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Impact of Intellectual Property Rights Reforms on the Diffusion of Knowledge through FDI

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This paper examines the impact of intellectual property rights (IPR) reforms on the technology flows between the U.S. and countries where U.S. multinationals have established affiliates. We use patent citations as a proxy for knowledge spillovers to examine whether the diffusion of new technology between the host countries and the U.S. is accelerated by the reforms. We test the hypothesis that strengthening patent protection facilitates knowledge flows (in the form of patent citations) between U.S. multinationals and their subsidiaries in the reforming countries and between other U.S. firms and reforming countries domestic firms. Our results suggest that the reforms favor innovative efforts of domestic firms in the reforming countries rather than U.S. affiliates efforts. In other words, reforms mediate the technology flows from the U.S. to the reforming countries.

JEL Classifications: O30, O34, F23

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1. Introduction

Foreign direct investment (FDI) facilitates the diffusion of new knowledge between countries. Because technology spillovers tend to be localized, one of the reasons why multinationals (MNCs) open overseas subsidiaries, in industry clusters with leading technologies, is to get access to new critical innovations. Often, their affiliates can contribute to the domestic knowledge stock of their host countries. Local companies in these countries have easier access to new technologies developed by foreign laboratories conducting R&D there. Even when the affiliates are not oriented towards innovation, their internal organization and social networks facilitate knowledge spillovers from their home to their host countries.

The intellectual property rights (IPR) regime of a country is one of the factors that play a critical role in the decision of multinationals to open a subsidiary in that country. It has a critical impact on the type of activity conducted by affiliates, as well. Strong IPR can encourage multinationals to open subsidiaries that develop new technologies or products and draw upon technical innovations developed by the parent firm in the home country because they are protected against imitation by local rivals. Affiliates in host countries with weak IPR may be more oriented towards adjusting existing products to the local markets. MNCs may limit the activities conducted by their affiliates in countries that pose a high risk of imitation. Tightening the IPR protection may change the scope of activity of these subsidiaries, which might become oriented more towards exploration of new technologies rather than exploitation of existing knowledge. Changes in the affiliates' scope of activity would entail changes in the way knowledge diffuses internationally between the home and the host country of the affiliate or changes in the type of technologies that are deployed overseas by multinationals.

The 1990s saw major reforms of the IPR laws and their enforcement in many developing countries, as the Trade-Related Aspects of Intellectual Property Rights Agreement set minimum standards for intellectual property regulation for all members of the World Trade Organization. This paper studies the impact of these reforms on the knowledge spillovers facilitated by the presence of subsidiaries in the reforming countries. It analyzes

the relationship between IPR strength and the diffusion of new technologies. We analyze the impact of the reforms on the technology flows from the country undertaking FDI in a few reforming countries. In other words, we test whether the IPR reforms facilitate the diffusion of international knowledge. This paper tests empirically whether knowledge diffuses at a higher rate after countries have undertaken reforms of their patent regimes. We study technology spillovers in the form of patent citations to prior art, as the analysis of citations has been the dominant way to address questions of knowledge flows. We expect to find that stronger IPR facilitates international knowledge diffusion. Our analysis consists of two parts:

First, we study the citing patterns of affiliates of multinational corporations conducting R&D in 12 reforming countries. Tighter protection of IPR could influence the parent firms to deploy new critical technologies because the new patent laws reduce the fear of imitation. One would expect to see technology flows from parent firms in the U.S. to their affiliates increase after the reforms. We test empirically whether subsidiaries' citations to their parent companies in the U.S. are more frequent after the reforms of the patent systems in the host countries. Although one might expect an increase in this frequency, we do not find evidence to support our hypothesis. However, the reforms might affect the flow of knowledge in a different way. After the implementation of the reforms, the type of technology transferred from the parent to the affiliate might change. The multinational might allow its subsidiaries to use its critical innovations, technologies that it might have restricted from spreading before the reform from fear of imitation in a country with a weak patent system. We look deeper, at different characteristics of the citations made by the U.S. affiliates. Even if the frequency has not changed after the reforms, changes in these citations' characteristics could indicate important benefits for the reforming countries. After the reforms, the affiliates might cite patents that are cited more or that make more citations. They might cite patents that are more "general" (cited by a wider range of technological fields) or patents that are more "original" (that cite a wider range of technological classes). We look for any changes in these characteristics that might suggest diffusion of more important or broader innovations between the U.S. and the reforming country. We explore the variation before and after reforms in the measures of originality (range of classes that are cited by the patent), generality (field range of patents that cite this patent), and number of citations made or received developed by Hall, Jaffe, and Trajtenberg (2002). We still find no significant changes after reforms, with one exception. Our results show a decline after

reforms in the importance or impact of patents assigned to American MNCs that are cited by their subsidiaries, when we use the number of citations received as an indicator of the performance of patents. In other words, patents of MNCs cited after reforms by their affiliates receive fewer citations.

Second, one would expect to see an increase in technology spillovers from U.S. companies to domestic firms in the reforming countries. As empirical studies suggest that distance inhibits knowledge flows, the geographic proximity to U.S. affiliates would give domestic firms easier access to American knowledge generated by U.S. companies after their countries have undertaken IPR reforms. In the second part of the analysis, we turn our attention towards the way the citing patterns of domestic companies in the reforming countries have changed after the reforms of the IPR systems. We do not find evidence that local firms make citations to U.S. companies more frequently. Nevertheless, our results suggest that patents assigned to American firms that are cited after reforms by reforming countries' domestic firms receive more citations, on the average. In other words, we find a relative increase in the importance of U.S. patents cited by local companies after reforms.

In the light of our previous result, we conclude that the reforms are beneficial for the reforming countries. They favor innovative efforts of the domestic firms in these countries rather than that of U.S. affiliates there. More important technologies or innovations with a larger impact are transferred from firms in the U.S. to domestic companies in the reforming countries after the reforms. The reasoning is highly intuitive. If a country institutes rigorous reforms, U.S. companies will be less concerned about sharing their knowledge with subsidiaries in the host country, and more willing to produce and market high-technology goods in the reformed country. Because this increases the effective proximity to advanced knowledge, reforms improve the ability of the host country's firms to access and make use of U.S. knowledge. The policy implication is obvious: countries should be much more eager to undertake TRIP-related reforms than most have been. Thus, our paper brings evidence that reforms of the IPR mediate the transfer of new technologies to domestic companies in the reforming countries, fostering the innovative activity by locals. Contrary to what we might expect, the reforms do not encourage innovation conducted by American affiliates in these countries.

The rest of the paper is structured as follows. Section 2 provides a description of the IPR reforms in the 12 countries studied. Section 3 gives a brief overview of the prior

literature. Section 4 illustrates the methodology, Section 5 describes the dataset construction, Section 6 presents the results, and Section 7 concludes.

2. Reforms of the IPR system

Numerous initiatives have tried to strengthen the IPR globally. The most significant change in global IPR protection is the Agreement on Trade-Related Intellectual Property Rights (TRIP), negotiated as a founding component of the World Trade Organization (WTO). Before the Uruguay Round trade negotiations, the World Intellectual Property Organization (WIPO) dominated IPR multilateral rulemaking. In the 1980s, the U.S. became increasingly dissatisfied with the WIPO's enforcement of the IPR conventions. As a result, IPR was introduced in the trade deliberations of the Uruguay Round by the American negotiators, supported by the EU, Japan and other first world states.

TRIP requires numerous developing countries to strengthen their IPR regimes by setting minimum standards to be fulfilled. It covers all aspects of IPR, including patents, copyrights, trademarks, and trade secrets, as well as the enforcement of these stronger rights. As a core component of the WTO, any country that joins the WTO seeking to obtain easy access to the international markets opened by the organization, has to adhere to TRIP. One example was China, who strengthened its IPR system to comply with the TRIP before becoming a member of the WTO.

Although the TRIP agreement constitutes the most important attempt of harmonization in the area of IPR, it remains a work in progress and there are still significant differences among countries. Using the annual National Trade Estimate Reports of the United States Trade Representative (USTR), Maskus (2000) makes inferences about the evolution of the IPR system in selected countries. Table 1 presents his estimates, an overview of the IPR protection changes between 1986 and 1998. We should bear in mind that the descriptors used – weak, moderate, good, and strong –offer only a rough description of the IPR system in the countries taken into consideration and summarize the views of USTR. Although implementation of the reforms in many countries is an ongoing process, there is one turning point in the reform process of the patent system of each of these countries, a point when the IPR system suffered a major change (Branstetter, Fisman and Foley (2004), Maskus (2000)). That is the year taken to be the year of the reform in our

analysis and it is illustrated in the last column of Table 1. Comparing the descriptors chosen for 1998 with those for 1986, we get the general impression that these 12 countries undertook patent reforms that led to considerable tightening of the protection of IPR.

Table 1. Evolution of IPR protection

Country	1986	1998	Reform Year
Argentina			
Laws	Weak	Moderate	1996
Enforcement/Administration	Weak	Weak	
Brazil			
Laws	Weak	Good	1997
Enforcement/Administration	Weak	Weak	
China			
Laws	Absent	Good	1993
Enforcement/Administration	Absent	Weak	
Indonesia			
Laws	Absent	Moderate	1991
Enforcement/Administration	Absent	Weak	
Japan			
Laws	Good	Strong	1995
Enforcement/Administration	Weak	Good	
South Korea			
Laws	Weak	Strong	1987
Enforcement/Administration	Weak	Good	
Mexico			
Laws	Weak	Strong	1991
Enforcement/Administration	Weak	Moderate	
The Philippines			
Laws	Weak	Good	1997
Enforcement/Administration	Weak	Moderate	
Spain			
Laws	Moderate	Strong	1986
Enforcement/Administration	Weak	Strong	
Taiwan			
Laws	Weak	Strong	1993
Enforcement/Administration	Weak	Weak	
Thailand			
Laws	Weak	Good	1992
Enforcement/Administration	Weak	Weak	
Turkey			
Laws	Weak	Good	1995
Enforcement/Administration	Weak	Moderate	

Source: Maskus (2000)

The agreement sets minimum standards in all areas related to IPR, but the most important changes are in the area of patents. It strengthens the scope of the patent rights, it mandates a minimum of 20 years of protection from the application date, and it sets standards for the efficient enforcement of IPR. The agreement requires a broader definition of patentable subject matter. Patents must be granted in "all fields of technology". Many countries, like Spain, Mexico, South Korea, Brazil, or Turkey had to extend the protection of patents to include areas such as chemicals, food products or pharmaceuticals. In addition, before the reforms, inventors could generally patent the process through which the product was obtained, but not the product itself.

Countries like Japan, Mexico, Turkey, the Philippines, or Brazil changed the administration of the patent system. Japan eliminated the pre-grant opposition system in favor of a post-grant opposition regime. Before 1995, any person could file written opposition to a patent application within three months of its publication, leading to increases in the file-grant lag and "patent flooding". The post-grant opposition system allows opposition to patents following publication of the patent grant. Mexico abolished in 1991 its old patent system in favor of a new one. Other countries that changed the patent laws, as well as their administration, were Brazil, Spain, Turkey, and the Philippines. Spain revised its patent system in 1986, as one condition for its entry into the European Union. Implementing the changes was delayed until 1992. Turkey tightened its protection laws anticipating a free-trade agreement with the EU. South Korea and Taiwan are examples of countries that undertook reforms to strengthen their patent systems due to domestic commercial interests. Argentina, Brazil, and the Philippines responded to TRIP obligations by adopting stronger protection only in the late 1990s. China undertook reforms in the 1990s, but the enforcement of these reforms is still inefficient.

As Table 1 illustrates, in 1998, as in 1986, there were major differences among these 12 countries in the level of IPR protection and its enforcement. Moreover, as mentioned above, some countries undertook reforms that changed the IPR laws, others undertook reforms that altered the administration of the laws, whereas some reforms targeted both the laws and their enforcement and administration. In the methodology section, we address how we deal in our analysis with these significant differences between reforms in each country.

3. Related Literature

The impact of IPR shifts on innovation has become an important question in the economics of technological change. Among the theoretical papers that analyze the impact of IPR changes on the global welfare, Helpman (1993) suggests that tighter IPR can, under certain conditions, decrease global welfare. The author uses a dynamic general equilibrium model, in which the North innovates and manufactures products, and then production is transferred to the South through imitation. He argues that, as the cost of imitation rises, tighter IPR shifts production to the North. As demand for labor increases in the North, Northern wages increase. Transferring production to the higher cost region decreases efficiency. Higher Northern wages raise the cost of R&D, discouraging innovation. Lai (1998) modifies Helpman (1993)'s model by allowing Northern firms to undertake FDI. He argues that, when imitation is the only channel of production transfer, tighter IPR lowers the rate of innovation, similar to Helpman (1993)'s model. However, when Northern firms can undertake FDI, stronger IPR increases the expected lives of the monopolies and the returns to FDI and multinationals move more quickly to the South, increasing the rate of innovation. Glass and Saggi (2002) endogenize imitation by the South. They argue that there are two effects of stronger IPR: "a resource wasting effect" according to which tighter IPR makes imitation more costly, it draws resources into less efficient imitation in the South, raising the scarcity of Southern resources and decreasing profits from FDI; and "an imitation disincentive effect" according to which production is transferred to the North due to a decreased level of FDI and resources are drawn into production and away from innovation in the North.

Besides theoretical studies that analyze global welfare in the presence of IPR reforms, the literature deals with the impact of changes in IPR on international trade. Maskus and Penubarti (1995) test empirically whether exporting firms take account of local patent laws in their decision to export in different countries. They find evidence of a positive relationship between international trade and importing country patent regime strength. Smith's (1999) empirical study confirms the theory that IPR and international trade are related. She argues that weak patent rights discourage U.S. exports to countries with a high risk of imitation. Thus, tighter IPR in these countries would encourage U.S. exports to their markets. Nevertheless, in nations that pose a low risk of imitation, the strengthening of the

IPR would only raise the monopoly power of patent holders, and U.S. exports to these countries would decrease.

Other empirical studies try to asses the response of domestic innovation in reforming countries to changes in IPR. Based on the observation that patent protection for computer programs was strengthened in the 1980s and 1990s, but firms that generated most of these patents reduced their R&D spending relative to sales, Bessen and Maskin (2000) argue that imitation might actually stimulate innovation. They suggest that, in a sequential setting, where each invention builds on the previous one, imitation may promote innovation, as the imitator might improve an idea that the initial inventor did not have. Therefore, stronger IPR may actually reduce the pace of innovation. Using firm level data on 307 Japanese firms from 1980 to 1994, Sakakibara and Branstetter (2001) analyze the response of innovation to the 1987 Japanese patent reform. They do not find much evidence that domestic innovation in Japan responded to the changes in the patent regime. Lerner (2002) analyzes the impact of major patent regime changes in 60 countries over a period of 150 years. Consistent with earlier work, he finds that domestic patent applications do not respond significantly to changes in patent policy. However, foreign entities do generate more applications in the reforming country after reforms. This suggests that FDI could be one alternative channel through which reforming countries could benefit from tighter IPR. Based on this observation, Branstetter, Fisman and Foley (2004) assess empirically the impact of tighter IPR on the technology flows from the country undertaking FDI to the host country. Using data on U.S. multinationals' affiliates in 12 countries that undertook major IPR reforms between 1982 and 1999, they find strong evidence that tighter IPR raises the technology transfers to the reforming countries. The volume of intrafirm royalty payments for intangibles, the affiliate R&D (considered a complement to technology transfers) and the foreign patent applications increase with stronger IPR in the host country of the subsidiary. Branstetter, et al. focus on deliberate technology flows, in the form of intrafirm royalty payments for intangibles paid by the subsidiary to the parent firm. These technology spillovers are deliberate, but an inventor may build his innovation using existing pieces of knowledge without compensating the original inventor. Nonetheless, one can still detect these spillovers through patent data. The inventor is legally obliged to disclose the source of any prior art in his patent application and this type of transfers of ideas or information is uncompensated. The literature, starting with the empirical research of Jaffe, Trajtenberg and

Henderson (1993), uses patent citations to prior art as a proxy for technology flows of this nature. Our analysis focuses on this type of knowledge spillover.

Other studies analyze the relationship between FDI and the strength of IPR regimes. Maskus (1998) provides empirical evidence that FDI by U.S. firms is sensitive to changes in patent regimes. To study the relationship between FDI and IPR, Lee and Mansfield (1996) use a survey of 100 major U.S. firms and data on U.S. FDI in manufacturing. They ask questions about firms' decision to invest in 14 developing countries in relationship to the IPR in those nations. They find evidence of a positive relationship between the perceived strength of the IPR in a country by the companies surveyed and the volume of U.S. FDI in that country. Their results are consistent with the earlier studies that found a positive impact of stronger IPR on FDI.

4. Methodology

The existing literature suggests that one of the potential benefits of the reforms for the countries undertaking them is that stronger IPR protection may induce larger knowledge spillovers between the U.S. and the reforming countries. American MNCs may be reluctant to let subsidiaries use their new technologies in countries with weak patent laws, from fear of imitation. Tightening of the IPR protection might be an incentive for these organizations to deploy critical technologies at a higher rate after developing countries have undertaken IPR reforms. One would expect to see this reflected in knowledge flows in the form of patent citations. U.S. multinational corporations might be cited more frequently by their subsidiaries in these countries. Moreover, domestic firms in the reforming countries might benefit from the geographic proximity to these American affiliates and start drawing more upon technical innovations generated in the U.S. This type of technology flow might be reflected in the patent citations of domestic companies to American firms. We use patent citation data to analyze how IPR strengthening affects these two forms of knowledge spillovers: (i) between U.S. parents and their affiliates, and (ii) between American and reforming countries domestic firms. This section describes our methodology in each case and addresses how it tackles two identification issues.

4.1. Knowledge spillovers between U.S. multinationals and their subsidiaries in the reforming countries

First, we empirically analyze whether the diffusion of new knowledge between U.S. parent firms and their affiliates in 12 countries increases after the reforms. We use a dataset composed of patents generated by affiliates of U.S. multinationals in the reforming countries. We test whether the subsidiaries make more citations to their parent firms in the U.S. after the countries' patent systems have undergone significant reforms.

Then, we study these citations, as it might be the characteristics of the patents cited that change after the reforms, not necessarily their frequency. As mentioned before, U.S. multinational corporations might deploy new technologies that they were reluctant to let spill over to their affiliates before reforms. We look for changes in the characteristics of the patents of MNCs cited by their subsidiaries, as they might indicate a change in the type of knowledge flowing between the host and home country of the multinational. We compare the number of citations received and made by these patents, but also measures correlated with these numbers, measures constructed by the authors of the NBER Patent-Citations data file. Nevertheless, finding differences might be unrelated to the presence of the U.S. affiliate in the reforming country. To be able to draw inferences, we subject our hypothesis to a stringent test. We compare these differences in characteristics of citations before and after reforms to a benchmark, that tells us what the expected difference is for the rest of citations in the dataset. We eliminate other confounding effects and try to get closer to distinguishing the impact of reforms on the diffusion of technology between the two countries.

4.2. Knowledge spillovers between American and reforming countries domestic firms

As mentioned above, stronger IPR might facilitate the diffusion of knowledge from the U.S. to the reforming countries, through multinational corporations. Numerous studies suggest knowledge spillovers are localized. The geographic proximity of the affiliates to domestic firms might increase the flow of new technologies from the U.S. to domestic companies in the reforming countries. These firms might not have access to American innovations otherwise. To analyze this second hypothesis, we use a dataset of patents generated by domestic companies in the reforming countries. We test whether the reforms facilitate the flow of American innovations to them. In other words, we analyze whether

these domestic firms make more citations to U.S. companies after the country has undergone the reform of its patent system. Using the same method as before, after analyzing how the frequency of citing U.S. companies has changed after reforms, we look at different characteristics of the U.S. patents cited by the reforming countries domestic firms.

4.3. Controlling for unobserved effects

Two issues deserve attention.

First, our data source is the NBER Patent-Citations data file. It contains all utility patents granted between January 1963 and December 1999. For each reforming country, we select patents with the application year 5 years before to 5 years after reforms. Because the application-grant mean lag is around 2 years [Hall, Jaffe, and Trajtenberg (2002)] and reforms in some of the countries took place in the late 1990s, some application years are missing from our dataset. For example, 1996 is considered the year of major law changes in Argentina and we would like to have patents granted to U.S. subsidiaries in Argentina with the application year between 1991 and 2001. However, the latest application year in our dataset for Argentina is 1997. These missing application years result in a nonrandom sample and, since the application year might be related to unobserved factors that affect the propensity to cite other patents, the selection might be endogenous and it can result in a sample selection bias in the OLS estimates. Even if other factors related to the application year are independent of the error term, our estimates are inefficient. We address this issue by using citing patent application year dummies that control for all unobserved factors that vary across application years.

Second, as illustrated above, countries differ greatly in the level of IPR protection and the enforcement of the IPR laws. Therefore, reforms are very different among countries. We control for the different time-invariant characteristics of the reforming countries that might affect the subsidiaries' propensity to cite by including country fixed effects. After running regressions both with and without these dummies, we find that these country differences are indeed strong.

5. Dataset Construction

This section describes the construction of our datasets and shows how it addresses some issues related to the variables used.

5.1. Patents assigned to U.S. subsidiaries in the reforming countries

To construct the dataset, we use the NBER Patent-Citations data file. The first inventor's country is taken to be the country where the innovation took place. Alternative methods were used in the literature to assign location to patents. Thompson (2004) selects at random one inventor's home address to denote the innovation location, while Jaffe, Trajtenberg and Henderson (1993) make the selection based on pluralities of inventors. We use the first inventor's address for programming ease and because it is a good estimator of the patent's location. Hence, patents generated by U.S. subsidiaries in the reforming countries are those assigned to U.S. companies and a reforming country of innovation. The NBER dataset includes the assignee type according to the classification used by the USPTO. For each of the 12 reforming countries, we select all patents assigned to a U.S. nongovernmental organization and the first inventor located in that country. From this initial set, we keep only 3,154 patents with an application date 5 years before to 5 years after the reform. Table 1 shows summary information about the patents assigned to U.S. subsidiaries in the reforming countries.

TABLE 1. Patents assigned to U.S. subsidiaries in the reforming countries: Summary Statistics

Number of citing patents	3,154	
Number of citations	19,942	
	Before reforms	After reforms
Number of citations	8,782	11,160
Mean citations per patent	5.7	6.9

Using the USPTO website, we extract information on these patents, including all their citations to prior patents. We supplement these patents' details with measures

constructed by the authors of the NBER dataset. Our dataset is composed of 19,942 citations contained in the patents of U.S. subsidiaries in the reforming countries. It is used to test whether subsidiaries in the reforming countries are more likely to cite their parent-firm after the reforms and whether these citations have different characteristics before and after reforms. We construct two dummy variables. The first, CITING PARENT is set equal to 1 if the parent firm is cited by its affiliate in the reforming country, and 0 otherwise. A citation made by one of the patents in our dataset to a patent assigned to the same U.S. company and American inventors is taken to be a citation to the subsidiary's parent firm in the U.S. The second variable, REFORM is set equal to 1 if the citing patent application year is the year of or any year after the reform.

5.2. Patents assigned to domestic companies in the reforming countries

To test whether domestic firms in the reforming country are more likely to cite U.S. companies after the reform, we construct a second dataset. Table 2 summarizes information about the patents assigned to local firms in the reforming countries.

TABLE 2. Patents assigned to domestic companies in the reforming countries: Summary Statistics

Number of citing patents	2,469	
Number of citations	12,696	
	Before reforms	After reforms
Number of citations	5,300	7,396
Mean citations per patent	5.1	5.2

We use again the NBER Patent-Citations data file. For each reforming country, we select the patents assigned to a firm and first inventor located in the country of reform. This is the set of all patents generated by domestic firms in the reforming country between January 1963 and December 1999. We consider the location of the first inventor as that where the innovation took place, the same method chosen to construct our first dataset. We keep 205,264 patents with the application date 5 years before to 5 years after the reform. We have disproportionately many observations for 3 countries (Japan, South Korea and Taiwan). The dataset is composed of 203,759 patents assigned to companies in these 3 countries and

1,505 patents assigned to the 9 other countries. To construct a balanced dataset, we randomly select the first 50 patents for each application year and each of these countries and end up with a dataset of 2,469 patents assigned to domestic firms in the 12 reforming countries. This second dataset comprises 12,696 citations made by these patents and we extract information about these from the patents' front page. We supplement our data with the constructed measures taken from the NBER data file. We construct two dummy variables. The first, CITING US is set equal to 1 for citations to a U.S. assignee and an American first inventor. These are taken to be citations to U.S. companies. The second variable is the same REFORM variable constructed for the first dataset, set equal to 1 for citing patent application year in the year of, or the years after the reform. This second set is used to test whether domestic companies in the reforming countries are more likely to cite U.S. firms after the reforms and whether these citations have different characteristics before and after reforms.

5.3. Characteristics of the patents

As mentioned above, our study uses measures that describe our patents. These are the measures of generality, originality, the number of citations made and received, variables created by the authors of the NBER Patent-Citations data file. Generality is measured by $Generality_i = 1 - \sum_j^{n_i} s_{ij}^2$ [Hall, Jaffe, and Trajtenberg (2002)], where s_{ij} is the percentage of citations received by patent i that belong to patent class j, out of n_i patent classes. The higher the generality, the wider is the range of fields of patents that cite this patent. Originality is measured by $Originality_i = 1 - \sum_j^{n_i} s_{ij}^2$ [Hall, Jaffe, and Trajtenberg (2002)], where s_{ij} is the percentage of citations made by patent i that belong to patent class j, out of n_i patent classes. The higher the originality, the wider is the range of classes that are cited by the patent.

The patent's originality and generality are positively correlated with the number of citations made and received, respectively. Patents that have a large number of citations received have higher generality scores on the average because, the higher the number of citations, the larger the number of technology classes covered. This leads to bias when we

compare the generality of patents before and after reforms because after reform patents are subject to a higher degree of truncation in the number of citations received. They can only receive citations before 1999, which is the last grant year in our dataset. Hall (2005) calculated a generality measure adjusted for the number of citations received. This adjustment reduces, but does not eliminate, the decline in the average generality in the 1990s. We tackle this issue by adding cited patent application year dummies in the regressions with generality as the dependant variable. This purges the data of the effects of truncation.

The number of citations made and received by the typical patent changes from year to year [Hall, Jaffe, and Trajtenberg (2002)]. To compare the number of citations received before and after a reform and draw conclusions about the effect of the reform, we have to separate the difference in citation intensity that is due to other, unrelated factors. We address this issue by using an approach suggested by Hall, Jaffe, and Trajtenberg (2002). We express the number of citations received as a ratio to the average number of citations received by the typical patent in the same year of application. This rescaling eliminates other confounding effects and we are closer to finding the real effects of the reforms. We use the same practice to rescale the number of citations made. This method eliminates the effects of truncation, those due to systematic changes in the propensity to cite or due to changes in USPTO practices, but it has the inconvenience of eliminating changes over time in the impact (citations received) or importance (citations made) of patents, as well.

6. Results

6.1. Raw mean tests

We start by conducting crude mean tests. Table 3 shows the results. We find that U.S. subsidiaries in the reforming countries made 8,782 citations before reforms and 7.3% of those were citations to their parent firm in the U.S. The frequency of citing their parent company did not change after the reforms. The patents of domestic companies in the reforming countries cite U.S. firms 46.6% of the time before reforms. We find that the frequency of citing the U.S. decreases, but the magnitude of the change is less than one percentage point.

TABLE 3. Comparison of means, before and after reforms

	CITATIONS ASSIGNED TO U.S. SUBSIDIARIES IN REFORMING COUNTRIES		CITATIONS ASSIGNED TO DOMESTIC COMPANIES IN REFORMING COUNTRIES	
Number of observations	19,942		12,696	
	Before reform	After reform	Before reform	After reform
Number of observations	8,782	11,160	5,300	7,396
	CITING PARENT		CITING U.S.	
Fraction	0.073	0.072	0.466	0.458

As mentioned above, the reforms might have an impact on the characteristics of the patents cited. We further explore the citing patterns of U.S. subsidiaries in the reforming countries. Table 4 shows the mean measures of originality and generality and the number of citations received and made of American MNCs patents cited by their affiliates. The numbers of citations received and made are rescaled by the mean per application year to account for the steep decline in the number of citations received in the 1990s, because 1999 is the last grant year in our dataset.

TABLE 4. Comparison of the characteristics of patents cited by U.S. affiliates in the reforming countries

	BEFORE REFORMS		AFTER REFORMS		
Number of observations	8,782		11,160		
	Citing parent	Not Citing parent	Citing parent	Not Citing parent	T-test
Number of observations	645	8,137	801	10,359	
Mean Originality	0.404 (0.011)	0.342 (0.003)	0.424 (0.010)	0.351 (0.003)	-0.71
Mean Generality	0.507 (0.011)	0.430 (0.003)	0.450 (0.010)	0.405 (0.003)	2.07
Mean Citations Made	1.230 (0.040)	1.029 (0.010)	1.355 (0.045)	1.032 (0.010)	-1.97
Mean Citations Received	3.928 (0.205)	2.804 (0.038)	3.938 (0.132)	3.082 (0.037)	1.07

Standard errors in parentheses

When we compare the citations to parents with the rest of the citations in the dataset, the average citation of a subsidiary to its parent is more original after reforms by

only about 0.011, an insignificant difference. Supportive of a positive correlation between the measure of originality and the number of citations made, the average citation of the affiliate to its parent makes 0.122 more citations after reforms, after rescaling the number of citations made by the mean per application year. The difference is significant at the 5% level. On the other hand, the average patent is about 0.032 less general after reforms, on the average and the difference is statistically significant at the 5% level. This effect is probably due to the fact that after reform patents are subject to a higher degree of truncation in the number of citations received and this number is positively correlated with the measure of generality. In other words, patents that are highly cited are more general, on the average. We will control for the different degree of truncation by introducing cited patent application year dummies in our specifications. Contrary to our expectations, we find that citations to parents receive 0.268 less citations after reforms, even after rescaling this number by the method described above, but the finding is not significant.

TABLE 5. Comparison of the characteristics of patents cited by domestic companies in the reforming countries

	BEFORE REFORMS		AFTER REFORMS		
Number of observations	5,300		7,396		
	Citing U.S.	Not Citing U.S.	Citing U.S.	Not Citing U.S.	T-test
Number of observations	2,470	2,830	3,387	4,009	
Mean Originality	0.400 (0.006)	0.327 (0.005)	0.386 (0.005)	0.307 (0.004)	-0.60
Mean Generality	0.499 (0.005)	0.429 (0.005)	0.439 (0.005)	0.364 (0.004)	-0.52
Mean Citations Made	1.238 (0.022)	0.847 (0.011)	1.207 (0.019)	0.781 (0.009)	-1.08
Mean Citations Received	2.905 (0.075)	3.888 (0.245)	2.771 (0.062)	2.454 (0.076)	-4.75

Standard errors in parentheses

Table 5 replicates Table 4 for citations made by patents assigned to domestic firms in the reforming countries. The difference in the mean measure of originality between the citations to the U.S. and the rest of the citations in the dataset does not change after reforms. The same difference in the number of citations made decreases by 0.035 after the reforms, a very small and insignificant number. Citations made by local companies to U.S. firms are less

general after reforms when compared to the rest of citations, but the finding is not significant. When we rescale the number of citations received to eliminate the effect of truncation, the citations to the U.S. receive 1.3 more citations after reforms when compared to the rest of the citations in the dataset. The difference is both large and statistically significant at the 1% level.

6.2. Estimation results for the citing patterns of U.S. affiliates in the reforming countries

As these univariate tests might be confounded with composition effects, we now turn to the results of our multivariate estimation. We first test the hypothesis that U.S. multinationals are cited more after the reforms by their affiliates in the reforming countries Table 6 summarizes the results of logit estimation.

TABLE 6. Citations of U.S. affiliates in the reforming countries: Logit Estimates
(Odds Ratios reported)

	(1)	(2)	(3)	(4)
	-	Year and country dummies	Year dummies	Country dummies
		(a) Conditional logit estimates		
REFORM	0.989 (-1.20)	1.212 (0.71)	0.656 (-2.31)	0.982 (-0.19)
Number of observations	12,120	12,120	12,120	12,120
		(b) Unconditional logit estimates		
REFORM	0.975 (-0.45)	1.328 (1.53)	0.676 (-2.97)	1.062 (1.08)
Number of observations	19,942	19,802	19,836	19,908
Z-scores in parentheses				

The dependent variable is CITING PARENT. The independent variable is REFORM. The citation patterns are not independent of the citing patents. A model with fixed effects per citing patent would not estimate the coefficient on REFORM, as there is no within-group variation in this independent variable. Because we still need to control for systematic differences across citations, we employ a conditional logit model with fixed

effects per primary examiner of the citing patent. Examiners differ in their field of specialization and we expect that citing patterns are not independent of the primary examiner of the citing patent. An advantage of the model with primary examiner fixed effects over the citing patent fixed effects specification is the reduction in the number of observations lost due to lack of within-group variation in the dependent variable. The average patent in our set makes 6.3 citations, but there are 17.8 patents, on the average, that share the same primary examiner. Hence, the number of groups with no variation in the dependent variable is reduced. Panel (a) summarizes the results of the conditional logit. Odds ratios are reported. Model (1) contains one independent variable, REFORM. As mentioned, our dataset is missing application years for some countries. To account for the missing observations and to control for any unobserved factors that vary across application years, we add citing patent application year dummies in specifications (2) and (3). Models (2) and (4) add reforming country dummies to account for the significant differences that exist across countries in the level of IPR protection and the reforms undertaken. The estimates for the year and country dummies are not reported. The use of the conditional logit does not allow us to obtain consistent estimates for the fixed effects. In addition, 7822 observations are lost due to lack of within-group variation in the dependent variable. An alternative is to use unconditional logit estimation. Panel (b) shows the results of unconditional logit estimation. Hausman specification tests were performed to decide whether estimation using the unconditional logit is appropriate. Under the null hypothesis of homogeneity, both estimators are consistent, but Chamberlain's conditional maximum likelihood estimator is inefficient. Under the alternative hypothesis, the unconditional estimator is inconsistent, whereas the conditional estimator is consistent and efficient. Only in model (4), that includes only country dummies, estimation using the conditional logit is needed, as the Hausman test suggests that there are significant primary examiner effects. For models (1), (2), and (3), the Hausman test suggests that, although both the conditional logit and the unconditional logit give consistent estimators, the conditional logit estimates are less efficient and thus, the unconditional logit is chosen. Only model (3) with year dummies produces significant estimates. Contrary to our expectations, it shows U.S. subsidiaries are less likely to cite their parent firms after the reforms. When we add country dummies, the estimate is marginally significant and it shows that affiliates are more likely to cite their parent companies after the reforms. The big change in the estimate of our coefficient suggests there are indeed

strong country differences, as we expected given the disparity of the IPR reforms and their enforcement among the 12 countries studied. Table 7 shows the frequency with which U.S. affiliates are citing their parent firms before and after reforms in each country. These results are not consistent with the hypothesis that U.S. multinationals are cited more by their affiliates after the reforms.

TABLE 7. Frequency of citations to parent company

Country	Before reform	After reform
Argentina	0.034	0
Brazil	0.093	0.053
China	0	0.022
Indonesia	0	0.032
Japan	0.074	0.080
South Korea	0	0.053
Mexico	0.045	0.013
The Philippines	0.526	0.231
Spain	0.194	0.097
Taiwan	0.023	0.051
Thailand	0	0
Turkey	0.048	0

We turn now to analyze the impact of the reforms on different characteristics of the American MNCs patents cited by their subsidiaries. When testing the hypothesis that the citations of affiliates to their parents have changed after the reforms, the dependent variable denotes the characteristic of the patent cited. We use four dependent variables, taken from the NBER data file: ORIGINALITY, GENERALITY, CITATIONS RECEIVED and CITATIONS MADE. As mentioned above, the measures of citations made and received are divided by the mean number of citations made and received by patents in the specific application year. We rescale these measures to separate other confounding effects that change the number of citations made and received by the typical patent during different application years. The measures of generality and originality, defined above, are numbers bounded between 0 and 1. If y denotes our dependent variable, the originality and generality

measures, respectively, and X denotes our independent variables, our model is described by the equation: $y = \frac{1}{1+\exp(-\beta X)}$. We perform the logit transformation to map the dependent variable to the real line. The resulting model is: $\ln\frac{y}{1-y} = \beta X$. The transformation will result in missing values for the observations where the dependent variable is 0 or 1 and the observations will be dropped when we estimate the new model, but we can now estimate the model with the transformed dependent variable using OLS.

Table 8 shows the results of estimation. Measures of originality, generality, the number of citations made and received are compared before and after reforms for citations to multinationals with the rest of the citations in the dataset. There are three regressors: CITING PARENT, REFORM, and INTERACTION, an interaction term between the two. We are most interested in our estimate of the coefficient on INTERACTION. It shows the change in the mean characteristic of the citations to parents before and after reforms compared with the same difference for the rest of the citations made by the multinationals' subsidiaries. If our hypothesis is correct, we expect to find a positive coefficient on INTERACTION, suggesting that the patents cited by the affiliates and assigned to their parents are more important or have a wider impact, relative to other patents cited by the subsidiaries, after the reforms.

Panel (a) summarizes the estimates of models without dummies. Panel (b) shows the same regressions with citing patent application year and reforming country dummies. When the generality measure is the dependent variable, cited patent application year dummies are added to eliminate the effects of truncation in the number of citations received at the end of the period. Hausman tests are conducted to decide between a primary examiner fixed effects model and a model without fixed effects. According to the Hausman test, the model without fixed effects would produce inconsistent estimates and the model with fixed effects per primary examiner of the citing patent is chosen in all instances. The results of the latter are reported.

TABLE 8. Citations assigned to U.S. affiliates in the reforming countries: Characteristics Estimates

Dependent variable	Number of observations	CITING PARENT	REFORM	INTERACTION
(a) Estimation without dummies				
ORIGINALITY	13,177	0.114	-0.063	0.016
		(2.90)	(-3.07)	(0.30)
GENERALITY	16,050	0.101	-0.028	0.005
		(2.71)	(-1.42)	(0.10)
CITATIONS MADE	19,942	0.169	-0.019	0.101
		(3.95)	(-0.91)	(1.76)
CITATIONS RECEIVED	19,941	0.934	0.102	-0.355
		(6.36)	(1.41)	(-1.80)
(b) Estimation with year and country dummies				
ORIGINALITY	13,177	0.111	-0.096	0.020
		(2.81)	(-1.74)	(0.37)
GENERALITY	16,050	0.099	-0.070	0.005
		(2.64)	(-1.34)	(0.09)
CITATIONS MADE	19,942	0.174	-0.146	0.093
		(4.06)	(-2.57)	(1.61)
CITATIONS RECEIVED	19,941	0.936	-0.311	-0.405
		(6.36)	(-1.60)	(-2.05)

T-values in parentheses

The estimates of the coefficient on CITING PARENT are all significant at the 1% confidence level, regardless if year and country dummies are used or not in the specification. We find that patents assigned to U.S. MNCs that are cited by their subsidiaries are, on the average, more original and general (by about 0.1) than the rest of the patents cited in the dataset, they make about 0.17 more citations and receive, on the average, almost 1 citation more than the rest of the patents cited.

The estimate of the coefficient on INTERACTION is close to 0 and insignificant for ORIGINALITY and GENERALITY. This suggests the citing patterns of U.S. affiliates

do not change in the average level of generality or originality after the reforms. In other words, the average citation to a parent firm is not different in originality or generality after the reform, after comparing it to the rest of the citations. We find that patents citing multinationals make about 0.10 more citations after reforms, when compared to the rest of the patents cited by the U.S. subsidiaries. The estimate of the coefficient on INTERACTION is significant at the 10% level when no dummies are used and it is marginally significant at the 10% level when dummies for country and application year are introduced. This is a counter-intuitive result, since the measure of originality and the number of citations made are positively correlated and we could not find any effect of the reforms on the originality measure. However, a magnitude of 0.10 difference of in the number of citations made after reforms is indeed quite small.

In contrast to the previous results, we do find significant effects of IPR reforms on citations received. Nevertheless, the result is surprising. After rescaling the dependent variable by the mean per application year to eliminate the effects of truncation, we find that patents that cite parents exhibit a relative decline in the number of citations received. They receive about 0.4 fewer citations after reforms, when compared to the rest of the patents cited by the U.S. affiliates. We find an estimate significant at the 10% confidence level for the model without dummies and at the 5% when dummies are introduced. These results show a decline of the importance of patents that cite parents after reforms, when compared to the rest of the patents cited by U.S. subsidiaries. They suggest reforms do not encourage U.S. multinationals to deploy new critical technologies at a higher rate after reforms and citations of affiliates to their parents become less important after reforms.

6.3. Estimation results for the citing patterns of domestic firms in the reforming countries

We continue the study of the impact of IPR reforms on the international diffusion of knowledge by testing the second hypothesis. We analyze whether domestic companies in the reforming countries change their citing patterns after the reforms. One would expect to find that they make more citation to U.S. companies after the reforms, as the strengthening of the IPR system might accelerate the diffusion of knowledge from the U.S. to the reforming country. Table 9 replicates Table 6 for the second dataset that contains patents generated by domestic companies in the reforming countries. The dependent variable, CITING US, is a

dummy variable equal to one for citations to U.S. firms. We construct the same dummy variable REFORM equal to 1 when the citing patent's application year is the year of or any year after the reform. Odds ratios are reported.

TABLE 9. Citations assigned to domestic companies in the reforming countries: Logit Estimates

(Odds Ratios reported)

	(1)	(2)	(3)	(4)
	-	Year and country dummies	Year dummies	Country dummies
		(a) Conditional logit estimates		
REFORM	0.921 (-1.38)	0.970 (-0.23)	0.893 (-1.59)	0.951 (-0.75)
Number of observations	11,949	11,949	11,949	11,949
		(b) Unconditional logit estimates		
REFORM	0.968 (-0.90)	0.913 (-1.12)	0.978 (-0.52)	0.907 (-2.49)
Number of observations	12,696	12,695	12,696	12,695
Z-scores in parentheses				

Panel (a) summarizes the results of the conditional logit estimation with fixed effects per primary examiner of the citing patent. 747 observations are lost due to lack of within-group variation in the dependent variable. Model (1) contains only one independent variable, REFORM. The following specifications add citing patent application year dummies and reforming country dummies. The dummies estimates are not reported. Panel (b) shows the results of unconditional logit estimation, without fixed effects. Hausman tests are performed to decide whether the conditional logit is needed as the citing patents are not independent of their citations. The unconditional logit is chosen only in the specification without dummies [model (1)], as the Hausman specification test shows both models are consistent, but the fixed effects model produces less efficient estimates. The estimate of the coefficient on REFORM is close to 1 and insignificant. It suggests there is no change in the frequency of citations made by local companies to American firms after reforms. These results do not change after controlling for unobservable factors that vary over time and among countries. The conditional logit with primary examiner fixed effects is chosen for the specifications

with dummies, as, according to the Hausman test, estimation without fixed effects would produce inconsistent estimates. The estimate of the coefficient on REFORM is insignificant. We conclude that we cannot find any change in the frequency of citations made by domestic firms to U.S. companies after reforms.

Although we do not find evidence for the hypothesis that the reforms of the patent systems accelerate the international flow of new technologies from the U.S. to the reforming countries, we look deeper at the characteristics of the American patents cited by the domestic firms. In other words, we study the hypothesis that, although stronger IPR does not affect the frequency of citing the U.S., it changes the type of patents being cited. Table 10 replicates Table 8 for patents assigned to domestic companies in the reforming countries.

The dependent variables are the same, but the explanatory variables are: CITING U.S., REFORM, and INTERACTION, an interaction term between the first two variables. Hausman specification tests suggest the primary examiner fixed effects models are needed in all instances, as the specifications without fixed effects generate inconsistent estimates. Panel (a) summarizes the estimation results for regressions without application year and country dummies. Panel (b) includes these dummies. We use the same method as before to eliminate the effects of truncation in the number of citations received at the end of the period. When GENERALITY is the dependent variable, specifications include cited patent application year dummies.

When we compare the citations generated by domestic companies to U.S. firms with all the other citations, we find that they are more original and general, they make more citations, but receive less citations, even after rescaling the number of citations received by the mean per year to eliminate the effects of truncation.

The results suggest there are no changes after reforms in the measures of originality, generality, and the number of citations made by citations of domestic firms to the U.S., when compared to the rest of the citations. All estimates of the coefficient on the interaction term are insignificant. Results are almost unchanged when application year and country dummies are added to control for unobservables that affect the characteristics of the citations and vary over time and countries. In contrast, we find that citations to American firms receive 0.78 more citations, on the average, after reforms. The estimate of the coefficient on the interaction term is significant at the 1% confidence level. That is, we find a relative increase in importance of U.S. patents cited after reforms. These results suggest

reforms are beneficial for the reforming countries' domestic companies. They foster innovation there, by mediating the transfer of new more important technologies from the U.S.

TABLE 10. Citations assigned to domestic companies in the reforming countries: Characteristics Estimates

Dependent variable	Number of observations	CITING U.S.	REFORM	INTERACTION
(a) Estimation without dummies				
ORIGINALITY	8351	0.060	-0.107	0.052
		(2.25)	(-3.48)	(1.49)
GENERALITY	10,361	0.144	-0.023	-0.022
		(5.68)	(-0.79)	(-0.64)
CITATIONS MADE	12,693	0.341	-0.016	0.037
		(13.32)	(-0.58)	(1.11)
CITATIONS RECEIVED	12,687	-0.313	-0.412	0.782
		(-1.52)	(-1.82)	(2.93)
(b) Estimation with year and country dummies				
ORIGINALITY	8351	0.056	-0.097	0.053
		(2.08)	(-1.71)	(1.51)
GENERALITY	10,361	0.144	0.170	-0.023
		(5.67)	(3.15)	(-0.70)
CITATIONS MADE	12,693	0.338	-0.019	0.033
		(13.19)	(-0.36)	(0.97)
CITATIONS RECEIVED	12,687	-0.287	-1.296	0.787
		(-1.40)	(-3.03)	(2.94)

T-values in parentheses

7. Conclusions

The existing literature suggests that one of the potential benefits of the reforms of the patent system is access to foreign innovations that the reforming country obtains in the presence of stronger IPR.

This paper assesses the impact of IPR reforms on the international diffusion of knowledge through FDI. We test two hypotheses. First, we construct a dataset composed of patents generated by U.S. affiliates in 12 reforming countries and test whether they change the pattern of citing their parent companies. We do not find evidence that supports this hypothesis. Moreover, our results show that these citations are not different in characteristics after the country has undertaken the reform. One exception is found when using the number of citations received as a measure of patent importance. We find a post-reform decline in importance of patents of MNCs cited by their subsidiaries, relative to all other patents cited.

We then construct a second dataset composed of patents generated by domestic companies in the reforming countries. We use it to compare their frequency of citing American firms before and after reforms. We hypothesize that, due to geographic proximity to U.S. subsidiaries, these domestic companies might benefit of increased knowledge spillovers from the U.S. after the reforms. We do not find evidence that the frequency of citing the U.S. has changed after reforms, but when the number of citations received is used as a proxy for the importance of patents, we find that patents of U.S. companies cited by domestic firms increase in relative performance after reforms. This suggests reforms favor domestic innovation efforts rather than affiliate efforts.

References:

Bessen, James and Eric Maskin (2004): "Sequential Innovation, Patents, and Imitation." MIT working paper.

Branstetter, Lee G., Raymond Fisman and C. Fritz Foley (2004): "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from U.S. Firm-Level Panel Data." Quarterly Journal of economics, forthcoming.

Glass, Amy Jocelyn and Kamal Saggi (2002): "Intellectual Property Rights and Foreign Direct Investment." Journal of International economics 56: 387-410.

Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg (2001): “The NBER patent citations data file: lessons, insights and methodological tools.” NBER working paper 8498.

Helpman, Elthanan (1993): “Innovation, Imitation, and Intellectual Property Rights.” Econometrica 61: 1247-1280.

Jaffe, Adam B., Manuel Trajtenberg, and Rebecca Henderson (1993): "Geographic knowledge spillovers as evidenced by patent citations." Quarterly Journal of Economics, 108(3):577-98.

Lai, Edwin L.-C. (1998): “International Intellectual Property Rights Protection and the Rate of Product Innovation.” Journal of Development economics 55: 133-153.

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

Lerner, J. (2002): “Patent Protection and Innovation over 150 Years.” NBER working paper 8977.

Maskus, Keith E. (1998): “The International Regulation of Intellectual Property.” Weltwirtschaftiches Archiv 134: 186-208.

Maskus, Keith E. (2000): “Intellectual Property Rights in the Global Economy.” Institute for International Economics, Washington D.C.

Maskus, Keith E. and Mohan Penubarti (1995): “How Trade-Related Are Intellectual Property Rights?” Journal of International economics 39: 227-48.

Sakakibara, Mariko and Lee Branstetter (2001): “Do Stronger Patents Induce More Innovation? Evidence from the 1998 Japanese Patent Reforms.” Rand Journal of Economics 32: 771-100.

Smith, Pamela J. (1999): “Are Weak Patent Rights a Barrier to U.S. Exports?” Journal of International Economics 48: 151-77.

Thompson, Peter (2005): "Patent citations and the geography of knowledge spillovers: evidence from inventor- and examiner-Added Citations." Review of Economics and Statistics, forthcoming.