

IPR, innovation, economic growth and development

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October, 2007

1. Introduction

The interaction between intellectual property rights (IPR) and the rate and direction of technological change has been a fertile ground for economic analysis and policy debate. It has long been recognized that IPR, with the monopoly right it grants to its holders, is a necessary compromise that society has to endure in order to ensure investors in new inventive and creative works of the profitability of these creations. The formal analysis of the tradeoff implicit in this policy dates to Nordhaus's (1969) demonstration that optimal patent life is finite because of decreasing returns to investment in innovation.¹ A voluminous theoretical literature followed to extend the normative theory of Nordhaus.² The basic question this literature asks is how to optimally balance the benefits and costs of innovation.

The empirical literature has seized upon the opportunity provided by a number of policy changes that were generally thought to have altered the incentive to innovate. These included changes in the U.S. legal system that might have changed the returns to IPR and new legislations that might have allowed for a higher private return to research conducted in American universities and government labs. While these pseudo-natural experiments are natural places to search for evidence of how IPR affects innovation, the actual results are mixed. The conclusion of an earlier comprehensive survey by Jaffe (2000) was that "despite the significance of the policy changes and the wide availability of detailed data relating to patenting, robust conclusions regarding the empirical consequences for technological innovation of changes in patent policy are few."

An almost parallel development has been the increasing pace of globalization and the centrality that IPR protection assumed in the emergence and resolution of international economic conflicts, particularly those between developing and developed countries. This development culminated in the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) that was negotiated and concluded in the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1994. In essence, the TRIPs agreement set an eventual goal of extending the rigor of IPR protection in

¹ See also Scherer's (1972) interpretation and extension of Nordhaus's theory.

² See for example the symposium in the Spring 1990 issue of the Rand Journal of Economics.

developed countries to developing ones. A normative theoretical literature ensued that investigated the implications of such international harmonization of IPR for the welfare of both developing and developed countries, subsuming in it, implicitly or explicitly, the tradeoff analyzed in the patent design literature in a domestic context.

The theoretical literature took a general equilibrium approach and largely concluded that developing countries suffer a welfare loss from adopting the same IPR standards as in developed countries. This is not surprising since technology transfer and diffusion has been a primary source of technological change in developing countries whose indigenous innovation capability is weak. An interesting insight, however, of this literature is that it is not always in the interest of the developed countries to push for extending their IPR regime to the less developed countries. Not only could the developing countries and the world as a whole to lose from the international harmonization of IPR, the welfare of developed countries could fall as well (Helpman, 1993). Another important insight from this literature is that cooperation between the developed and developing countries, i.e., international agreement that is incentive compatible for both sides, is able to achieve a higher level of welfare than if they were to act non-cooperatively (Grossman and Lai, 2004).

Empirical work to quantify these theoretical predictions regarding the welfare implications of the international harmonization of IPR has been limited in a number of ways. Most studies have focused on a single country or industry. And the focus is often placed on the impact of more rigorous IPR regime on a certain aspect of technology diffusion in developing countries, for example, arm's length technology transfer, foreign direct investment (FDI), and exports from developed countries. While most of these studies reported a positive effect of the former on the latter, they should be interpreted at most as confirming the higher returns to innovation stronger IPR generates for developed country firms. World Bank (2001) and McCalman (2005) estimated large income transfer implicit in TRIPs with the U.S. being the largest beneficiary.

Normative analysis of the effect of IPR on the development process can also gain insight from examination of the historical and cross-sectional patterns of nation's choices regarding their own IPR regimes. An important finding of this literature is a U-shaped cross-section relationship between the rigor of a country's IPR regime and the country's GDP per capita (Maskus, 2000 and Chen and Puttitanun, 2005). The notion that the strength of a country's IPR regime is endogenous to its level of economic development finds further support in economic history. Studies of the early American IPR regime (Sokoloff and Khan, 2001 and Khan, 2004) showed a weaker and more liberal patent and copyright systems than those in Europe, and Britain in particular, at the time. This early U.S. IPR regime both encouraged more incremental innovation and constrained the market power of IPR holders. Natural parallels exist between this early American IPR regime and that adopted by East Asian economies such as Japan, Korea and Taiwan in their process of graduating from imitation to innovation. Lall (2003) observed that:

"Many rich countries used weak IPR protection in their early stages of industrialization to develop local technological bases, increasing protection as they approached the leaders."

Thus normative theoretical analysis, empirical analysis of the effects of different IPR regimes, and examinations of countries' own choices of IPR regimes at different stages of development all call into question the very notion of harmonization, by suggesting that a globally efficient IPR regime will entail different IPR policies for countries with different technological capabilities and at different stages of

economic development. We return to this theme in the Conclusion.

The organization of this survey is as follows. The next section begins with a brief overview of the patent design literature, and then proceeds to summarize the general empirical evidence on the effects of different IPR regimes. Section three discusses the literature that has explored the welfare implications of the international harmonization of IPR. Section 4 explores the literature that has tried to assess the impact of IPR on specific aspects of the development process, particularly trade, FDI and technology licensing. Section 5 looks at the relationship in the other direction, by examining historical and cross-sectional analysis of the determinants of IPR regimes themselves. Section 6 offers conclusions and policy implications.

2. Patents and policy and technological innovations

2.1 The patent design literature

The literature on the optimal design of patent system is premised on the notion that patents confer an effective means to secure returns to inventions. The discussion then proceeds to analyze how the parameters of a patent system affect incentives and welfare. The parameters most frequently analyzed are patent duration, and patent breadth or scope. Duration has a relatively simple interpretation as the statutory life of a patent, which varies both historically and across countries. The breadth or scope is a more elusive concept. Some authors relate scope to the size of the “inventive step” that a patent must represent, i.e. the magnitude of improvement over previous technology that is required to earn patent grant. This can be related to the standards of “novelty” and “non-obviousness” that are imposed in patent examination. Other authors relate scope to the number and complexity of distinct “claims” that are contained within a given patent. To the extent that technology can be represented by a multi-dimensional space, scope thus captures both the distance that a new invention must lie from territory previously claimed, and also the volume that can be captured by a given patent grant. Unlike duration, which is set by statute and changed relatively infrequently, effective patent scope results from a complex interaction of statutory standards, practice of the patent-granting body, and judicial decisions, and hence is much harder to measure or compare across time and space.

The early literature (Nordhaus, 1969 and Scherer, 1972) focused on patent duration. In Nordhaus's model, the optimal length of patent protection was obtained by weighing the balance between the deadweight loss from the static inefficiency of a patent holder's monopoly power and the cost reduction generated by the patented invention. With greater incentive to invention, diminishing returns set in, so that at some point the marginal static welfare loss from greater duration must exceed the marginal dynamic gain from invention. Thus optimal patent life is finite. It naturally follows that the optimal patent length is sensitive to characteristics of consumer demand and the technology of inventing that bear upon the social cost-benefit calculation.

A subsequent literature developed to bring the breadth of patent protection into the analytical framework. Initially, this literature ignored the possibility that part of the social benefit of inventions is knowledge spillover to future innovators; it can thus be thought of as addressing the case where inventions are independent of each other on the supply side of invention. The objective of a social planner is to find a combination of patent width and length that minimizes the social cost of inducing a given innovation. Gilbert and Shapiro (1990) equate patent width with the patent holder's ability to raise price, which makes sense if distance in “technology space” is highly correlated with

substitutability in product space. In a homogeneous good setting (i.e. products differ only with respect to a common quality index), they found a simple tradeoff between width and length: a long but narrow patent can be as socially efficient as a broad but short patent. Using a model of product differentiation, Klemperer (1990) differentiated two kinds of consumer welfare loss due to patents: that resulting from consumers' dropping the product from their consumption; and that generated by consumers' substituting to a less preferred variety. While obtaining similar tradeoff between the length and width of a patent as in Gilbert and Shapiro, his analysis showed that such tradeoff is likely to be sensitive to the nature of the products.

The central concern of another strand of this literature (Scotchmer and Green 1990, Scotchmer 1991, Green and Scotchmer 1995, Scotchmer 1996) has to do with the inter-temporal knowledge spillover of research and development when innovation takes place sequentially and is undertaken by different firms. This poses an additional challenge to the task of designing optimal patents since part of the social return generated by inventions is captured by or embodied in future inventions that build on the earlier inventions. The extent to which the early inventors can internalize such inter-temporal externality depends on the width of their patents. On the other hand applications developers need to be assured of returns to their efforts. The socially optimal solution to the tension between the two generations of innovators is to allow for ex ante agreement between the two generations of innovators so as to avoid the double marginalization problem. But even then, the first generation innovator cannot capture all the profits that would ensure socially optimal rate of investment in the first generation innovation since the second generation innovator has bargaining power. Green and Scotchmer (1995) suggested longer life of patents to ameliorate the problem. Scotchmer (1996) went on to show that in the case of basic innovations, it is preferable to use exclusive license rather than patents to protect the profits of second generation innovators.

Because of the abstraction of theorizing and the richness of the strategy space in the game theoretical models, this literature has not produced many testable hypotheses that empirical economists can take to data to validate. As a result the vast empirical literature has developed in a somewhat parallel and disjoint fashion.

2.2 Patent policy changes and patent explosion

The last two decades of the twentieth century saw a number of major changes to the U.S. patent policy. These changes raise important questions about patent policy, but also provide, in principle, possible "experiments" regarding the effect of parameters of patent policy on the rate of invention and innovation. The major changes were 1) the creation of the Court of Appeals for the Federal Circuit (CAFC), 2) the Bayh-Dole Act and 3) the expansion of the realm of patentability. The Court of Appeals for the Federal Circuit was created in 1982 to hear appeals from district courts of patent cases. It was a procedural reform and was meant to standardize patent law across the U.S. In practice, however, the CAFC has strengthened patent protection in the U.S. Patent holders now win more often; are more likely to achieve injunctive relief shutting down their competitors; and earn larger damages, on average (Jaffe and Lerner, 2004). The Bayh-Dole Act of 1980 allows universities and other non-profit institutions automatically to retain title to patents derived from federally funded R&D, and encouraged technology transfer to the private sector. Finally, decisions of the CAFC and the implementation of these decisions by the Patent Office have expanded the range of inventions that are potentially patentable, to include genetically engineered bacteria, genetically altered mice, particular gene sequences, surgical methods, computer software, financial products, and methods for conducting

auctions on the internet.

None of these huge changes in patent policy and practice relate directly to the parameters of patent policy that have been scrutinized by economic theory. On some level, their consequences ought to be so obvious as to be theoretically uninteresting: if you increase the probability of winning a patent case, the economic reward you receive when you win, and the number of different kinds of technologies that are eligible for patent protection, you have increased the incentive to patent and the rate of patenting should rise. To first order, the returns to invention have also risen, and so the rate of invention itself should also rise. From a policy perspective, the important question is whether this second effect is quantitatively significant.

Since the mid 1980s, U.S. patent grants and applications have been growing at an annual rate of 5 percent, reversing a long-term secular decline in the intensity of patenting over the previous century. A number of researchers have attempted to determine whether this change can, in fact, be attributed to the approximately contemporaneous changes in policy, and to what extent the increase in *patenting* corresponds to an increase in the underlying rate of *invention*, as distinct from a change in the propensity to apply for patents on inventions that are produced.

Kortum and Lerner (1998) formulated four hypotheses that might explain the U.S. patent explosion. The “friendly court” hypothesis conjectured that the creation of the CAFC had made patents more valuable and hence increased the propensity to patent in the U.S. According to their “regulatory capture” hypothesis, large American firms are likely to be primarily responsible for the patent explosion, since they dominate the R&D process in the U.S. and therefore are a major beneficiary of pro-patent policy changes and they have the ability to influence the regulatory changes. The third hypothesis, the “fertile technology” hypothesis, postulates that newly emerged technology opportunity may have led to higher rate of innovation and therefore more patents. The final hypothesis considered by Kortum and Lerner was that the process of R&D had become more productive. The higher R&D productivity could have been caused by the application of information technology to the process of R&D and increasing emphasis on applied research that was likely to generate patents.

They rejected the friendly court hypothesis by looking at trends in the patenting by foreigners in the U.S., and by U.S. nationals abroad. If the CAFC was the source of increased U.S. patenting, this should have applied to foreigners as well as domestic inventors, and there would not necessarily have been an increase in patenting by U.S. nationals in other jurisdictions. In fact, there was no acceleration of foreign patenting in the U.S. during the friendly court period, and patenting by U.S. inventors abroad did increase during the same period. The fertile technology hypothesis was rejected because the patenting surge was widespread across patent classes instead of concentrating in some of the niche technology areas such as biotechnology and information technology that might have been most fertile. Finally, Kortum and Lerner found that the fraction of patents going to new firms and the fraction going to firms that previously had relatively few patents had both increased. This seemed to refute the regulatory capture hypothesis. Through this process of elimination, Kortum and Lerner then concluded that there must have been an increase in the productivity of R&D to account for the patenting surge.

That the explanation of the patent explosion lies outside the patent system itself received further support in the survey evidence that Cohen et al (1997) reported. R&D managers surveyed did not perceive patents to be more effective during the 1980s than before. Cohen et al (1997) attributed the higher rate of patenting to the increased propensity of firms using patents as a strategic tool to block

products of competitors, improve bargaining position in licensing negotiations, and prevent or defend against infringement suits.

The strategic patenting hypothesis also found support in Hall and Ziedonis's (2001) study of patenting activity in the U.S. semiconductor industry. They found that large firms tended to use patents in large portfolios in negotiation of cross-licensing agreements. Two features of the semiconductor industry made it particularly amenable to such strategic use of patents. The semiconductor technology is "complex"³ in the sense that a product usually embodies a web of interrelated and overlapping technologies that are likely to be protected by patents owned by different semiconductor firms. The need to negotiate a license and the likelihood of infringement are therefore greater than in a "simple" technology industry where products are not subject to this intricate web of patented technologies. Furthermore, semiconductor firms, particularly foundries, are capital intensive so that it is costly to shut down the production facility in the face of patent litigation threat.

Following the passage of Bayh-Dole and related legislation, patenting by American universities and National Labs has increased substantially. Though this is what is to be expected from the statutory changes, the question does remain as to how much of this increase is a "real" increase in technology production, and how much just an increase in the fraction of technology that is patented. Henderson et al (1998) showed that more universities were receiving patents over time. In 1965, 30 academic institutions received patents. This figure increased to 150 in 1991 and over 400 in 1997. Health sciences accounted for a disproportionate share of university patents. The increase in university patenting was accompanied by a decrease in patent quality, as measured by citations. Mowery and Ziedonis (2002) did not find such a decline in citation intensity for patents of Stanford University and the University of California, but did find a fall in the average licensing revenue per patent.

Unlike university patenting, the surge in patents taken out by National Labs did not seem to be accompanied by a decline in quality (Jensen and Thursby, 2001). As in universities, the institutionalization of patenting through the creation and expansion of technology transfer offices had played a key role in the patenting surge.

In one of the few studies that examined the role of economic incentives in the supply of creative work, Hui and Png (2002) examined whether the production of movies responded to changes in economic incentives. In particular they examined how variation in movie demand shifters such as ownership of TV and video tape recorders and the population and personal disposal income influence the production of motion pictures. Their data spanned 38 countries and the period from 1990 to 2000. They conjectured that video tape recorders and movies are complements, because people watch movies on video tapes, but TV and movies are substitutes. Their results confirmed these conjectures. For example, a 1-percent increase in video tape recorder ownership in the U.S. in 2000 would have led to a 1-percent increase in motion pictures. They then assessed the impact of a 1998 increase in the term of copyright, or the Sonny Bono Act, on the supply of movies. This effect turned out to be insignificant. It is not clear to whether this is because the duration of copyright protection is relatively unimportant, or because the 1998 extension—which added to an already long period of protection—simply had an unmeasurable marginal effect.

Kanwar and Evanson (2003) is one of the few studies that examined directly the relationship between

³ See Merges and Nelson (1990) for a discussion of complex vs. simple technologies.

innovation and IPR by regressing the R&D expenditure/GDP ratio on IPR strength and other control variables. Using a cross section of 29 countries from 1981 to 1990, their estimation strategy was to use a “random effects” model rather than a fixed effect one on the grounds of efficiency of the estimators, the nature of their panel data – large N and small T, and the confirmation of the result of a Hausman test. The elasticity of R&D to GDP ratio with respect to the Ginarte and Park patent index was estimated to be from 0.3 to 1.8. Therefore they concluded that IPR strength had a strong positive effect on R&D investment. As noted below, however, other authors have explored a causal relation running from the stage of economic development to the strength of IPR. Since R&D/GDP is highly correlated with other aspects of the development process, it is unclear whether the measured effect of IPR on R&D intensity is contaminated by causality running from stage of development to strength of IPR.

Lanjouw and Cockburn (2001) focused on the response of the global pharmaceutical industry to the trend of strengthening IPR that started with GATT negotiations in the mid 1980s. Their approach was to identify potential shift of the research focus of the pharmaceutical industry as a result of the increasing strength of IPR protection in developing countries. In particular, they asked whether there had been a greater weight placed on drugs against tropical diseases, which are specific to developing countries. They surveyed pharmaceutical company executives and health researchers and collected statistical data to test their hypothesis. Their data showed that research related to malaria increased significantly from the mid-1980s. Since there was no indication that the science of developing malaria drugs was getting “easier”, i.e., there did not seem to be any change in technology opportunity, the shift could only have come from the demand side, which the strengthening of IPR could have played a role. But malaria seemed to be the only case where such shift took place. They suggested that tropical diseases might not be the only area where strengthening IPR protection might have an effect.

2.3 Empirical studies of patent scope

Despite the difficulty of measuring patent scope, a small number of empirical studies have tried to relate aspects of patent scope to the rate of innovation. Examining the historical development of electrical lighting, automobiles, airplanes and radio, Merges and Nelson (1990) argued that the assertion of strong patent positions, and disagreements about patent rights, inhibited the broad development of these technologies. These case studies, while perhaps not definitive, do call into question the basic premise of much of the cumulative-innovation/patent-design literature that initial inventors and subsequent inventors of improvements will reach agreements that can ameliorate the problems of inter-temporal knowledge spillover when innovation is sequential.

Sakakibara and Branstetter (2001) examined the effects of a change in the Japanese patent system in 1988, which effectively expanded patent protection in Japan by increasing patent scope. They hypothesized that if the increase in patent scope had increased the return to innovation, this should be reflected in both higher R&D spending and more patents produced. They found no evidence for either potential outcome.

3. International Patent Protection Harmonization and Welfare

Studies in this literature largely rely on models that pitch an imitative or less innovative South against an innovative North and investigate the welfare implications for both the South and the North of extending the North's IPR regime to the South.

Both Chin and Grossman (1990) and Deardorff (1992) examined welfare implications of patent protection harmonization and found an important role played by the size of the South's market. In Deardorff (1992), under plausible parameterization, the inventing North gains from extending patent protection to the South as its monopoly profit from invention increases; the South loses as the welfare loss associated with monopoly pricing dominates the consumer surplus generated from the higher level of invention in the North. The optimal level of world patent protection is determined by weighing the higher level of inventive activity in the North against the consumption distortion of monopoly pricing in the South. Just as Nordhaus showed that optimal patent life is not infinite, Deardorff finds that optimal patent coverage is not global: there are diminishing returns to the invention incentive effect as more and more countries in the South adopt patent protection, so that world welfare is not maximized by extending patent protection to all countries in the South.

Helpman (1993) investigated the welfare implications of international harmonization of IPR protection by examining four channels through which such effects may materialize: (1) terms of trade, (2) production composition, (3) availability of products, and (4) inter-temporal allocation of consumption. When IPR is tightened in the South, some manufacturing is relocated to the North. Thus demand for factors of production decreases in the South and increases in the North. The average price level rises in the North relative to the South. Terms of trade are therefore worsened for the South and improved for the North. With some manufacturing relocated from the low cost South to the high cost North, both countries lose from manufacturing inefficiency. The rate of innovation in the North responds to the tightening of IPR in the South by initially rising and then declining over time. The result is driven by lower cost of capital in the North due to lower risk of imitation and rising cost of innovation over time. Helpman showed that this inter-temporal pattern of innovation and thus product availability hurts both the welfare of the North and the South. The bottom line of the paper is that the South clearly loses from tightening IPR in the South, whereas the welfare impact on the North is more complex and depends on the initial rate of imitation in the South and whether FDI is allowed in the South, among other factors.

FDI played a critical role in Lai's (1998) investigation of how strengthening IPR in the South affects the global rate of innovation and technology diffusion. He finds that the effects depend on whether technology diffusion takes place through FDI or imitation only. If technology diffuses to the South through Southern imitation, then strengthening IPR in the South lowers the rate of innovation and technology transfer and therefore widens the wage gap between the south and the North. On the other hand, if FDI is the primary agent of technology transfer, strengthening IPR in the South has the opposite effects. The difference is driven by the different impacts of the two channels of technology diffusion on the cost of innovation in the North. When IPR is tightened in the South, the lives of Northern monopolies are extended. The resulting increase in demand for production labor is completely met in the South – due to its lower wage rate – and this relieves wage pressure in the North. Furthermore, as more production is moved from the North to the South, more resources in the North are freed up for innovation.

Lai and Qiu (2003) introduce a model that allows for innovation in both the South and the North. They find that having the South adopting the IPR standard of the North increases global welfare with the North gaining at the expense of the South. They recognize that strengthening IPR domestically generates an externality in the sense that the availability of more variety enhances foreign consumers' welfare, which the domestic economy does not internalize. A game-theoretic model is used to show that the Nash equilibrium level of IPR protection in the South is lower than that in the North. However, global welfare is higher under IPR harmonization. In order to make it incentive compatible for the

South to adopt the North's IPR standard, they argue that the North should liberalize its traditional goods sector to the South so that both countries reap welfare gain from IPR harmonization.

In an analytical setting similar to Lai and Qiu, Grossman and Lai (2004) analyzed determinants of a country's incentive to protect intellectual property when countries interact with each other in a strategic fashion in setting their IPR policy. They showed that in non-cooperative settings countries have weaker incentives to protect IPR when they are engaged in international trade than when they are not, reflecting the international externality of IPR protection that we discussed earlier. They then defined an efficient global regime of IPR as one that provides the optimal aggregate incentives for innovation to inventors around the world. An important finding is that this efficient global regime of IPR protection can be achieved through different combinations of national IPR policies so that harmonization is neither necessary nor sufficient to achieve global efficiency. Grossman and Lai showed that the North is likely to gain at the expense of the South in any move from the non-cooperative Nash equilibrium setting of national IPR policy making to an efficient and harmonized global regime.

McCalman (2001) was one of the few studies that provided empirical estimates of the welfare implications of patent protection harmonization. He adopted the analytical framework of Eaton and Kortum (1996) to impute the value of patents. The value of a patent taken out in country j that belongs to an inventor from country k depends on j 's market size, the inventive step of the patented invention, and the likelihood that the patent will be imitated and/or become obsolete. The hazard rate of imitation is in turn assumed to depend on the IPR regime of country j , which is measured by a number of indicators such as whether certain industries are excluded from patent protection, whether the patent holder is required to undertake production in the patent granting country. The structural parameters are recovered by estimating a bilateral patent equation that determines the number of country j patents taken out by inventors from country k , along with a labor productivity equation. With the structural coefficients estimated, he then performed a counterfactual analysis assuming those features of a country's IPR regime that are at variance with TRIPs are rectified. In this manner he is able to estimate the hypothetical value in a TRIPs-harmonized world of country k 's patents taken out in country j . Using data on 29 mostly OECD countries, McCalman found large income transfers implicit in TRIPs: the U.S. receives a net transfer that is equal to 40 percent of the gains of trade liberalization, while developing countries suffer losses of up to 64 percent of the gains from trade liberalization. Transfers made by Canada, U.K., and Japan to the U.S. would also be large.⁴ It is important to note, however, that this analysis is a static one, and therefore does not include any benefits from the potentially higher incentive to innovate.

Unlike the previously discussed work, Diwan and Rodrik (1991) found that patent harmonization maximizes global welfare. A unique feature of their model is that the South and the North have different technological needs. For example, the North would like to develop drugs against cancer and heart disease, whereas the South would give priority to drugs against tropic diseases. Global R&D resources are limited, so that the South and the North have to compete for them in order for their preferred technologies to be developed. Extending IPR to the South increases the likelihood that the South's preferred technologies will be developed. A policy implication is that North-South negotiations regarding harmonization of IPR protection may proceed along product lines: concession from the South may be easier to obtain over products that are of greater importance to the South.

⁴ The estimates of welfare implications of trade liberalization were obtained from Harrison et al (1995)

Lall (2003) highlighted the enormous heterogeneity among the developing countries in their innovative capability and level of economic development. Such heterogeneity is likely to produce different impact of international IPR harmonization on these developing countries. Lall argued that TRIPs should recognize the differences in the benefits countries can expect to reap from a universal strengthening of IPR protection.

4. IPR, technology diffusion, trade and FDI

Much of the variation in conclusions about patent harmonization can be traced to the manner in which they treat trade and FDI as mechanisms of international technology transfer. The theoretical literature yields ambiguous predictions about the direction of the relationships among IPR, FDI and trade. The empirical literature has largely indicated a positive relationship between IPR and both trade and FDI, although the robustness of the results is not always clear.

4.1 IPR and trade

The theoretical literature, for example, the monopolistic competition model of Helpman and Krugman (1985), suggests two countervailing effects of strong IPR: market power and market expansion. Strong IPR enhances exporter's market power and induces a lower volume of sale; on the other hand, stronger IPR may open up new markets where exporters otherwise would fear to tread. The empirical analysis of the relationship between IPR and trade has investigated the monopolistic competition model as well as the simple gravity equation.

Maskus and Penubarti (1995) examined whether the distribution of bilateral trade across nations depends on the importing country's patent regime. They estimated the relationship between imports by 77 developing and developed countries from 22 OECD countries in 28 sectors and the strength of the importing country's patent regime. The index of patent laws developed by Rapp and Rozek (1990) was modified and used to measure the strength of the importing country's patent regime. The equation was estimated both for the pooled sample and the 28 individual sectors. The patent index variable was found to have a significant and positive effect on imports, but mostly for the subgroup of large developing countries. The magnitude of the effect is, however, quite modest. Based on the information given in the paper, we calculate that if a large developing country improved its patent index from the lowest of all countries (0.902) to the highest of all countries (5.329), its imports would increase by only 3 percent.

Smith (1999) also examined how sensitive trade was to national differences in patent regime. Her innovation was to link such sensitivity to the importing country's technological capability to imitate. She focused on exports from U.S. states to countries that she grouped into high imitation-threat countries and low imitation-threat ones. The former are countries that combine weak patent rights with strong capability to imitate American technologies. She estimated export elasticity with respect to a patent index and found that weak patent rights are a barrier to U.S. exports, but only in countries with high imitative capabilities. Her estimates indicated that a one percent increase in the patent index would increase U.S. machine exports to the high-threat countries by 1.92 percent, but would lead to a 6.94 percent reduction in U.S. transportation equipment export to the weak threat group. These are enormous effects compared to what Maskus and Penubarti found. They seem to suggest that in high-threat countries the market expansion effect of IPR dominates the market power effect, whereas it is the opposite in the low-threat countries. She also constructed the counterfactual of full compliance with

TRIPs by assuming that all countries brought their patent index to a certain value, 3 and 4 on a scale of 5 in her case. She found that if the high-threat countries brought their average patent index from their average of 1.27 to 4, the U.S. patent sensitive industries could increase their exports to these countries by 43.5 billion dollars in 1992 dollars.

In a related paper, Smith (2001) investigated whether and how U.S. firms' decision in servicing foreign markets was sensitive to the strength of the foreign country's patent regime. She examined three mechanisms through which American firms serve foreign markets: setting up affiliates, export, and licensing. She used a cross-section sample of U.S. bilateral exchange with 50 countries in 1989. Her findings showed that strong foreign patent rights increase all three kinds of foreign-market-serving activities by U.S. firms. Strong patent rights also create a location advantage in the sense that affiliate sales and licenses increase more than exports, particularly in countries with strong imitative abilities.

Liu and Lin (2005) is the only paper of which we are aware that examined the IPR and trade relationship for a newly industrialized economy. They investigated whether Taiwan's exports were related to the rigor of patent protection in the importing country. The latter was measured using the Ginarte and park index. They focused on Taiwan's exports to 54 countries from 1989 to 2000 in three high-tech industries: semiconductor, information and communication equipment. The trade partners of Taiwan were grouped into low imitative capability countries and high imitative capability ones, as in Smith (1999), with the imitative capability defined by the number of researchers per million population. Those with a ratio greater than 1000 were considered to have strong capability to imitate Taiwan's technology. They found that Taiwan exported more to those countries with stronger IPR protection. But unlike Smith (1999), Liu and Lin found that Taiwan exports more to those countries with a stronger R&D ability than Taiwan. It is unclear what these results imply. It could simply be that Taiwan is engaged in large volumes of intra-industry trade with developed countries.

4.2 IPR and FDI

Mansfield (1994) was the first comprehensive empirical study to investigate how IPR affects multinational firms' decision to invest in a foreign country. Mansfield's sample included 94 U.S. multinational corporations that reported their evaluation or perception of the rigor of IPR protection in 16 developing and developed countries. The sample represented firms from a survey Mansfield conducted in 1991 for which he randomly selected 100 major U.S. firms that were listed in the Business Week in the year prior to that. He inferred from the survey responses how these companies' perception of the strength of a country's IPR regime affected their investment strategy in the country. He found that the importance of IPR for the companies' investment decision depends on the nature of the activity: 80 percent of the firms considered IPR to be important for R&D facilities, but only 20 percent thought it was important for sales and distribution functions. The importance of IPR also varies with industry. The Chemical industry (including drugs) is the most sensitive to IPR rigor. Another interesting finding is that companies from different industries tend to rank the IPR rigor of the 16 countries differently. Firms in the survey also reported that IPR protection was more important in decisions regarding the transfer of advanced technology than in investment decisions. When IPR protection changed in Mexico, for example, firms' willingness to transfer more advanced technology increased. Weak IPR thus seems to reduce the level of sophistication of the technology transferred.

Javorcik (2004) extended Mansfield's work to companies that reported their perception of the strength of IPR protection in Eastern Europe and the former Soviet Union for the period of 1989 to 1994. He

tested two hypotheses: that the likelihood of IPR sensitive sectors receiving FDI is related to the host country's IPR strength; and that the IPR regime affects foreign investor's choice as to whether to set up a production facility or merely engage in distribution. He ran Probit regressions with the interaction between a dummy for IPR sensitive sectors and the Ginarte-Park patent index and found the term to be statistically significant. We are unable to assess the magnitude of the effect as it is unclear whether what was reported is the coefficient or the marginal effect. But his findings affirmed those of Mansfeld. First, investors in sectors that rely on strong IPR tend to shun countries with a weak IPR regime. And, in all sectors, weak IPR tends to prompt FDI to focus on distribution rather than production.

McCalman (2004) investigated a similar issue to that of Javorcik (2004): whether the strength of a country's IPR regime affects the governance structure of the FDI it receives. The hypothesis is that stronger IPR encourages more arm's length transactions, thereby facilitating licensing rather than FDI. Using data on the governance structures of major Hollywood studios in 40 foreign markets, he estimated a bivariate Probit model to investigate the determinants of whether a movie was marketed through an affiliate, and thus by FDI, or through licensing. The Ginarte and Park patent index was again used to measure the strength of IPR. He found a non-monotonic relationship between IPR and FDI characterizes the behavior of Hollywood studios abroad: while Hollywood studios are likely to service a foreign market through an affiliate if the standards are either low or high, they are more likely to enter into a licensing agreement if a country offers a moderate degree of IPR protection.

4.3 IPR and licensing

The literature that investigates the relationship between IPR and technology transfer in the form of licensing largely finds that a stronger IPR regime induces more licensing. This seems to point in the direction of stronger IPR leading to more technology transfer. However, the limitation of this literature is that the magnitude of licensing is typically measured as dollars of licensing revenue. All else equal, licensing dollars are likely to be higher where technology transfer is greater, but the increase in such revenue where IPR is stronger could simply reflect monopoly power allowing more revenue to be collected for a given amount of technology transferred

Branstetter, Fisman and Foley (2006) use data on U.S. affiliates in 16 countries that have undergone IPR reform from 1982 to 1999. They found that royalty payments for technology transfer to those affiliates that used patents intensively increased by over 30 percent after the reform. There was also a concurrent increase in R&D spending by these affiliates, although by a smaller proportion. They also reported that following the reform, non-resident patent filings at the U.S. Patent and Trademark Office had increased faster than domestic filings. While it could be that U.S. multinationals have been able to appropriate a higher rate of private return to their inventions without changing the rate of technology transfer, the evidence on R&D and patent filings suggests that at least some of the increase in royalty payments associated with IPR reform reflects an increase in technology transfer.

Branstetter et al (2007) adopt the theoretical frameworks of Helpman (1993) and Lai (1998) to analyze the effect of strengthening IPR in developing countries on production and innovation in developing and developed countries. Their theoretical model confirms findings of the earlier literature, that is, strengthening IPR in the South reduces Southern imitation and encourages more FDI from the North and therefore more production shifting from the North to the South. They show that under reasonable parameterization, the latter, positive, effect to the South dominates the former and negative effect on Southern industrial development. As more manufacturing of new goods migrates to the South, more

resources are freed up in the North for innovation. However, their theoretical analysis does not evaluate the welfare implication of the change in South's IPR regime, e.g., the effect on price levels as a result of less imitation. They then take the prediction of their theory to data on the economic activities of foreign affiliates of U.S. multinationals. Their analysis exploits the potential impact of patent system reform in 16 developed and developing countries and inquires whether such strengthening of IPR had led to U.S. multinationals to accelerate investment and increase production in their affiliates in these countries. These results show that the patent reform only boosts affiliate economic activities of those multinationals that made a larger than average technology transfer, measured by royalty payment receipts, to their affiliates before the patent reform. The impact ranges from an eight percent increase in affiliate labor compensation to a 19 percent increase in affiliate plant and equipment. The impacts on affiliates' royalty payments to the parent and R&D intensity are statistically significant, but the magnitudes are very small, 0.4 percent increase in royalty payments to sales ratio, and 0.05 percent increase in R&D to sales ratio. They also find that the number of goods a country starting to export to the U.S. increases by 20 percent after the country's patent reform.

The interpretation of these results is complicated by a number of issues. For example, patent reform is unlikely to be an exogenous event. Also the patent reform may well have been undertaken as part of a trade liberalization agreement, which would affect both the shifting of affiliate activities among foreign countries by the U.S. parent and U.S. import from these countries.

McCalman (2005) addressed the issue of whether stronger IPR regime in destination countries leads to faster diffusion of new products and technology. Using data on the international release patterns of 60 Hollywood movies from 1997 to 1999, he estimated an equation in which the dependent variable was the number of days that lapsed between the U.S. release and a foreign release of a Hollywood movie. The explanatory variables included IPR measured by the Ginarte and Park index and other characteristics of the foreign country that are relevant to movie production and marketing. He found a non-monotonic relationship between the two: moderate standards of IPR encourage the spread of movies, but very weak or very strong property rights tend to slow the speed with which American movies are released abroad.

Kim (2003) recounted Korea's experience with technology transfer in its early stage of industrialization. He made the distinction between simple, mature technology and intermediate technology. Korean firms obtained the former through "informal" channels, in part because the owners of this type of technology were not enthusiastic about enforcing their property rights as the technology was no longer critical to the firm's competitive strength. While it was hard to quantify the contribution of reverse engineering to technological change, Kim argued that case studies showed that it was "dominant and widespread" in electronics, machinery, computers and pharmaceuticals. He acknowledged that this was facilitated at least in part by the developed country firms' choice not to pursuing their IPR aggressively. The intermediate technology was largely acquired through formal channels such as licensing, FDI, and personnel flow in combination with increasing indigenous R&D efforts.

Without the benefit of a counterfactual analysis, Kim argued on the basis of Korea's experience that strong IPR would have hindered technology transfer to Korea. This could have further diminished indigenous learning that had been part of Korea's experience in the early stage of industrialization. He proposed that international harmonization of IPR should therefore be sensitive to the level of economic development.

Park and Lippoldt (2005) examines whether international technology transfer has responded to the strengthening of IPR in developing countries in the 1990s. Their study is different from Branstetter, Fisman and Foley (2006) in a number of ways. They use four different indices to measure the national variation in IPR protection along four dimensions respectively. These are patent rights, copyrights, trademark rights and enforcement effectiveness. They regressed the royalty and licensing receipts of U.S. firms from unaffiliated foreign sources on the four indicators of the strength of the foreign country's IPR regime. They did this for both different sources of royalty or licensing income (e.g., books, software, etc.) and for different industries. In addition to U.S. multinationals' licensing activities, they also used data on international alliances. They found the most robust effect of IPR in the effect of the patent rights index on licensing. The licensing–patent rights elasticity was statistically significant and ranged from 0.3 to 1.7. The relationship also varies across sectors and by a country's level of economic development. For example, patent rights are found to be influential in the services, electrical and electronic, and transportation industries, but not in the machinery and wholesale trade industries. Stronger patent rights also have a bigger effect on licensing in countries with per capita GDP over \$18,000 in 1995 dollars.

Yang and Maskus (2001) studied the effect of stronger IPR on technology licensing from the North to the South in a dynamic general equilibrium model. While technology licensing increases with the strengthening of IPR in the South, the impact of stronger IPR on the wage of the South relative to that of the North is ambiguous.

5. IPR and economic development

Most of the work reported above treats IPR as an exogenous policy choice, and then investigates its effect on economic behavior in the form of innovation, investment, and technology transfer. There is also a considerable literature that examines the political economy of IPR, looking at the economic determinants of IPR policy in the history of a country at different stages of economic development or a cross-section of countries at different level of economic development. At a low level of economic development, countries develop by bridging their technology gap through imitation. A weak IPR regime serves to reduce the cost of imitation. But as they develop indigenous innovation capability so that they start producing intellectual property, the welfare calculus changes such that countries find it in their own interest to strengthen IPR protection. This pattern of association between IPR and development has been affirmed in studies that investigate the historical relationship between the two, as well as those that use contemporary, cross-country data.

5.1 Empirical studies on the relationship between IPR and economic development

Lerner (2002) investigated determinants of the strength of patent protection in 60 countries with the highest GDP in 1997 over a 150-year period. In addition to the welfare calculus of innovation and imitation, Lerner argues that the economics of institutions suggests that administering an effective patent regime is costly to an authoritarian regime and that the evolution of institutions is path dependent. He used four indicators to measure the rigor of a country's patent system: whether a country had a patent system, maximum duration of patent protection, the time until the government could revoke or license a patent awarded to domestic applicants if it was not put to use, and the number of discriminatory provisions against foreign patent applicants. He found that the strength of patent rights is positively correlated with the level of economic development: wealthier countries are more likely to

offer stronger patent protection. Democratic countries also provide stronger patent protection, all else equal. Patent protection also varies by a country's legal tradition.

The correlation between IPR and economic development is confirmed in many studies using data on a cross-section of countries. However, instead of the linear relationship between IPR and economic development that Lerner's analysis implied, these studies found a U-shaped relationship between the two. Using a cross-section of 77 developed and developing countries for 1984 and by regressing a modified version of the Rapp and Rozek (1990) patent index on the logarithm of per capita income and the square of it, Maskus (2000) found that the strength of IPR bottomed out at per capita GNP of \$523 in 1984 dollars and the income variables explained half of the cross-country variation in the patent index. Maskus likened this to the “environmental Kuznets curve,” which suggests that countries’ environmental standards decline up to a certain level of development and then increase afterwards. But as Maskus acknowledged, the estimated parameters yield a U-shaped curve with a minimum that is at a very low level of development— only 17 of the poorest countries in his sample had per capita income lower than \$523.

Ginarte and Park (1997) ran similar regressions using their patent index. They included in their regressions income per capita, but not the squared term, R&D to GDP ratio, and proxies for education achievement, openness, political freedom, and market freedom. When the latter variables are added in their regressions, the coefficient of the income variable changed from positive and statistically significant to statistically insignificant. R&D intensity and market and political freedom are significant and raise the explained proportion of the variation in patent index from 0.31 to 0.51. Maskus (2000) managed to reproduce the U-shaped result using Ginarte and Park’s data. But he was only able to retain the result using a different set of proxies for the other variables and obtained an R^2 of 0.37, substantially lower than Ginarte and Park’s 0.51. On the other hand, the Ginarte and Park results do not necessarily negate a U-shaped relationship between IPR and economic development since per capita income and variables such as R&D intensity, market and political freedom are likely to be highly correlated.

These results suggest a rather complex empirical interplay among income, IPR regimes, and other specific aspects of the development process such as education levels, R&D and political/institutional variables. Chen and Puttitanun (2005) provide a structural interpretation for the U-shaped relationship between development and IPR. They present a theoretical model where the government chooses the optimal level of IPR protection balancing between the ease of imitating foreign technology and incentives for indigenous innovation. Under plausibly parameterized situations, there exists a U-shaped relationship between IPR and economic development, generated by the relative strength of the imitation motive and the innovation motive. For their empirical analysis, Chen and Puttitanun used the Ginarte and Park patent index and data for a panel of 64 developing countries. They estimated two equations, one for IPR and a patents production function. For the IPR equation, they regressed the patent index on GDP per capita and the squared term, tertiary education enrollment, economic freedom, international trade to GDP ratio, WTO membership dummy, and year specific effects. The inclusion of these other controls does not diminish the economic and statistical significance of the GDP per capita variables. It is not clear how well their model fits the data since they did not report R^2 of their regressions. But their point estimate suggests that the minimum level of IPR protection on the U-shaped curve occurs at a level of GDP per capita of \$854 in 1995 prices.

Rasiah (2002) relates the enforcement of TRIPs to a country's technology capability and high-tech

infrastructure and argues that vastly heterogeneity in East and South Asia along these dimensions makes universal enforcement of TRIPs difficult.

5.2 The case of the U.S. patent and copyright protection

The U.S. has been a pioneer in building the modern patent system. Sokoloff and Khan (2001) provide an informative account of the early American patent system as conceived by the American constitution. In sharp contrast with the British patent system at the time, the American patent system in the early nineteenth century was built with the goal of providing broad access to property rights on technology. This was achieved through low application fee - only 5 percent of that of the British patent system - and an impersonal and non-discriminatory application process. Such a democratic system of granting intellectual property rights had contributed to the rising number of patents granted in the 19th century. One cannot help drawing parallel between the early American patent system, which was initially a registration system, to the liberal use of “utility model” patents, also known as petty patents, in East Asian economies such as Japan, Korea and Taiwan in their early stage of development in the 20th century.

The early U.S. history of copyright protection has been drastically different from that of patent protection. The U.S. statues have been protecting the copyrights of American citizens since 1790. But such protection was not extended to foreign citizens until 1891 when the U.S. signed the Berne Agreement. And it did so only when “the balance of trade in literary and artistic works was swinging in its favor” (Sokoloff and Khan, 2001). Khan (2004) examined this episode of piracy in the U.S. history and investigated whether the piracy had reduced the incentives of American authors. Using data on prices of foreign and domestic authored books and various book characteristics, Khan did not find any significant differences in book prices that could be attributed to the lack of copyright protection of foreign authors. The general public gained wider access to foreign authored books than they would have otherwise. Khan concluded that in general Americans benefited from the country's disregard for foreign copyright in the nineteenth century.

The U.S. was not alone in providing IPR protection only as it saw such protection fitted its own interests. During the patent controversy in the mid-19th century, the Netherlands and Switzerland did away with their patent systems for a significant period of time. One could argue that the movement of international harmonization of IPR protection was much less forceful as it has become in the late 20th century. The fact that IPR harmonization has assumed such urgency in recent decades perhaps has to do with the increasing pace of globalization, a process in which a country's economic interests have become ever more entwined with those of other countries.

6. Conclusions

Given the breadth and strength of the international efforts over the last 15 years to extend U.S.-style IPR regimes to the less-developed world, it would be desirable if the economics profession could speak confidently about the consequences of such “harmonization” for the countries being asked to change their policies, and for the world at large. Unfortunately, the complex interplay of decisions regarding R&D, trade, FDI, licensing, other forms of technology transfer, and economic development make this difficult. At the risk of dangerous over-simplification, we suggest the following observations that seem to have theoretical and/or empirical support in the literature:

- Looking at the historical U.S., the post-war industrializing countries of East Asia, or today's industrializing countries, societies in the position of catching up to technological superiors have preferred not to adopt the strongest of available IPR regimes. Though the theory of revealed preference does not strictly apply to social decisions, this certainly suggests that the process of development at this stage is not served best by harmonization to current U.S. standards.
- Analytically, the first-order effect of harmonization on developing countries is higher prices for patented goods and services. Empirical and simulation analyses indicate that this effect is significant, both in absolute terms, and relative to the magnitude of the gains that might be enjoyed by patent owners in the developed countries.
- The strongest theoretical argument for benefit to developing countries from stronger IPR is that it will encourage innovation in areas specific to their needs. Evidence for the empirical significance of this effect is extremely limited. The only real example that has been identified is research on tropical diseases. It is widely acknowledged, however, that the largest barrier to significant private investment in this area is the lack of significant buying power for any potential cures, rather than weak IPR.
- There does seem to be fairly robust evidence that a country's inbound trade, FDI and licensing activity depends on its IPR regime, with regimes perceived as weak acting to inhibit all of these processes to some extent. Though it is difficult to quantify the distinct effects of particular mechanisms, or to identify clearly the effects of IPR separately from other aspects of a country's social, political and economic institutions, it is likely that countries navigating the transition from middle income to fully industrialized need to pay attention to the effects of their IPR policies on their development trajectory.
- Even within the technologically-advanced world, there is surprisingly little empirical evidence for the proposition that stronger IPR regimes produce faster innovation. While it is surely true that a global absence of property rights in inventions and other creations would inhibit technological advance, it does not follow that incremental strengthening of such rights, or an increase in the fraction of the world economy governed by the strongest rights, would lead to more innovation. Further, since investment in innovation is likely to be subject to decreasing returns within any given time period, extension of strong IPR to all countries is unlikely to be globally efficient.

Thus an honest overall appraisal of harmonization—defined as universal adoption of U.S.-like IPR policies—is as a policy initiative that hurts developing countries for the benefit of rich countries, with the possibility but no certainty that the global benefits exceed the global costs. If this is true, then the only defensible basis on which to pursue harmonization is for the rich countries to compensate the industrializing countries for making the change. If the compensation comes in an efficient form, such as the elimination of our own trade barriers, then it is likely that the overall initiative would be globally welfare-improving.

The most likely globally efficient IPR policy is not harmonization, but rather selective and gradual IPR reform, in which each country is allowed to devise policies that are appropriate for its particular technological situation and stage of development. For countries in the early stages of catch-up to the world technological frontier, this will mean policies that facilitate technology transfer and even a certain amount of imitation. At some point, however, countries need to recognize that movement toward fuller IPR protection will facilitate foreign FDI and licensing. Eventually, as a domestic innovation sector emerges, countries will find it in their interests to provide greater protection in order

to protect their own inventions. There is nothing wrong with the rich countries encouraging this process of reform, but bullying, or suggestions that early adoption of our system is in their own self-interest, are likely to be counter-productive.

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