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Intellectual Property Rights and Trade:

Analysis of Biological Products, Medicinals and Botanicals,

and Pharmaceuticals

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Abstract. This paper analyzes the impact of international intellectual property rights on US exports of biological products, medicinals and botanicals, and pharmaceuticals. Intellectual property rights are particularly relevant to these industries given their substantial R&D investments and the self-replicating nature of their technologies. We estimate bilateral trade equations that account for intellectual property rights, using cross-section data for five years from 1972 to 1992. We find that: (1) strong intellectual property rights enhance the market power of US exports in countries with weak imitative abilities (e.g., developing countries) by ensuring US monopoly over the exported technologies and products; (2) strong intellectual property rights stimulate market expansion of US exports in countries with strong imitative abilities (e.g., developed countries) by providing recourse against violations of US technologies and products in these foreign markets; and (3) these effects of intellectual property rights are particularly strong in the period 1982-92 during which intellectual property rights were given high priority in trade policies.

Key words: Intellectual property rights; Exports; Biotechnologies; Medicinals; Botanicals; Pharmaceuticals
JEL classification: F10; F13; Q16; Q17; K55; O34

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1. Introduction

This paper analyzes the impact of international intellectual property rights (IPRs) on the competitiveness of US exports of biological products, medicinals and botanicals, and pharmaceuticals. The objective is to determine whether strong foreign IPRs impact US exports in the these industries, and if so, how and during what time periods.

International IPRs are believed to affect US exports because US exports are not protected under US IPR laws, but rather US exporters need to secure protection of their technologies under foreign IPR laws. Laws governing IPRs vary widely across countries. Studies in the international trade literature reveal that national differences in IPRs have an indeterminate effect on trade because strong IPRs simultaneously increase trade via "market expansion" and decrease trade via "market power" (see Section 2). Further, this literature indicates that the market expansion effects of IPRs are important in countries with strong imitative abilities and the market power effects of IPRs tend to apply in countries with weak imitative abilities. Strong IPRs reduce threats of imitation in countries with strong imitative abilities; whereas strong IPRs enhance monopoly power over the protected technologies or products in countries with weak imitative abilities. This paper provides the first empirical evidence on the market power and market expansion effects of IPRs on US exports of biological products, medicinals and botanicals, and pharmaceuticals.

The paper also analyzes whether the effects of IPRs on trade have changed over time. There are two reasons to expect changes. First, one expects that linkages between IPRs and trade are enhanced as global trade increases and IPRs are strengthened internationally. To assess such cross-time changes, we analyze the impact of IPRs on trade during each of five years between

1972 and 1992. We also examine whether the trade effects of IPRs are stronger in 1982-92 than in 1972-77. The more recent period coincides with the pre-and early-Uruguay Round negotiations of the GATT which identified IPRs has a high priority trade distortion. The Uruguay Round firmly linked IPRs to trade policy in the Trade Related Intellectual Property Rights (TRIPs) agreement which covers patent rights, plant breeders rights, copyrights, trademarks, and trade secrets.[1]

A second reason to expect changes in the relationship between IPRs and US exports over time is that the biological, medicinals and botanicals, and pharmaceuticals industries have become increasingly concentrated. Industry concentration has occurred, in part, because different firms hold IPRs to the multiple technologies that are required to bring a product to the market. For example, pharmaceutical companies have pursued research collaborations and mergers and acquisitions of biotechnology companies, and biotechnology companies have acquired seed companies, in order to ensure delivery of biotechnology via seeds to the market. A small number of large firms now dominate the biotechnology market.[2]

We analyze whether such industry concentration has translated into increased market power of US exports in countries where IPRs are strong and imitative abilities are weak. The intuition is that strong IPRs ensure that holders of the rights have monopoly power over the protected technologies or products. This monopoly power can result in output and price changes that alter the structure of the industry and thus affect trade.

2. Theory: IPRs and trade

The theory literature on IPRs and trade provides no definitive priors on whether strong IPRs increase or decrease bilateral trade. However, the literature does provide guidance for

interpreting the direction of the effects in terms of market expansion and market power.[3]

According to the *market expansion* explanation, strong IPRs expand international markets available to exporters by ensuring exclusive rights to the technologies embodied in their exported goods. In the absence of strong IPRs, firms reduce their exports to countries where they expect their technologies will be imitated. This expectation is pronounced when importers have the resources to reproduce or imitate the technologies or products that embody the technologies. Strong IPRs increase (expand) exports to such markets by reducing the costs associated with preventing loss of the technologies. Such costs include foregone revenues from reduced exports and expenses incurred in making the technologies difficult to imitate. Applying this market expansion concept, we expect US exports are biased toward importers with relatively strong IPRs, especially when importers' imitative abilities are strong and the costs of weak IPRs are high.

Alternatively, according to the *market power* explanation, strong IPRs reduce trade by ensuring a temporary monopoly over the protected technologies. This market power is attributed to the holder of the IPRs (grant) whether domestic or foreign. Firms that secure strong intellectual property protection in foreign markets can exercise their market power by restricting the quantity of exports and increasing their unit price (to extract monopoly rents). Less stringent IPRs are required to ensure monopoly power when imitative abilities are weak. Applying this market power concept, we expect US exports are biased against importers with relatively strong IPRs particularly when importers' imitative abilities are weak.

Since the market power and market expansion effects are countervailing, the direction of the relationship between IPRs and trade is indeterminate. However, under both effects exporters respond to the imitative abilities (or absence thereof) in the importing country. To relate imitative

abilities to market power and market expansion, we group the countries of the world into two categories based on their imitation abilities and then consider US export responses to differences in IPRs across countries within a given imitation group. Based on the concepts described above, we expect US exports are biased against importers with "relatively" strong IPRs within the group with weak imitative abilities (e.g., developing countries).[4] That is, the market power effect of IPRs should apply when importers' imitative abilities are weak. Alternatively, we expect US exports are biased toward importers with "relatively" strong IPRs within the group with strong imitative abilities (e.g., developed countries). That is, the market expansion effect of IPRs should apply when importers' imitative abilities are strong. Thus, trade distortions arising from national differences in IPRs can be positive or negative, yet the direction of the relationship can be predicted based on importers' imitative abilities.

3. Method

This section provides specifications for analyzing IPRs and US exports. The Gravity model provides a flexible general equilibrium framework for evaluating the market power and market expansion effects of IPRs on US exports. We define IPRs within the Gravity framework as a "distortion" to US exports that would otherwise occur under free exchange conditions. We estimate three expressions of the Gravity equation.[5] These expressions are written in log-linear form and define the exporter as the US. The baseline equation is

$$\ln(X_{ik}) = \beta_{0i} + \beta_{1i} \ln(Q_k/N_k) + \beta_{2i} \ln(N_k) + \beta_{3i} \ln(D_{jk}) + \beta_{4i} \ln(O_{jk}) + \beta_{5i} w_k \ln(IPR_k) + \beta_{6i} s_k \ln(IPR_k) + e_{ik} \quad (1)$$

where X_{ik} is US exports to country k in commodity i; Q_k/N_k is the per capita income of country k; N_k is the population of country k; D_{jk} is the geographic distance between the US and country k;

O_{jk} is openness of country k to trade with the US; IPR_k is the strength of IPRs in importer k; w_k and s_k are dummy variables for importers with weak and strong imitative abilities, respectively;[6] and e_{jk} is a log normally distributed error term. Eq. (1) says that US exports depend on the per capita income and population of importers, the distance between the US and importers, and distortionary factors including openness (the absence of trade barriers) and IPRs. The IPRs term is interacted with the imitative abilities dummy variables to examine the impact of IPRs across countries with either strong or weak imitative abilities.[7] Positive parameters on these interaction terms indicate that IPRs confer a market expansion effect, and negative parameters on these terms indicate that IPRs enhance US market power in foreign markets.

Second, we introduce a time term in order to analyze the impact of IPRs on US exports during the separate years: 1972, 1977, 1982, 1987, and 1992. This gives

$$\ln(X_{ijk}) = \ß_{0i} + \ß_{1i} \ln(Q_k/N_k) + \ß_{2i} \ln(N_k) + \ß_{3i} \ln(D_{jk}) + \ß_{4i} \ln(O_{jk}) + \ß_{5i}' w_k \ln(IPR_k)\, \underline{t} + \ß_{6i}' s_k \ln(IPR_k)\, \underline{t} + e_{ik} \quad (2)$$

where $\underline{t}$ is a vector of dummy variables for each year. The parameters on the IPRs terms in Eq. (2) have the same interpretations as in Eq. (1), however, they now indicate whether IPRs confer market expansion or market power in a given year, rather than indicating the average effect across the years.

Third, we introduce a time-shift term to analyze whether IPRs have a stronger impact on US exports in 1982-92 relative to 1972-77. This third expression is

$$\ln(X_{ijk}) = \ß_{0i} + \ß_{1i} \ln(Q_k/N_k) + \ß_{2i} \ln(N_k) + \ß_{3i} \ln(D_{jk}) + \ß_{4i} \ln(O_{jk}) + \ß_{5i} w_k \ln(IPR_k) + \ß_{6i} s_k \ln(IPR_k) + \ß_{7i} w_k \ln(IPR_k)\, t_{82\text{-}92} + \ß_{8i} s_k \ln(IPR_k)\, t_{82\text{-}92} + e_{ik} \quad (3)$$

where $t_{82\text{-}92}$ is a (single) shift-dummy variable for the years 1982, 1987, and 1992. We retain the baseline IPRs terms as controls. The parameters on the baseline terms indicate the effect of IPRs on average from 1972-77 whereas the parameters on the shift-interaction terms indicate deviations in the effects of IPRs for 1982-92.

Finally, in each specification, interpretations of the standard Gravity equation parameters are as follows: The parameters on income per capita and population are positive elasticities. The parameter on openness is positive when the absence of trade barriers stimulates US export to country k. The parameter on distance is negative when the costs of trade (e.g., transportation) increase with the distance between the US and country k.

4. Data[8]

We estimate Eqs. (1), (2), and (3) using comparable cross-section data for 133 countries, 5 years, and 3 industries. The industries are biological products, medicinals and botanicals, and pharmaceuticals. We focus on these select industries because they have two important characteristics that enhance incentives to protect intellectual property. First, these industries have substantial investments in R&D. IPRs are particularly relevant to technologies and products that require substantial R&D investments because IPRs allow the holders of the rights to exclude others from using the protected technologies. Consequently, IPRs help ensure that those who invest in R&D reap the returns from their investments and are able to cover their R&D costs.[9] Second, the selected industries tend to have technologies or products with self-replicating qualities that make imitation (by others) less costly. IPRs are particularly relevant to such technologies and products because IPRs provide the holders of the rights with legal recourse against imitation or replication.

We use an index developed by Ginarte and Park (1998) to measure national intellectual property laws. This index is based on criteria concerning: (1) coverage of inventions, (2) examination procedures, (3) term of protection, (4) transferability of rights, (5) compulsory licensing, and (6) enforcement against infringement. The index takes continuous values between zero and five with larger values indicating stronger intellectual property laws. We use the index that reflects laws in place two years prior to the trade flow to represent predetermined foreign laws that are exogenous with respect to (future) US exports.

5. Results

Table 1 reports estimates of Eqs. (1), (2) and (3) for each industry (in columns). The estimates on the IPRs terms describe the response of US exporters to the strength of IPRs of an importer "relative" to other importers within a given imitative-abilities group. These estimates conform remarkably well with the interpretations suggested by the theory literature.

First, strong IPRs confer US exporters with market power across countries with weak imitative abilities (see significant negative estimates w-terms); and strong IPRs stimulate market expansion of US exports across countries with strong imitative abilities (see significant positive estimates on s-terms). Clearly, whether strong IPRs increase or decrease US exports hinges critically on the imitative abilities of importers.

Second, these positive and negative linkages between IPRs and US exports tend to be stronger (statistically significant) during the years 1982, 1987 and 1992 relative to the earlier years 1972 and 1977 (see Eq. (2) estimates). This result is consistent with the high priority status given to reducing IPRs distortions to trade in both multilateral and US policies during late 1970s and beyond. For example, the Patent Cooperation Treaty was established in 1978 to supplement

the terms of the 1934 Paris Convention; and US protections granted to microorganisms, plants and plant parts, and nonhuman animals were strengthened considerably during the 1980s.

Third, the market power effects of IPRs on US exports are considerably stronger during the period 1982-92 than 1972-77 (see Eq. (3) estimates). This is consistent with the increased concentration of industries that tends to occur when IPRs are strengthened. As noted earlier, strong IPRs provide an incentive for firms to consolidate in order to benefit from access to the multiple technologies required to bring a product to market. Indeed, the magnitude of the market power effects of IPRs on US exports to countries with weak imitative abilities is 0.62 to 1.32 percent larger in 1982-92 than in 1972-77.

Finally, the above findings describe the impact of IPRs after controlling for the standard Gravity model determinants of bilateral exchange. We find that the estimates on these determinant are statistically significant and have signs and magnitudes consistent with the predictions of the model. As expected, elasticities with respect to importers' income per capita and population are positive; the US exports more to countries that are open; and US exports decrease as the distance between the US and her trading partners increases.

5.1. Select industry results

The above results apply to all three industries, however, each industry exhibits unique results that are worth mentioning. For biological products, the market expansion effects of IPRs on US exports to countries with strong imitative abilities are particularly strong. This result suggests that the legal recourse provided by foreign IPRs is critical to US exporters who are servicing countries that have the resources to imitate the biological technologies or products (e.g., developed countries). Indeed, a one percent strengthening of IPRs (across such importers) leads

to a 0.65 percent increase in US biological exports to these countries on average for 1972-92. The magnitude of these market expansion effects is 0.81 percent stronger in 1982-90 than 1972-77, and the magnitude increases over the years from 0.70 percent in 1982 to 1.07 percent in 1990. To put these magnitudes in perspective, Argentina's IPRs are roughly 38 percent stronger than India's IPRs; and Canada's IPRs are roughly 22 percent stronger than Argentina's IPRs (based on the Ginarte and Park index).

For medicinals and botanicals, the market power effects of IPRs on US exports to countries with weak imitative abilities are particularly strong. This result reveals that IPRs do enhance the ability of US medicinals and botanicals exporters to behave monopolistically when servicing foreign markets with weak imitative abilities (e.g., developing countries). In fact, a one percent strengthening of IPRs (across such importers) leads to a 1.14 percent decrease in US exports to these countries on average for 1972-92. The magnitude of these market power effects is 1.32 percent larger in 1982-90 than in 1972-77.

In contrast, the market expansion effects of IPRs on US exports of medicinals and botanicals to countries with strong imitative abilities (e.g., developed countries) is evidenced in 1977. During this year, a one percent strengthening of IPRs (across such importers) leads to a 0.48 percent increase in US exports of medicinals and botanicals. Not surprisingly, the timing of this market expansion falls between the 1972 and 1978 Conventions that strengthened the Union for the Protection of New Varieties of Plants.

Finally, for pharmaceuticals, the market power effects of IPRs on US exports apply across countries irrespective of their imitative abilities. This result suggests that US pharmaceuticals exporters benefit sufficiently from IPRs in foreign markets that they are able to behave

monopolistically regardless of the importers imitative ability. This result is consistent with the concentration of the pharmaceuticals industry, which serves to ensure that firms have "exclusive control" over a broad range of technologies.

6. Conclusion

This research provides the first application of the market power and market expansion concepts to US exports of biological products, medicinals and botanicals, and pharmaceuticals. The research provides a cross-time perspective that clearly demonstrates the strong linkage between IPRs and trade during the 1980s and 90s. We find that strong IPRs enhance market power of US exports in countries with weak imitative abilities by ensuring US monopoly over the exported technologies or products. Such market power was particularly strong for pharmaceuticals and medicinals and botanicals in 1982, 1987, and 1992. Further, we find that strong IPRs stimulate market expansion of US exports to countries with strong imitative abilities by providing recourse against violations of US technologies and products. This market expansion was particularly strong for biological products in 1982, 1987, and 1992 and for medicinals and botanicals in 1977. Finally, the results show that these linkages between IPRs and US exports are stronger in 1980s and 90s than in the 1970s, reflecting the high priority given to "trade-related intellectual property" in trade policies of the latter period. The strong market power effects during the 1980s and 90s are consistent with increased industry concentration, particularly in pharmaceuticals.

Endnotes

1. For background, see Maskus (1998) and World Trade Organization (1995).

2. See Fulton (1997), Lesser (1997), and Ruttan (1999).

3. Theoretical studies of IPRs and trade appear in Brown (1991), Diwan and Rodrik (1991), Flam and Helpman (1987), Schwartz (1991), and Taylor (1993; 1994). Empirical studies for manufactures are provided by Ferrantino (1993), Maskus and Penubarti (1995), and Smith (1999a; 1999b).

4. Mansfield (1989) and Siebeck et. al. (1990) provide surveys of IPRs and development.

5. For the origins of the Gravity model, see Linneman (1966). For recent references on the theoretical foundations of the Gravity model, see Anderson (1979), Bergstrand (1985; 1989; 1990), and Deardorff (1998).

6. Indicators of national imitative abilities include: R&D scientists and technicians per 10,000 people; total number of R&D scientists and technicians; and R&D expenditures as a percent of GNP.

7. We also replace the intercept in the equations with two dummy variables to allow for fixed effects related to imitative abilities but unrelated to IPRs.

8. A data appendix is available by request from the author.

9. For studies of IPRs and innovation, see Aoki and Prusa (1993), Glass (1997), Helpman (1993), Langford (1997), Mansfield (1986), and Reinganum (1982).

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Table 1.--Cross-Country Estimates of Equations (1), (2), and (3): Data Pooled for 1972, 1977, 1982, 1987, and 1992

	Average Effects of IPRs: 1972-92 ----------Equation (1)----------						Annual Effects of IPRs ----------Equation (2)----------						Deviations in Effects of IPRs: 1982-92 ----------Equation (3)----------					
	Biological Products		Medicinals and Botanicals		Pharma-ceuticals		Biological Products		Medicinals and Botanicals		Pharma-ceuticals		Biological Products		Medicinals and Botanicals		Pharma-ceuticals	
Income Per Capita (Qk/N	1.26	**	1.00	**	1.31	**	1.27	**	1.32	**	1.53	**	1.27	**	1.29	**	1.51	**
	0.08		0.11		0.11		0.09		0.15		0.13		0.09		0.14		0.12	
Population (Nk)	0.78	**	1.26	**	0.94	**	0.80	**	1.30	**	0.97	**	0.79	**	1.29	**	0.96	**
	0.06		0.08		0.07		0.06		0.08		0.07		0.06		0.08		0.07	
Distance (Djk)	-1.04	**	-1.23	**	-1.26	**	-1.06	**	-1.16	**	-1.22	**	-1.06	**	-1.17	**	-1.21	**
	0.10		0.16		0.16		0.10		0.16		0.16		0.10		0.16		0.16	
Openness (Ojk)	0.21	*	0.51	**	0.58	**	0.22	**	0.47	**	0.57	**	0.20	*	0.47	**	0.55	**
	0.12		0.18		0.17		0.12		0.17		0.17		0.12		0.17		0.18	
w * IPRs	-0.04		-1.14	**	-0.70								0.36		-0.23		-0.02	
	0.27		0.42		0.47								0.28		0.45		0.55	
s * IPRs	0.65	**	0.44	**	-0.15								0.06		0.36	*	-0.22	
	0.20		0.18		0.27								0.20		0.22		0.31	
w * IPRs * t																		
1992							-0.50		-1.53	**	-0.98	*						
							0.47		0.55		0.53							
1987							-0.37		-1.53	**	-1.31	**						
							0.34		0.52		0.51							
1982							-0.09		-1.62	**	-0.77							
							0.34		0.52		0.57							
1977							0.29		-0.43		-0.26							
							0.31		0.48		0.61							
1972							0.41		0.02		0.28							
							0.33		0.50		0.59							
s * IPRs * t																		
1992							1.07	**	-0.24		0.09							
							0.28		0.34		0.34							
1987							0.79	**	0.21		-0.68	**						
							0.26		0.30		0.33							
1982							0.70	**	0.30		-0.80	**						
							0.26		0.29		0.32							
1977							0.07		0.48	**	-0.35							
							0.22		0.28		0.33							
1972							0.03		0.22		-0.15							
							0.22		0.27		0.33							
w * IPRs * t82-92													-0.62	**	-1.32	**	-0.99	**
													0.22		0.35		0.32	
s * IPRs * t82-92													0.81	**	-0.32		-0.21	
													0.15		0.23		0.21	
R2	0.76		0.70		0.63		0.78		0.72		0.66		0.77		0.71		0.65	
Observations	415		410		426		415		410		426		415		410		426	

NOTES:
Significant POSITIVE estimates on IPRs terms indicate MARKET EXPANSION effects.
Significant NEGATIVE estimates on IPRs terms indicate MARKET POWER effects.
** Significant at 5 percent level. * Significant at 10 percent level.
Heteroscedasticity corrected standard errors are in parentheses.
All regressions control for fixed effects related to imitative abilities.
w = dummy variable for weak imitative abilities; s = dummy variable for strong imitative abilities.
t = vector of dummy variables for the years: 1972, 1977, 1982, 1987, 1992.
t82-92 = (single) dummy variable for the years 1982, 1987, and 1992.