concludes that this does not seem to be the case. In this paper he provides survey evidence that MNCs in India have actually been establishing R&D centers, entering into R&D joint ventures, and contracting

9 This sort of confusion is not confined to researchers only, but may also be present in the minds of policy-makers as well. According to Maskus (2000), the impression that many governments have formed about the importance of stronger IPRs for potential investors is probably exaggerated, and this may help explain why some of them have rushed to strengthen their IPR laws despite serious doubts about the wisdom to do so or the applicability of the proposed laws to the particular conditions in their countries.

research to third parties in the chemical and pharmaceutical fields despite the Indian patent regime not recognizing product patents in these sectors. Therefore, the abundance of trained, low-cost human resources and the scale of ongoing R&D aptitude in the local economy appear to be more important considerations for location of R&D than the strength of the IPR regime. These hypotheses are verified in another recent study (Kumar 2001) that explains R&D intensity of US and Japanese MNE affiliates in 74 countries. This work finds that the strength of patent protection offered by the country is a statistically insignificant determinant of R&D intensity. Rather, the bulk of the variation in the dependent variable is explained by the availability and relative cost of technical manpower and the overall technological capability of the host country. Findings like these help us understand why countries like China, India, and Brazil with weak protection have attracted so much foreign investment in recent years. As Maskus (2000) remarks, if weak IPR laws cast a clear-cut negative impact on FDI, these inflows would have gone instead to sub-Saharan Africa (where the laws are uncharacteristically strong, thanks to remnants of the colonial era).

In concluding this section the following two comments (adapted from Maskus, 2000) are in order. The first relates to the anticipated future role of IPRs with regard to incoming FDI. If varying levels of patent protection across countries do in fact serve as a locational determinant of FDI, the current trend toward harmonization could, on the long run, dilute any advantages that specific countries now possess. As more countries make the required adjustments (in theory and practice), IPRs cease to be a factor in choosing subsidiary sites.

The second comment relates to policy implications. While it is certainly in countries' best interest to attract foreign investment and technology, policies to promote such activities must be accompanied by programs to build local skills, improve socio-political conditions, and develop appropriate regulatory regimes. In other words, intellectual property rights work in conjunction with a whole gamut of enabling conditions that are meant to ensure a level-playing field for local firms. Depending on a country's stage of development, these other conditions may be more important than the patent system. This is not to say that inventiveness is marginal in the process of development. On the contrary, it is crucial. The key is to distinguish between innovation and intellectual property, and to constantly bear in mind that any mapping between the two is an imperfect abstraction. It has long been recognized (see, for instance, Griliches [1990]) that many (perhaps most) important innovations are not patented. With that in mind, it is possible to place patents and patent scope within the context of inventiveness in developing countries. This is what we attempt to do briefly in the next section.

3.3 Knowledge Acquisition and the Possible Role of Patent Scope

How do countries "develop"? In many ways, the quest for development is a struggle to gain problem-solving capabilities. Countries advance over time partly because they undertake deliberate efforts towards finding creative solutions to problems. In the present day context, developing countries --poorly endowed with trained personnel-- rely on imported technologies. But the extent to which a country can find "external" solutions, and the quality and fit of these solutions, is influenced by the country's own problem-solving abilities. A related argument is that while laggards have the potential to grow faster than leaders because they can exploit their knowledge, that potential is conditional on these countries' absorptive capacities (see Cohen & Levinthal, 1989, and Criscuolo & Narula, 2002).

Unfortunately, this concept is frequently underestimated in the development jargon. Change and modernization are mainly seen as "external shocks". This leads to simplistic advice encouraging developing countries to (passively) acquire foreign technology, with little thought to how they should best harness it. Often, "technology transfer" is understood as purchasing devices and reading manuals. Freeman (1992), for instance, laments that the developed world has become a huge technological supermarket where any country with the required financial resources can find a ready solution to almost any problem. From the proactive problem-solving perspective introduced above, however, such passive technology transfer does not lead to genuine development. Instead, developing countries must "create" knowledge. This does not have to be a cataclysmic feat. More often than not, it is a humble process based on incremental innovations that only gradually improve the underlying technological base.

Using the above framework, one may ask whether imitation is the "second rate" activity it is often purported to be. According to Nelson and Winter (1982):

> “An imitator working with an extremely sparse set of clues about details of the imitatee’s performance might as well adopt the more prestigious title of ‘innovator’, since most of the problem is really being solved independently.” (124)

In a recent book on the undervalued importance of imitation in modern industrial history, Schnaars (1994) reminds us that the bulk of research and development (R&D) done all over the world is really imitative[10]. Furthermore, imitation is not monochromatic, but assumes various shapes and forms: counterfeits or product pirates, clones, design copies, creative adaptations, and technological leapfrogging. Only the first two of those are pure imitations of the type banned by modern intellectual property laws. The others are sometimes referred to as creative imitation. When policy makers and economists talk about “imitation”, it is not always clear what they mean. Often, the activity is perfectly legal (i.e. does not violate any patents). At times, it infringes an idea or a component embedded within a product or process but can hardly be branded as piracy. Generally, it seems safe to suggest that as innovation becomes cumulative in nature, the lines between it and some forms of imitation are blurred. To the extent that R&D is, in fact, overwhelmingly D, many activities that fall under the rubric of “development” may unjustly receive the “imitation” label when performed by a rival despite considerable inventive effort on the part of the latter.

This description may well characterize much of what goes on in the developing world. Unfortunately, such arguments have received little more than the scantiest attention in the current global technology environment. The debate over process versus product patents in pharmaceuticals is a case in point. With the passage of the TRIPs agreement, many countries that had allowed only the former must now observe the new standards which prohibit the reproduction of a patented product via *any* process (no matter how innovative). Not only that, but because process manipulations can no longer be used as the basis for new patent filings, many inventions that were previously patentable (under national law) now constitute illegal piracy, subject to prosecution.[11]

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10 For a leading study on the rate of imitation, see also Mansfield *el al* (1981), who find, for instance, that up to 60 percent of patented inventions are imitated by others within 4 years.

11 Despite their present non-compliance with TRIPs, these process innovations have led to the discovery of cheap generic AIDS medicines without which millions of patients in poor countries could not receive

Another example of how developing country firms may "tamper" with patentable products is when they adapt them to local conditions. It is often the case that something crucial for the proper operation of a product is missing. This may be a component required for making the product work right under certain circumstances, or it may be an ingredient needed to adapt it to local tastes. In this context, it is essentially correct to qualify people able to solve these types of problems as innovators, even if what they really do is a mixture between imitating and inventing. Some times, moreover, these inventive activities (whether to adapt a product or substitute a component by a more cost-effective one) give rise to new devices with a life of their own (Forbes and Wield, 2000)

It is in this connection that the issue of patent scope gains special relevance for developing countries. The Forbes and Wield paper (and literature surveyed below) provides abundant examples of creative incremental innovations by firms all over the developing world. Under a more stringent patent regime, a good chunk of these might be considered infringing. Also, because many of the emerging high-tech industries are characterized by cumulative innovation, new entrants from developing countries will find it almost impossible to penetrate the thicket of patent rights that already exist in these fields in order to begin making their own contributions. This is most pronounced in fields like software programming, semiconductors, and genetic engineering, where there is significant path-dependence.

A common assumption among economists and policy-makers appears to be that developing countries are mainly engaged in traditional industries. In fact, most of the advice on export-led growth focuses on these so-called mature industries. This paper argues that whether developing nations get into high-tech fields or not, the type of R&D they will be conducting is mostly of the *development* variety, such as the diversification of product designs, or the adaptation of technology imports to suit local needs and preferences.[12] As such, firms from developing countries may succeed in penetrating the

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treatment. Another example of how important process innovations could be was brought into focus recently when Canada had to override Bayer's patent on Cipro –an antibiotic for the Anthrax virus- and use versions produced via other processes. Around the same time, an Indian generic drug maker offered to supply the U.S. with 20 million tablets a month of its anthrax antibiotic, demonstrating once again that long product patents are not necessarily welfare enhancing (Reuters, October 2001).

12 According to Forbes and Wield (2000) developing countries should not engage in the same type of R&D done in leading regions, as this will only waste their scarce resources. Instead of focusing their modest efforts on "research and development", they would be better off if they apply them to "development and

newer technology fields provided they are given the necessary latitude to experiment with, and improve upon, existing products and processes. An example would help illustrate this point. One R&D area that has been gaining momentum in the pharmaceutical industry in recent years is drug delivery. The invention of an alternative drug delivery mechanism represents a design modification to the underlying medicinal invention. Lately, a number of entrepreneurial firms from developing countries have broken with their traditional roles of producing generics by inventing creative drug-release and administration methods. In a few cases involving Indian manufacturers, this has resulted in sizeable international profits.[13] Yet, wide patent scopes may prove to be a large impediment for future progress along these lines --if not for countries like India and Brazil who have already made some headway in this field, then definitely for most other developing countries that have yet to set foot in the sector. If the TRIPs agreement compels developing nations (whether directly or indirectly) to reform patent scope practices in a manner that significantly expands the interpretation of coverage and width of granted rights (mostly foreign held), this may stymie a sizeable proportion of their attempts at independent innovation.

What has been the formal status of patent scope in developing nations? A recent paper by Sakakibara and Branstetter (1999) sheds some light on the possible impact of alternative practices. Even though the paper itself deals with the case of Japan, it is probably one of the very few empirical studies that tackle this subject for a country other than the US. Through its exploration of whether the 1988 patent reforms have affected the level of R&D performed by domestic firms, a story unfolds about the whole process of technological development in Japan. Here we learn that many of the technological advances made by companies like Mitsubishi, Sony, or NEC could not have been possible under a much broader patent system --such as the one instituted in 1988, mainly at the behest of American firms who wanted to harmonize the Japanese system with that of other countries. Prior to the reforms, Japanese firms could file *single-claim* patents that were also much narrower in scope than similar patents awarded in other advanced countries. This meant that many more Japanese patents had to be filed to cover the same

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design". In other words, the research activities of those countries should aim to closely follow the technology frontier rather than push it forward.

13 See, among others, rediff.com (July 14, 2003) and Pharmabiz.com (August 23, 2003).

technology. It also meant that more Japanese inventors were motivated to do R&D unperturbed by the threat that all the awards might accrue to just one inventor. Furthermore, as pointed out in Maskus and McDaniel (1999), by providing protection for industrial designs and utility models the Japanese patent system rewarded firms for their efforts in introducing small modifications to already existing technologies.[14] The authors suggest that these features have obviously facilitated the transfer and absorption of technology by allowing reverse engineering, and that this must have contributed to the striking growth of TFP in Japan during the three decades under observation.

More generally, the consensus among authors who work in this area has been that the striking technological success in East Asia owes a lot to the ability of these countries to creatively imitate, replicate, or assimilate foreign inventions (Schnaars, 1994; Kim, 1997; Kim, 2000; Hobday, 1995). In Korea, for instance, Lee (2000) observes that during the imitation stage, the government tried to minimize IPR protection to help domestic firms use foreign intellectual property. Toward that end, laws and regulations were formulated in such a way as to meet minimal international standards (which were much more lenient at the time). Korea also followed an IPR regime that was heavily dependent on utility models (see footnote 14) and industrial designs. This is evident from the fact that over 90% per cent of all awards granted in Korea over the past several decades have gone to Korean nationals (see WIPO statistics), which stands in stark contrast to most developing countries where the bulk of intellectual property registered with national offices is typically foreign owned.[15] In Brazil, the World Bank reports evidence of utility models helping producers gain a significant share of the farm machinery market by encouraging adaptation of foreign technologies to local conditions. In the Philippines, a similar trend occurred with the domestic market for rice threshers thanks to utility models (World Bank, 2001).

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14 In fact, utility models (sometimes also called petty patents) have been popular in most NICs. This type of patents generally protects changes in tools or machinery that improve their functionality. Utility patent applications need not prove much inventiveness. They are thus concerned with the sort of minor innovations that prevail in developing countries, and may provide incentives for creativity in small and medium enterprises. Again, the TRIPs agreement is silent on the matter of utility modes.

15 For a detailed description of aspects of the Taiwanese patent system that are relevant to this discussion see Wade (1990).

From the previous discussion, it appears that the balance of anecdotal evidence allows some preliminary conclusions about the role of "soft" patent laws, even though most of the mainstream literature is not explicit in acknowledging such a role. One could safely state that the IPR regimes adopted by Japan, Korea, Taiwan, and others in the early period of reverse engineering, including narrow interpretations of patents, has served an important function in facilitating technology diffusion and learning.

3.4 This Paper's Contribution

There seem to be two gaps in the literature on IPRs in developing countries. While it may be intuitive to say that stronger IPRs are not sufficient for firms to invest in a country --and ample anecdotal is available to support this—the empirical analysis has apparently failed to lend credence to this conclusion. As said, the evidence has been quite thin and hardly supportive of any generalization. Why do some empirical studies show such a strong positive impact of IPRs on FDI, while others do not?

One reason may be found in the methodologies employed. An obvious problem is variable choice. The standard approach is to regress some performance variable (growth, R&D investment, or FDI) over several independent variables, including a measure of the strength of IPRs. The measure of choice has been the Ginarte and Park (1997) index, which captures cross-country variations in patent laws along five dimensions: extent of coverage[16], membership in international patent agreements, provisions for loss of protection, enforcement mechanisms, and duration of protection. The index ranges from zero to five with higher values of the index indicating stronger patent protection. The main disadvantage of this index is the fact that it only tells us about the laws present in the books; it does not capture the underlying situation in terms of actual patent-violating activities. That is why a country may have a relatively high IPR index (or one that has improved as a result of TRIPs-induced legislative action) but still harbor a considerable degree of patent infringement, or concealed patent infringement.

The second gap in the literature is related to the matter of causality. Developed countries might naturally have stronger IPR regimes than the poorer ones. In other words,

16 Note that in this context, "extent of coverage" means whether both process and product patents are recognized and the fields in which patents are allowed. It does not relate to patent scope as used in this study.

the level of development is likely to be a determinant of the strength of IPR laws rather than the other way around.[17] Similarly, countries are likely to have stronger IPRs *because* they engage in more international trade, not vice versa. Models that use IPR indices as independent variables are therefore prone to simultaneity bias (especially where data for developed and developing countries are pooled together). Interestingly, the original Ginarte and Park study was actually based on the reverse causality: it ran regressions with the proposed index of protection as the dependent variable in an attempt to explore formally the determinants of countries' commitment to protect intellectual property. It found some support of the hypothesis that the more developed a country is the greater its propensity to provide patent protection. This seems to be a more logical conclusion than that reached by some of the newer studies which have employed that index.

Another shortcoming of the literature is the near lack of empirical studies on patent scope in developing countries, even though this is likely to be one of the most challenging issues confronting them. The only exception may be the afore-cited research by Sakakibara and Branstetter (1999), which revealed that the impact of reforms that drastically broadened allowable patent width in Japan was modest in terms of additional investment resources and innovative output (as measured by patent counts covering 307 firms)[18]. The paper's authors suggested that the scope of an award, while theoretically influential, works in conjunction with other important determinants of innovation (such as firm size, financial structure, state of relative development, etc.).

The present paper will make another contribution to this line of inquiry by attempting to evaluate the impact of patent scope practices on one development indicator, namely FDI. The paper proposes an alternative methodological approach based on using a different measure of patent protection. Instead of the standard indices that capture the

17 According to the World Bank, countries have historically adopted stronger IPRs only when domestic conditions became tipped in their favor. Invariably, this has happened at higher stages of development when domestic firms have reached a level of sophistication that they can produce distinctive goods and generate new technologies (World Bank, 2001).

18 It is worth mentioning that other research on changing patent strength in *advanced* countries has also found little evidence of the hypothesis that enhancing patent protection spurs innovation. The policy changes addressed in those papers include the establishment of a specialized court (the Court of Appeals for the Federal Circuit) in the United States and entrusting it with the sole responsibility of investigating patent cases (Kortum and Lerner [1998], Hall and Ziedonis [2001]), and the strengthening of patent protection for pharmaceuticals in Italy in 1979 (Scherer and Weisburst [1995]).

"legal" situation (i.e. whether systems are lax or strict), the paper suggests a more concrete measure that captures the extent of "creative" imitation that actually occurs in a country. The paper then tests the impact of this variable on FDI in industries that are known to be patent-sensitive. The next section presents a detailed description of the model and the methodology.

4. Research Methodology and Variable Definitions

4.1 Propensity to Infringe

The available literature does not offer much guidance on how to quantify imitation. Gadbaw and Richards (1998) provide some piracy estimates, but, other than that, there seems to be a total dearth of economics papers that explore this matter systematically.[19] This is not surprising in view of the difficulty of collecting any real data on this phenomenon.

The variable proposed in this study is a proxy for patent-infringing activity. (We could also call it creative imitation, but the patent infringement label is more suitable for conveying what the variable really measures.) This was first introduced by Connolly (1999, 2001), but the present paper refines it both conceptually and computationally.[20] It is defined as the gap in the number of applications for domestic patents filed by home residents and the number of US patent filings by the same country, *as a share of domestic patent applications, minus the corresponding (proportional) patent gap for Switzerland* (this will be clarified later). According to international patenting rules, an application for a foreign patent must be submitted within one year of original filing in the country of the inventor. Furthermore, no patent application can be filed in a foreign territory if one has not already been filed in the home country. (The author of this paper checked the web sites of the national patent offices of the countries included in the study to confirm that they all abided by the above regulation.) If we adopt the simplifying assumption that the

19 The *International Intellectual Property Alliance (IIPA)* also produces periodic statistics on software and other forms of piracy around the world, with a focus on resultant losses to U.S. firms. For details, the reader is referred to their site at www.iipa.com.

20 The Connolly papers can be downloaded from the web site of Duke University Economics Department (Working papers no. 97-34 & 97-25). To the best of this author's knowledge, no one has thus far used this (or a similar) variable to analyze how a country's real imitation track record reflects on its attractiveness to foreign investors.

two patent applications are filed simultaneously, the gap between domestic and US applications would basically represent all the patents that were filed by local residents with their national offices but not in the US. By applying for a national patent, an inventor obviously believes there is a good chance one may be granted in the home country. If an application is also filed in the US, then that inventor must have a high level of confidence in the validity and novelty of their invention. If no application is filed in the US, there may be several reasons for that. The first is that the invention may simply not be relevant there, either because the inventor does not wish to commercialize it in that market or because it is strictly domestic in nature. It could be argued that many inventions that fall under this category are plausibly covered by other IPRs, such as copyrights, designs, or utility models. As said in the previous section, design and utility models are very common. Recall again that utility models are a type of intellectual property rights, granted in some but not all countries, that are designed to protect minor changes in existing machines (probably covered by existing patents) that improve their functionality, external appearance, or use. Of the sample countries included in this study, roughly three quarters award utility patents (and, according to statistical data published by their national patent offices, a majority of domestic inventors do in fact seek them instead of straight patents). This may detract from the validity of this reason for the absence of a US patent application. It could, however, still account for part of the "application gap". At any rate, this is not a particularly interesting factor for us (and a way to purge the proxy of its influence will be suggested below). Another reason for not filing in the US has to do with the stricter novelty requirements there; US patent inspectors tend to be more meticulous. A third reason would be that a US (or other international) patent already exists for part or all of the invention for which protection is sought. These are the two factors that we hope to capture by this proxy, namely situations where a local firm has "invented" a product or process by introducing some incremental modification(s) to an existing technology, but where the degree of novelty is not expected to pass US standards and/or the new invention is patent-infringing. If the inventor believes the national patent laws are more relaxed than US laws, then that inventor seeks a national award but refrains from seeking a US one under this premise.

Going back to the sort of inventions that may be irrelevant to the US, one way of backing them out of the proxy would be to subtract from it the corresponding proportional gap for Switzerland. Why? Upon computing the patenting gap for several European countries (France, Germany, Sweden, UK, Netherlands, and Switzerland), the last was found to have the smallest: 62.10%[21]. In other words, 62% of all patents filed in Switzerland are not also filed in the US. (The other five countries ranged in values from 65% to 72%, while the average for our sample of countries was around 88%.) If we assume that all the "strictly Swiss" patents are characterized by the perception that they are irrelevant in the US market (and not by the perception that they may not pass the novelty/non-infringement tests), and we further assume that this proportion of irrelevancy is more or less common across all countries, then the remaining portion represents patents that are potentially infringing or that otherwise miss the novelty benchmark.[22] This, of course, is a very crude procedure, and the use of one common "floor" is a source of error. Furthermore, it does not change the ranking of the countries in terms of their patenting gaps. It may, however, help improve the definition of the proxy (provided the assumptions made in constructing it are not unreasonable).

Another improvement to the original Connolly use of this proxy is scaling. In the Connolly papers, the patent gap is defined as national applications minus US applications. No factor of proportionality is used, and the measure is labeled the "imitation proxy" (see Connolly, 1999, 2001). Our calculations reveal that according to this definition all the major European countries would come out as more serious imitators (by far) than any of the developing countries. This is especially egregious in view of the fact that she then uses the proxy to run growth regressions over pooled samples including both developed and developing countries. In the present paper, the gap is recomputed in proportion to the volume of domestic applications, which drastically improves its

21 Two years, 1994 and 1995, were used to obtain these estimates.

22 There remains the issue of whether developing country firms are as likely as Swiss (or other developed country) firms to seek US patents in the first place. Understandably those firms are less sophisticated than their Northern counterparts to do so, and/or they may not have the financial means to cover the costs of US patents. In this paper, however, we shall make a further assumption that if a developing country firm has already patented a discovery at home, and if this discovery is relevant in the US market (and both criteria are already factored in the numbers as calculated), then that firm has a modicum of sophistication and financial capability. We shall then assume that in the majority of these cases, a US patent will be sought unless the discovery does not satisfy the novelty requirement or is not truly innovative. This way of constructing the index makes it all the more important to back out the "irrelevant" patents as defined.

significance. Now all the major industrialized countries have much lower patenting gaps than most developing countries, including all the countries in our sample. This makes sense as one would expect a higher percentage of inventors in developed countries to trust the value of their inventions (enough to seek US patents).

Finally, this paper follows Connolly in using patent applications rather than patent awards to compute the patent infringement proxy. Although the later might better capture differences in novelty requirements across countries, it has two disadvantages. The first is already pointed out in Connolly, and that is that the amount of time taken by patent offices to process applications varies across countries, and so computing an annual gap would not be feasible. The second disadvantage is that, for the purpose of our paper, the *intention* to seek a patent, and the *perception* of what is patentable, are more important than the actual awards themselves. That is because our proxy is concerned with activity that is potentially patent violating, so what matters is the extent of that activity and whether it has any impact on foreign investment in the country.

At this point, it is useful to emphasize again that the proposed proxy does not reflect all imitative activity. In particular, it probably does not reflect knock-out imitations, product copies, or counterfeits as these flagrant violations are unlikely to appear in patent applications anyway. (Note that for the most part, the period under observation is one where IPR awareness was generally on the rise.) Furthermore, since the data used are just for patents, the proxy does not reflect negligible improvements to existing products, as those are covered under designs and utility models. Rather, the patenting gap, as defined, mostly captures incremental innovations and creative imitations that exceed a minimum threshold.

The proxy -hereafter called the propensity for patent infringement (PPI)- is calculated for several emerging countries from Asia and Latin America for the period 1992-2001. This is shown in table 1 below.

Table 1- Propensity for Patent Infringement (Averages)			
Country	**Domestic Patent Applications**	**US Patent Applications**	**PPI**
Argentina	792	98	0.256
Brazil	2985	168	0.316
Chile	206	18	0.293
China	16432	256	0.365
Columbia	81	17	0.156
Indonesia	103	7	0.278
Korea	62922	4656	0.303
Malaysia	211	62	0.100
Mexico	465	136	0.091
Peru	44	5	0.253
Philippines	154	20	0.243
Thailand	381	39	0.271
Venezuela	194	41	0.153

The time span under observation witnessed some of the fastest rates of technological transformation for the countries concerned, yet many of them continued to sanction lax intellectual property practices despite the passage of TRIPs in 1994. To the extent that the average allowable patent scope is narrower in a country than in the US, we should see a high number of locally, but not internationally, registered patent applications. Likewise, countries with softer novelty requirements are likely to have higher PPIs. Thus, a large proxy may indicate two things: a) that the country adopts a narrower interpretation of the scope of existing claims, and/or b) that the novelty requirements in that country are less stringent (which also means, generally, that the patent office in the country is perceived to favor narrow claims).

4.2 The Dataset

The study employs a sample of 13 developing countries from Asia and Latin America over the 1992-2001 period. The countries were selected based on their high US FDI inflows. Data for this study are derived from the US Department of Commerce annual FDI statistics, the World Development Indicators published by the World Bank, the World Intellectual Property Organization (WIPO), national patent offices, and the UNESCO databases. The sections below describe how each variable was constructed. Technical details on sources and computations are included in a special annex. Since most developing countries did not report consistent patent data before 1990, a longer time span is not feasible.[23]

4.3 Defining the Dependent Variable

It is very likely that foreign investment is relatively insensitive to IPRs in standardized, labor-intensive industries, but quite sensitive to them in technology-intensive fields. In empirical analyses involving these variables the need is acute for sectoral breakdowns of investment flows. This paper, therefore, distinguishes between high- and low-tech FDI. A major data problem confronts the researcher seeking to perform this type of analysis: beyond the United States, very few countries publish more than minimal information on inward and outward investments and MNC operations. Due to this data limitation, FDI in this study refers to FDI inflows originating from the US in high technology sectors. The selected sectors are chemicals, industrial machinery, electronics (including computers), and scientific and technology services. The classification follows that used by the Department of Commerce in annual FDI statistical reports. [The same sectors were investigated in Smarzynska (2000)]. Naturally, restricting the data to US-based FDI is very limiting from a practical point of view. In some cases (especially for the Asian countries in the sample), the US contributes a smaller share of total inflows than Japan. This measure may therefore underestimate the relative amount of incoming FDI into these countries. From a theoretical perspective, however, the variable is well suited to this paper given the greater concern with imitation risks among US firms.

An important caveat about this data is in order. Almost every country has some missing observations for some years. According to the tables published by the Department of Commerce, these data points are “suppressed” to protect the proprietary information of individual companies. Excluding these countries and years would render any meaningful analysis practically impossible. In order to enhance the sample size, mechanical extrapolations for each year were done as follows. First, the share of each country in the aggregate regional volume of U.S. FDI inflows was computed. For

23 Data on US FDI for the years 1990-91 could not be accessed, which prevented the inclusion of these two years in the study.

chemicals, machinery, and electronics the aggregate manufacturing FDI volume was used as the denominator. For information technology and other scientific services, the aggregate industrial FDI volume was used. This share was then utilized to calculate the best estimate for a missing value under each category. The country-based and industry-based sums (i.e. row and sub-column headings) were then checked to make sure they continued to add up within an acceptable error margin after the estimates have been plugged in.[24]

Finally, it should be pointed out that the FDI figures are not scaled (by dividing them over total GDP or population, for example), despite the fact that most empirical studies investigating the determinants of FDI do so (Singh and Jun, 1995; Campos and Kinoshita, 2003). For the purposes of this study, it was felt that scaling creates an unacceptable bias in favor of the smaller countries and against some of the larger ones (like China). The fact that only US FDI is included worsens this bias.

4.4 Selection of Control Variables

The following is a description of the control variables employed to test the main hypothesis of the study.

* *Human Capital* --The role of human capital has long been recognized in endogenous growth theories. It is suggested that the technological capabilities associated with human capital (education and training) are the channel through which this variable impacts growth (Romer, 1990; Lucas, 1988). Some authors (e.g. Benhabib and Spiegel, 1998) have also argued that human capital facilitates the adoption of technology from abroad. With regard to its significance as a possible determinant of FDI the literature has been less conclusive but generally supportive of a positive relationship (Dunning, 1988; Lucas, 1990; Zhang and Markusen, 1999).

Several measures have been used as proxies for human capital. This study follows much of the extant literature in representing human capital by secondary school enrollment rates (SECOND) in one variant of the model. Additionally, two other specific

24 On average, this procedure was performed once per country per year. The missing data involved at least one and at most three sectors.

measures are used. This is based on the realization that for analyses involving high-tech FDI, explicit accounting for the kinds of skills required in these industries is needed. Secondary school enrollment rates probably do not provide that. The first of those alternative measures is the number of technical and scientific articles published by the country's residents each year (TECHPUB). The other is the more standard innovation measure of US patent *grants* awarded to the country's residents (PATAW-US). In a recent World Bank study (Chen & Dahlman, 2004), these two indicators are used to identify cross-country knowledge-based growth determinants and are found to be have greater explanatory powers than the more classical education indicators like enrollment rates.[25]

* *Market Potential* -- The existing literature finds the host country market size to be an important determinant of FDI inflows (see Dunning, 1993; Caves, 1996; Braunerjelm and Svensson, 1996). Most studies show that a large market size encourages FDI inflows. However, Root and Ahmed (1979), Singh and Jun (1995) and UNCTAD (1998, 1999) propose that while the size of the market is important initially -local market size should reach a certain threshold for production to be profitable- the continued expansion of FDI requires that market *growth* prospects be favorable. This paper accommodates both concerns by including a measure of current market size, gross domestic product (GDP), and a measure of potential size, growth of per capita GDP (GRPCGDP). Current per capita GDP (PCGDP) is also used as a potential determinant in some specifications. The rationale for such a variable is that in the case of high-tech FDI, selecting among several potential locations for a projected subsidiary is likely to be influenced by the average customer's income. High-tech products of the sort manufactured by those corporations tend to be more expensive than labor-intensive goods. To the extent that multinationals are attracted to markets with relatively higher affluence and sophistication, PCGDP may be a significant factor. Another purpose of employing both GDP and per capita GDP in different regressions may be to check whether scaling has any substantial effects on the study's outcome.

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25 A third variable that was considered in this connection R&D expenditure. The required values were missing for three of our sample countries, however.

* *Market Facilities* -- Good infrastructure is a necessary condition for foreign investors to operate successfully. This is probably true for all types of FDI, but particularly so for high-tech FDI. In this study, infrastructure is proxied by the number of fixed phone lines per 1000 people in the largest cities.[26]

* *Export Orientation* --The role of trade openness in influencing FDI inflows is not straight forward. A restrictive trade regime may encourage MNCs to serve a local market via FDI rather than exporting. This would be the case for tariff-jumping FDI, for instance. On the other hand, trade restrictions can impede the operations of a subsidiary because of perceived difficulties in importing inputs such as equipment and components. Accordingly, trade liberalization can have indeterminate effects. In general, however, open economies do encourage confidence and promise high returns, especially from the perspective of efficiency-seeking FDI. An example would be export-oriented industries, where MNCs stand to reap economies of scale and scope under open trade regimes even when the domestic market is small. Hein (1992) and Dollar (1992) have found that outward-oriented developing economies (that rely on new export markets) have been relatively successful. Using appropriate Granger causality tests, Singh and Jun (1995) determine that the direction of causality runs from export orientation to FDI for most of the countries they investigate.

Openness has been measured in various ways, including trade shares, export shares, and black market exchange premiums. Since the sample economies selected for this study are all quite open (at least during the study period), the variable chosen is the extent of export-orientation. If efficiency-seeking FDI is mostly interested in securing export markets, then countries already successful in that respect hold the greatest

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26 Two other variables were considered for infrastructure. The first is the number of phone and cellular subscribers per 1000 people as published by the World Bank *WDI*, but this measure was deemed to be too biased towards countries where the most people lived in urban areas. Countries with an overwhelmingly rural population have much smaller values as a small percentage of the rural population has access to telephones or cell phones. From the perspective of an MNC contemplating investment in a country, it is the quality of urban infrastructure that mostly matters. The second variable that was considered is the percentage of computer and internet users (also published in *WDI*). In addition to suffering from the same type of bias as the previous variable, most data points for this indicator were actually missing.

attraction for MNCs. Following common practice, export intensity (EXPINT) is measured as the share of exports in GDP.

For high-tech FDI, the amount of exporting that a country's high-tech industries perform is also plausibly important as an indicator of reputation and competence. The World Bank's *WDI* provide figures on the share of high-tech exports in total manufactured exports (HTEXP). The paper uses this measure as an indication of the high-tech orientation of a country's export industries. However, since contemporaneous correlation may exist between this regressor and the residuals (see below), lagged values of HTEXP are used as well as instrumental variable estimation to improve the consistency of the coefficient estimates.

Finally, it might be worth mentioning here that the methodology of estimating empirical models featuring unscaled, full levels of FDI inflows along with per capita levels of the standard independent variables is not new. The same approach has already been pursued in various other studies, including Slaughter (2003), Hanson *el al* (2001), and Brainard (1997).

4.5 The Econometric Model and Estimation Issues

The proposed model estimates the following equation:

$$FDI_{it} = \beta_0 + \beta_1 PPI_{it} + \beta_2 EXPINT_{it} + \beta_3 HTEXP_{it} + \beta_4 GRPCGNP_{it} + \beta_5 PCGNP_{it} + \beta_6 (TECHPUB \text{ or } SECOND \text{ or } PATAW\text{-}US)_{it} + \beta_7 PHONES_{it} + \mu_{it},$$

where all the variables are as previously defined. All figures are transformed into natural logarithms (and GRPCGDP is calculated as a log difference). Since FDI inflows vary widely from year to year --with disinvestments or large repatriation of profits in one year followed by positive investment flows the next-- these large fluctuations may obscure the effect of the various determinants. The analysis in this paper uses two-year averages in an attempt to smooth some of the erratic nature of these inflows. (As it turned out, doing so also eliminated negative figures in the original dataset so natural logs could be taken.) This implies that we have five data points for each country, for a total of 65 observations.

An important question that arises with panel data estimation is whether the individual country effects ought to be treated as fixed or random. The former requires estimating the individual effects as parameters. In some studies (Nickell, 1981; Nerlove, 1971) it has been shown that treating individual effects as constants leads to poor estimates of the system parameters. According to Kennedy (1997), the advantage of random effects model follows from the fact that the alternative (fixed effects) entails a substantial reduction in the degrees of freedom. This would be particularly serious in a study, such as ours, where the number of individual units in the panel substantially exceeds the number of time periods (in this sample, the factor is 13 to 5). In such a situation, Kennedy suggests that we must make efficient use of the information across the individual units to estimate that part of the behavioral relationship the cross-sectional variations (in our model, the variations across the sample countries). For these reasons, pooled cross-sectional estimations will first be performed followed by random effects model estimations.[27] In this way, the error term in the above model can be redefined as

$$\mu_{it} = \varepsilon_i + \eta_{it}$$

where ε_i represents the cross-section error component (fixed across time) and η_{it} denotes the remaining (combined) disturbance. No time-series errors are assumed to exist.

5. Empirical Analysis

5.1 Summary Statistics

Table 1 presents sample averages for the thirteen countries as well as a correlation matrix for the regressors. Countries like China, Korea, and Brazil have highest PPI levels but they are also among the largest recipients of US FDI in technology intensive sectors. On the other hand, Mexico and Malaysia have also received high volumes of US investments during the period under consideration but appear to have much lower patent application gaps (and lower PPIs). For the most part, countries with a high export orientation seem to also export a lot of technology intensive goods, which is not surprising considering the substantial correlation between EXPINT and HTEXP (0.78). Besides that, four other pairs of explanatory variables exhibit relatively high positive

27 Fixed effects model estimations were also run, but ue to their poor performance, these results are presented as an appendix.

correlations, and those are per capital income and US patent awards (0.70), patent awards and phones (0.63), per capita income and phones (0.59), and per capita income and secondary education enrollment (0.56). The last two are self-explanatory. The high correlation between PCGDP and US patents can be explained in a straightforward way, which is that higher income levels lead to higher R&D expenditures, which in turn generates greater patentable inventions. The fact that concomitant with that we also have a relatively low correlation between per capita income and technical publications may cast some doubt on the validity of this relationship. If a high per capita income leads to more R&D and more US patents, why does it not also lead to a greater volume of technical publications? One explanation for that may be that private firms are simply more interested in patenting their inventions than in writing about them. Finally, the correlation between patent awards and phones follows naturally from the correlation between phones and per capita income. Before turning our attention to estimation findings, it is noteworthy that PPI is negatively correlated with both HTEXP and EXPINT. This could mean that as countries become further inserted into the global economy, the incentive to tighten up their IPR regimes increases and, subsequently, the propensity of their residents to seek low-quality patents decreases. This may find weak support in the fact that PPI's correlation with income growth is higher than it is with income. Countries in high growth mode seem to be less attentive to patent quality than quantity. (Recall that from a wide patent perspective a larger PPI is an indication of the prevalence of lower-quality patents.)

5.2 Estimation Results

The univariate analysis discussed above suggests that a higher propensity to infringe patents does not necessarily lead to less FDI. Model estimation results support this preliminary conjecture. Table 2.3 reports the pooled and random effects model estimations for two basic configurations. In order to address endogeneity problems, a standard approach is to identify an instrumental variable. Such a variable ought to be positively correlated with the potentially endogenous explanatory variable but not correlated with the dependent variable. The variables chosen as instruments for HTEXP are the intensity of manufactured imports (i.e. manufactures as a percentage of total imports) and credit to the private sector as a share of GDP. The rationale is that both are correlated with high-tech export intensity but not with FDI or the residuals.[28] Additionally, lagged values of HTEXP were used throughout.[29] In this study, we start with a general model and then remove variables one by one. Beginning with columns (1) and (2) in table 2.3, we see that none of the standard explanatory variables is significant in the pooled 2SLS estimation, and the adjusted R^2 of the equation is very low. The random effects model, however, shows a significantly positive influence for infrastructure (phones in large cities) and a significant (but wrongly signed) influence for secondary school enrollment. The PPI variable comes out insignificant in both models. The negative sign before the school enrollment coefficient seems to be in contradiction with theory. One plausible explanation for that is that these types of indicators are computed on a country-wide basis. This may underestimate the urban schooling achievement in predominantly rural countries (such as Brazil, China, and Thailand in our sample). To the extent that MNC subsidiaries are generally located in large metropolitan areas, the school enrollment rate does a poor job of capturing the effect of human capital on FDI.

Columns (3) and (4) of table 2.3 report pooled and random effects estimates after substituting technical publications for school enrollment and dropping the infrastructure variable. The new human capital variable is highly significant in both models, but all the other variables (including PPI) are still insignificant, even though the adjusted R^2 is better than in the previous specification.

Similar exercises are presented in table 2.4 after GDP is substituted for per capita GDP. The results are very similar in terms of the relative explanatory power of the various determinants. The only time GDP comes out significant is in the first specification (column 1) where neither technical publications nor patent awards are included as variables. Otherwise, TECHPUB comes out to be the most significant determinant in all the other specifications.

Table 2.5 reports the random effects model estimates for four additional specifications. In the first two, both HTEXP and EXPINT are dropped in order to isolate

28 Manufactured imports are inputs for high-technology industries, and credit to the private sector is potentially influential in as far as these industries normally have high credit needs.
29 Data on the HTEXP variable used in this study are therefore for the years 1990 thru 1999.

the effects of the remaining variables. Another rationale for doing so is that in neither of the previous two models did these variables exhibit any significant influences, and so dropping them would help purge the equations from needless multicollinearity.[30] Columns (1) and (2) are models that account for technical publications and US patents, respectively. The explanatory power of the former is shown to be much higher than the latter (with a *t* value of 4.277 versus 1.546). Again, PPI is still insignificant. The next two models, therefore, drop PPI completely from the specifications and re-introduce HTEXP and EXPINT in order to check for robustness. The results [under columns (3) and (4)] are very similar to the previous two models, namely technical publications is still highly significant but US patents is not. It would appear that FDI in technology intensive sectors is less sensitive to the amount of patents held by local residents than by their degree of general scientific and technical sophistication. This is in agreement with the consensus that patent counts underestimate innovative activity (Grilliches, 1990). The common strand across all the performed regressions is the strong influence of the technical publications variable, set against an almost total lack of influence for all the other variables (with the exception of phones which comes out significant in one of the specifications).

Finally, it was felt that a comparison with the bulk of the extant literature in this domain might be in order. As mentioned in the literature review presented earlier in the paper, most studies have normally utilized the Ginarte and Park index of intellectual property protection as the primary patent-related determinant of FDI. So, in table 2.6, some of the previous specifications are repeated with the PPI variable replaced by the Ginarte and Park index of IPR protection (for 1990). The results show little influence of this index as a determinant of US FDI inflows into the selected sectors. This is an interesting outcome, especially in view of the fact that, again, the only variable of any significance is technical publications. (The phones variable is also somewhat significant in a couple of specification but assumes the wrong sign.) These exercises improve the robustness of the analysis and demonstrate once more that this type of FDI is mostly resource-seeking (particularly human capital resources).

6. Conclusions

30 In those two specifications without the export orientation variables no instrumentation is employed.

This paper set out to achieve two objectives. The first was to propose a new methodology for quantifying creative imitation in developing countries. To provide a partial measure of this type of imitation, a new variable that captures the propensity for patent infringement was defined. The second objective was to test for the impact of this propensity on FDI inflows in technology-intensive sectors.

It should be pointed out that the model employed was very modest in terms of structure and performance. While the obtained results were not as strong as would have been hoped (perhaps due to data limitations), the significance of one explanatory variable was particularly robust. This is the human capital variable proxied by technical and scientific publications by home country residents. This result lends support to the conclusion that high-tech FDI is mainly driven by the skills of the local workforce.

With regard to the variable of interest, namely PPI, the results show no significance at all in determining FDI inflows. At the same time, country patterns revealed that some of the largest recipients of US FDI in high technology sectors practice narrow patent policies (with a few number of claims per patent) and/or impose lenient novelty requirements. This is mostly reflected by the perception of domestic inventors who apply for patents. One legitimate conclusion would be that the type of narrow scope policy that may lead to patent infringement has not deprived the more dynamic developing countries of technology-intensive FDI. The case for narrow scope is buttressed by this analysis. As a policy recommendation, developing countries that are now starting to enter some of the more advanced fields should insist on devising the appropriate patent scope policies in accordance with their national priorities.

Table 2—Descriptive Statistics

Country Averages

Country	U.S. FDI	GDP	PCGDP	EXPINT	HTEXP	GrPCGDP	TECHPUB	SECOND	PHONES
Argentina	217	2.83E+11	8140	10.08%	5.45%	-0.03%	2142	85.06%	251
Brazil	831	7.40E+11	4499	9.18%	6.82%	1.27%	4458	78.91%	225
Chile	100	7.37E+10	4979	29.34%	3.03%	3.95%	830	78.22%	257
China	726	8.70E+11	696	23.62%	8.64%	6.60%	9946	65.34%	303
Columbia	53	9.50E+10	2352	16.91%	6.60%	0.19%	186	66.41%	281
Indonesia	56	2.07E+11	1036	35.02%	7.66%	1.25%	132	54.56%	200
Korea	458	5.44E+11	11749	37.67%	24.82%	4.23%	5543	98.75%	536
Malaysia	493	9.96E+10	4542	105.78%	46.99%	3.09%	392	64.87%	276
Mexico	617	3.31E+11	3512	29.11%	15.57%	0.72%	2041	67.88%	138
Peru	18	5.69E+10	2287	14.10%	2.65%	2.01%	58	78.98%	161
Philippines	176	8.19E+10	1128	45.91%	49.44%	1.56%	152	77.63%	132
Thailand	235	1.68E+11	2809	52.23%	27.05%	1.90%	424	65.35%	349
Venezuela	96	7.91E+10	3437	26.89%	2.43%	-0.45%	425	51.20%	343

Note: All figures are annual averages. FDI is in millions of US $.

Correlation Between Explanatory Variables

	PPI	EXPINT	HTEXP	%PCGDP	PCGDP	TECHPUB	SECOND	PHONES	PATAW-US
PPI	1.00								
EXPINT	-0.35	1.00							
HTEXP	-0.28	0.78	1.00						
%PCGDP	0.23	0.03	0.01	1.00					
PCGDP	0.02	0.00	0.04	-0.01	1.00				
TECHPUB	0.41	-0.19	-0.09	0.26	0.19	1.00			
SECOND	0.12	-0.05	0.18	-0.08	0.56	0.26	1.00		
PHONES	0.00	0.20	0.13	-0.12	0.59	0.41	0.42	1.00	
PATAW-US	0.15	0.07	0.16	0.07	0.70	0.41	0.44	0.63	1.00

Table 3
Determinants of FDI
Pooled IV (2SLS) and Random Effects Model w/ GDP Per Capita
(Dependent Variable : High-Tech FDI Inflows)

Variable	(1) Pooled (2SLS)	(2) RE (2SLS)	(3) Pooled (2SLS)	(4) RE (2SLS)
Propensity for patent infringement	0.572	-1.346	-0.507	-0.592
	(0.630)	(-1.083)	(-0.815)	(-0.881)
Growth of per capita GDP	0.293	-0.240	-0.693	-0.708
	(0.161)	(-0.237)	(-0.577)	(-0.513)
Per capita GDP	0.006	0.023	-0.0007	-0.0002
	(0.105)	(0.609)	(-0.047)	(-0.014)
Secondary enrollment rate	0.500	-1.487***		
	(0.151)	(-3.880)		
Technical & Scientific Publications			0.008***	0.008***
			(3.659)	(3.322)
High-tech export intensity	-2.195	-3.203	1.043	0.537
	(-0.252)	(-1.022)	(0.286)	(0.137)
Export orientation	1.692	1.516	-0.260	-0.047
	(0.337)	(1.041)	(-0.139)	(-0.023)
Phones in largest cities	-0.176	0.002***		
	(-0.118)	(3.189)		
Intercept	-0.385	1.028**	0.204	0.229
	(-0.19)	(2.555)	(1.168)	(1.211)
Adjusted R^2	0.07	0.18	0.36	0.41
Observations	65	65	65	65

Notes:
***, **, and * indicate 1 percent, 5 percent, and 10 percent significance level, respectively.
Figures in parenthesis are *t* values. Share of manufactures in imports (MIMPINT) and credit for private sector as a share of GDP (CREPS) are used as instruments.

Table 4

Determinants of FDI --Random Effects Model w/ GDP
(Dependent Variable : High-Tech FDI Inflows)

Variable	**(1)** **RE (2SLS)**	**(2)** **RE (2SLS)**	**(3)** **RE(2SLS)**	**(4)** **RE (2SLS)**
Propensity for patent infringement	-0.179	-0.16	-0.092	-0.234
	(-1.033)	(-0.97)	(-0.62)	(-1.38)
GDP	0.94***	0.29	-0.092	0.11
	(4.54)	(0.99)	(-0.29)	(0.34)
Secondary enrollment rate	-0.593	-0.672		-0.781
	(-0.77)	(-1.08)		(-1.38)
Technical & Scientific Publications			0.694***	0.567**
			(4.15)	(2.16)
Patent Awards in US				0.078
				(0.46)
High-tech export intensity	0.395		0.476	
	(1.51)		(1.38)	
Export orientation	0.079	0.507**	0.07	
	(0.19)	(2.41)	(0.21)	
Phones in largest cities	-0.076			-0.386
	(-0.22)			(-1.03)
Intercept	-3.196	9.354	18.60***	18.15***
	(-0.48)	(1.23)	(2.47)	(2.08)
Adjusted R^2	0.51	0.57	0.64	0.53
Observations	65	65	65	65

Notes:
***, **, and * indicate 1 percent, 5 percent, and 10 percent significance level, respectively.
Figures in parenthesis are *t* values. Share of manufactures in imports (MIMPINT) and credit for private sector as a share of GDP (CREPS) are used as instruments in all regressions that use HTEXP as a variable.

Table 5 - Additional Exercises

Random Effects Model w/ GDP Per Capita
(Dependent Variable : High-Tech FDI Inflows)

Variable	(1) RE (2SLS)	(2) RE (2SLS)	(3) RE (2SLS)	(4) RE (2SLS)
Propensity for patent infringement	-0.824 (-1.492)	-0.071 (-0.112)		
Index of Intellectual Property Protection (Ginarte & Park)				
Growth of per capita GDP	-1.004 (-0.888)	-0.063 (-0.054)	-1.3894 (-0.943)	0.1037 (0.087)
Per capita GDP	0.015 (0.680)	-0.003 (-0.685)	0.0018 (0.727)	-0.0009 (-0.298)
Patent Awards in U.S.		0.002 (1.546)		0.00014 (0.838)
Technical & Scientific Publications	0.094*** (4.277)		0.0093*** (2.963)	
High-tech export intensity			0.749 (0.178)	-0.0319 (-0.007)
Export orientation			0.0734 (0.032)	0.5765 (0.262)
Phones in largest cities	-0.007 (-1.288)	0.004 (-0.744)	-0.001 (-1.048)	0.0077 (0.13)
Intercept	0.466** (2.449)	0.273 (1.02)	0.185** (1.836)	0.108 (0.54)
Adjusted R^2	0.25	0.01	0.43	0.13
Observations	65	65	65	65

Notes:
***, **, and * indicate 1 percent, 5 percent, and 10 percent significance level, respectively. Figures in parenthesis are *t* values. Share of manufactures in imports (MIMP) and credit for private sector as a share of GDP (CREPS) are used as instruments in all regressions.

Table 6 - Additional Exercises

Model w/Park & Ginarte Index of Intellectual Property Rights
(Dependent Variable : High-Tech FDI Inflows)

Variable	**(1) RE (2SLS)**	**(2) RE (2SLS)**	**(3) RE (2SLS)**	**(4) RE (2SLS)**
Index of Intellectual Property Protection	-0.010	0.294	-0.45*	0.112
(Ginarte & Park)	(-0.047)	(1.25)	(--1.87)	(0.59)
GDP		0.34	-0.60	0.287
		(1.12)	(-1.47)	(0.93)
Growth of per capita GDP	-1.645			
	(-0.745)			
Per capita GDP	0.004			
	(1.351)			
Secondary Enrollment Rate		-1.008		
		(-1.33)		
Technical & Scientific Publications	0.002***	0.524***	0.930***	0.568***
	(3.871)	(2.62)	(4.02)	(2.85)
High-tech export intensity	-0.860		0.855***	
	(-0.298)		(3.26)	
Export orientation	1.355	0.551***	-0.306	0.665***
	(0.891)	(2.38)	(-0.93)	(3.06)
Phones in largest cities	-0.002***	-0.590*		-0.662**
	(-2.617)	(-1.88)		(-2.13)
Intercept	0.158	11.65	28.16***	8.960
	(0.649)	(1.56)	(2.90)	(1.23)
Adjusted R^2	0.60	0.61	0.63	0.59
Observations	65	65	65	65

Notes:
***, **, and * indicate 1 percent, 5 percent, and 10 percent significance level, respectively. Figures in parenthesis are *t* values. Share of manufactures in imports (MIMP) and credit for private sector as a share of GDP (CREPS) are used as instruments in all regressions that use HTEXP as variable.

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