Do Stronger Intellectual Property Rights Raise High-Tech Exports to the Developing World?

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Abstract

Despite over 20 years of debate, the TRIPs agreement remains very contentious. This paper evaluates the impact of strengthening intellectual property rights (IPRs) in developing countries on developed countries' exports over the 1962-2000 period. Colonial origin is used to isolate exogenous variation in IPRs. The impact is then identified by examining the cross-industry difference in sensitivity to IPRs. I find that the increase in IPRs made in response to the TRIPs agreement added about \$50 billion (1994 US dollars) to the annual value of developed countries' exports in IPR-sensitive industries. The increase in the value of exports was driven by a quantity, rather than a price, increase.

Keywords: Trade; International law; Intellectual property rights

JEL classification: F10, K33, O34

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I. Introduction

Despite over twenty years of debate, and almost fifteen years of post agreement experience, the 1994 agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) remains contentious. Proponents of the tougher standards embodied in the agreement argued that lax intellectual property rights (IPRs) in developing countries prevented innovators from earning a fair return on their inventions and reduced exports of technologically advanced products to the less developed world. Not surprisingly, opponents of the agreement disagreed, arguing that more stringent IPRs would restrict trade in the developing world's legitimate imitative products and do little more than strengthen the monopolistic power of innovators. While the TRIPs debate and the subsequent 1994 agreement led to ample and still growing theoretical literature, the major and still unresolved questions are largely empirical: how has the agreement affected exports from the innovating North to the imitating South?; and in general terms, how does a strengthening of IPR protection affect the flow of innovative products from North to South?

This paper attempts to isolate, and then estimate, one of the important impacts of strengthened IPRs. Specifically, it evaluates how stronger IPRs in developing countries have affected the innovating developed world's exports into their markets. To answer this question I utilize data from both the pre- and post-TRIPs agreement period (spanning the 1960-2000 period) and examine export flows from the innovating North (an aggregate of 24 OECD countries) to the potentially imitative South (an aggregate of 69 developing countries). The empirical challenge is to credibly measure a causal effect from strengthened IPRs to trade flows by accounting for several econometric and data problems.

My empirical strategy starts with a simple observation. Changes in the strength of IPRs in developing countries is strongly correlated with their colonial origin. During the 1960-1990 period former colonies of Britain and France increased their IPRs significantly more than other developing countries. For example, during this period former colonies increased their IPRs by 17 percent while IPR protection in non-colonies fell during this period.[1] The opposite is true in the 1990-2000 period. Developing countries that were

[1]IPR protection here is measured by the Ginarte and Park (1997) index. See Section 2 for details

not British or French colonies increased their IPRs by 30% more than colonies. The increase in stringency in this later period is clearly due to the imposition of the TRIPs agreement that required countries with lax protection to make serious adjustments to IPR protection. The increase in IPRs within the colonies over the earlier period may have been due to the legal and institutional legacies left by their British and French colonizers.[2] The observation is that colonies differ significantly from non-colonies in the time pattern of their strengthening of IPRs: the expectation is that this variation can be used to deduce something causal about IPRs and trade flows.

Specifically, I perform a difference-in-difference analysis in which the growth rates of exports from the developed North to the less developed South are differenced along two dimensions: former colonies of Britain and France versus non-colonies, and IPR-sensitive industries versus IPR-insensitive industries. The period is also divided into the pre- and post-TRIPs period. The growth rates of exports are examined separately for the pre-TRIPS period of 1962-1994 and the post-TRIPS period of 1994-2000.

The empirical results are striking. For both periods, I find a strengthening of IPRs in developing countries raises the value of developed countries' exports in IPR-sensitive industries. Perhaps not surprisingly, this effect is the strongest for industries that rely heavily on patent protection, such as as medicinal and pharmaceutical products and professional and scientific equipment. The empirical results are also consistent across the two distinct periods; i.e., similar results are found when the largest increase in IPRs occurs within former colonies (pre-1994) and when they are within non-colonies (post-1994). The results also survive two robustness checks that relax both the definition of sensitive and insensitive industries and the definition of time periods.

Applying the further assumption that changes in IPR protection should have no effect on the growth rate of exports in IPR-insensitive industries, I provide estimates of the

concerning its construction.

[2] I focus on colonies that received their independence in the 20th century. This implies the U.S., Canada, and Australia are not colonies under this definition. Since all Spanish colonies, save Philippines, were independent by 1826 they appear here as non-colonies.

dollar value of new exports created by the changes in IPRs. Using this method, I find that the increase in IPRs made in response to the TRIPs agreement added about $50 billion (1994 US dollars) to the annual value of developed countries' exports in IPR-sensitive industries. Further, the data for the 1994-2000 period suggest that stronger IPRs increased the value of exports into developing countries by increasing the quantity, rather than the price, of exports.

The empirical strategy underlying these results is deceptively simple. It starts with the observation made above concerning the time pattern of IPR changes but recognizes that simply correlating trade flows with IPR protection is likely to be of little value. Large exports into former colonies are likely the consequence of relationships established through colonization. Colonies could be geographically proximate, and in many cases they are connected to their colonizers through now well-worn trade routes. To address this concern, the growth rates (as opposed to levels) of export volumes are compared; that is, I examine the *over time variation* in both IPRs and exports.

While this is surely a step in the right direction, it is unlikely that a strengthening of IPRs is exogenous to other policy reforms ongoing in these countries. Over the pre-TRIPs period this seems especially significant since the change in IPRs we observed in the former colonies was not required by any international agreement, and therefore could well have been part of more general market reforms intended to promote industrial development and trade. This problem can, at least partially, be addressed by examining the *across industry variation* in exports. For example, by grouping industries into IPR sensitive and insensitive, I examine whether the growth rate of IPR sensitive exports from the developed world responds differentially to stronger IPRs in the developing world.

Finally, there is the issue of endogeneity. A large level, or fast growth rate, of trade with the developed world could very well provide an incentive for a developing country to strengthen its IPRs in the hope of fostering further trade. In this sense, trade causes IPR protection and not the reverse. While this is a serious concern in the 1960-1990 period, when each country chose to what extent, if any, to regulate its IPRs, it is likely absent in the post-TRIPs period. During this later period, the overall push to strengthen IPRs in countries with lax protection was exogenously imposed by the TRIPs agreement. While my empirical results do differ quantitatively across the two periods, the qualititative conclusions remain the same.

There is a large literature examining the TRIPs debate. Much of the theoretical literature has focused on the impact of stronger IPRs on R&D and growth, but almost all contributions contain predictions concerning Northern exports. For example, in a static partial equilibrium world, extending IPRs from the innovating North to the non-innovating South encourages Northern firms to develop new technologies (Chin and Grossman, 1990; Deardorff, 1992), which may be more suitable to Southern tastes (Diwan and Rodrik, 1991). If Northern firms also compensate for lax IPRs by masquing their technologies, which takes resources away from production, then stronger IPRs lead to increases in Northern output (Taylor, 1993). In addition, if stronger IPRs prevent imitation, then production of imitative products in the South falls and demand for Northern products rises (Maskus and Penubarti, 1997). All of these changes are expected to promote Northern exports.[3] It is also true however that stronger IPRs enhance the monopolistic power of innovators (Deardorff, 1992; Chin and Grossman, 1990; Maskus and Penubarti, 1997), and if this market power effect is strong enough then Northern exports can fall.

The empirical literature also exhibits a wide range of results. For example, for the aggregate of manufacturing industries, researchers have found no significant impact of a strengthening in IPRs (Ferrantino, 1993) to a significantly negative impact (Smith, 1999) or a significantly positive impact (Maskus and Penubarti, 1995; Rafiquzzaman, 2002). When researchers consider finer divisions than the aggregate of manufacturing, the results are often counterintuitive. Maskus and Penubarti (1995) found that exports

[3]See also the contributions by Taylor (1994), Helpman (1993), and Grossman and Lai (2004) within a growth context. In these papers exports are affected when the rate of innovation and imitation change in response to strengthened IPRs.

in the least patent-sensitive industries rise with a strengthening of IPRs, while exports in the most patent-sensitive industries are unaffected; Co (2004) found that exports in non-R&D-intensive industries falls, but exports in R&D-intensive products are unaffected on average; and Fink and Braga (1999) found that trade in non-fuel products expands but trade in high technology products is unchanged. Part of this variance in results surely comes from the different methods and time periods considered. As well, studies differ in the extent to which they attempt to address endogeniety and measurement error issues, and relatively few studies employ more than one cross-section of data.[4]

The empirical strategy employed in this paper is a combination and an extension of the approaches adopted in the literature. As such I owe much to previous work. First, I employ a country's British or French colonial origin to divide countries into groups with very different histories of IPR protection. This is similar to the approach of Ferrantino (1993), who showed a systematic relationship between a country's economic and geographical conditions and the strength of their IPRs; my use of the colony vs. non-colony variation in the data is also akin to that of Maskus and Penubarti (1995), who employ a dummy for former British and French colonies as an instrument for their measure of IPRs. I also follow Rafiquzzaman (2002) and Co (2004) by using export data over several years to focus on growth rates and not the levels of trade; and build on contributions by Maskus and Penubarti (1995), Fink and Braga (1999), Smith (1999), Rafiquzzaman (2002), and Co (2004) by exploiting industry heterogeneity in the sensitivity to IPRs to measure their effect.

The rest of the paper proceeds as follows. In Section II, I describe the pattern of changes in IPRs in colonies and non-colonies over the 1960-2000 period. In Section III, I classify industries by their sensitivity to IPRs using Cohen et al. (2000) and additional

[4]The stringency of IPRs in a destination country is commonly measured by Rapp and Rozek (1990) or Ginarte and Park (1997) index. The Rapp and Rozek index was used in Maskus and Penubarti (1995). The Ginarte and Park index was used in Fink and Braga (1999), Smith (2002), and Co (2004). Smith (1999) and Rafiquzzaman (2002) employed both indices and concluded that, because the indices were constructed using similar categories of patent laws, they produced almost identical results. The correlation between the Rapp and Rozek index for 1984 and the Ginarte and Park index for 1985 is 0.75.

sources. The empirical strategy is outlined in Section IV. The results are presented in Section V, and their economic significance is discussed in Section VI. In Section VII, I examine export price. Section VIII concludes. Data description and further sensitivity results are in the appendix.

II. Colonial Status and IPR Protection

I measure the stringency of IPR protection by the Ginarte and Park (1997) index. The index is available for each 5-year time period from 1960 to 2000, and is constructed using five measures of patent laws (coverage, membership in international IPRs treaties, provisions against losses of protection, enforcement mechanisms, and duration of protection). Each measure is assigned a value from 0 to 1 which equals the share of conditions a country satisfies. The final index is a sum of these five values. The Ginarte and Park index is an index of patent rights. It does not include other categories of intellectual property, such as copyright rights, trademarks, plant variety rights, industrial designs, or geographical indications. Nonetheless, a fairly high correlation of this index with indices for copyrights and trademarks has been documented (Park and Lippoldt, 2003, 2008).

The Ginarte and Park (1997) index is commonly used in the literature (Fink and Braga, 1999; Smith, 2002; Co, 2004). It is preferred over the alternative index developed by Rapp and Rozek (1990), because it encompasses more countries and years.[5] Both indices are constructed using similar measures of patent law and therefore produce similar results (Smith, 1999; Rafiquzzaman, 2002).

It has been recognized in the literature that the Ginarte and Park index is potentially subject to significant measurement error and may not reflect the actual stringency of IPRs in a country (Maskus and Penubarti, 1995; Fink and Braga, 1999). An important concern is that the index is based on laws on the books. To the extent that enforcement is imperfect, the index overstates the true stringency of IPRs.

[5]The Rapp and Rozek index was used in Maskus and Penubarti (1995).

The approach adopted in this paper attempts to overcome the problem of measurement error in the index. Specifically, I use former British or French colonial status of a country as an instrument for the changes in the stringency of IPRs over time. It may be true that measurement errors in the values of the index are correlated with colonial status. However, this correlation is unlikely if the *changes* in the index over time are considered. Suppose colonies received high scores of the index based on the laws of their colonizers,[6] but these laws were not enforced. Then the gap between the measured and actual levels of protection will be wide. Once colonization is over, however, there are few if any reasons to expect these scores to increase over time without proper enforcement mechanisms. Therefore, if the change in the index (instead of its values) are proxied for by former colonial status, the problem of measurement error is likely to be insignificant.

I begin with analyzing the index data for all countries. Following this, I concentrate on developing countries and examine the correlation between the changes in IPRs over time in these countries and their former British or French colonial status.

The index means are reported in Table 1, where countries are classified into three groups: developed countries, developing countries formerly colonized by Britain or France (Colonies), and developing countries not colonized by Britain or France (Non-colonies). The list of countries for which the index is available is presented in Appendix A.[7] The developed countries are the OECD members. The developing countries are the countries classified by the World Bank as lower-middle or low income economies (according to 1995 GNP per capita). The developing countries for which the IPRs index is available only for 1995 and 2000 (i.e. China, Vietnam, Bulgaria, Lithuania, Poland, Romania, Russia, Slovak Republic, Ukraine) are excluded from the analysis.

It is apparent that in every 5-year period under consideration developed countries had the most stringent IPRs of all country groups, followed by formerly colonized developing

[6] Ginarte and Park (1997), for example, observe that African countries formerly colonized by Britain or France received high values of the index because their patent laws are similar to those of their colonizers.

[7] Data for colonization origin is available at: https://www.cia.gov/cia/publications/factbook/countrylisting.html. Detailed descriptive statistics of the IPRs index are available in Appendix B.

countries. Further, for these two groups the index has been increasing throughout the entire period. Non-colonies, in contrast, had the least stringent IPRs, and their index increased considerably only in the 1990s.

Table 1: **The means of the IPRs index**

	1960	1965	1970	1975	1980	1985	1990	1995	2000
Developed countries	2.60	2.77	2.90	2.91	3.25	3.30	3.38	3.75	4.01
Developing countries									
Colonies	1.99	2.09	2.14	2.15	2.26	2.32	2.33	2.43	2.84
Non-colonies	1.73	1.75	1.65	1.67	1.69	1.70	1.70	2.22	2.57

Changes in the index over the 1960-1990 and 1990-2000 periods are presented in Figure 1. It is shown that the pattern of changes observed in the earlier period is very different from the one observed in the later period. Developing countries, which did not strengthen their IPRs much before the 1990s, strengthened their IPRs the most during the 1990s. Across the two groups of developing countries, Colonies increased their IPRs relatively more prior to 1990s, whereas Non-colonies increased their IPRs more in 1990s.

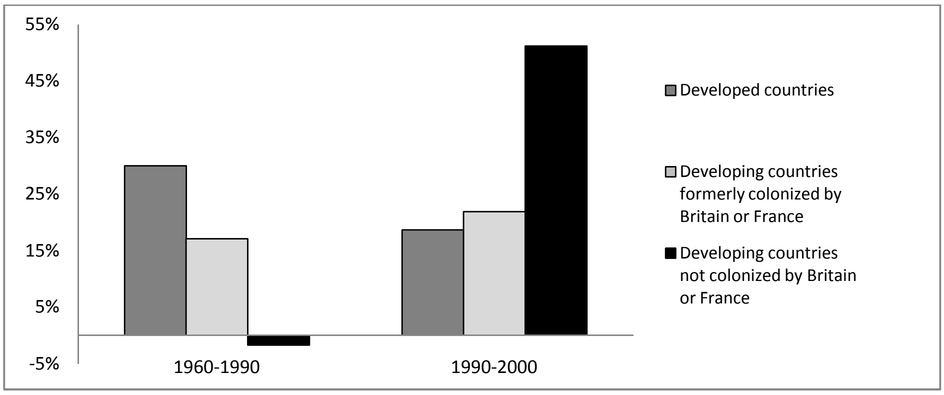

Figure 1: **Percentage changes in the IPRs index**

Table 2 enumerates the changes in the index (measured in log points) for Colonies and Non-colonies. The null hypothesis that the mean changes are equal across the two country groups is rejected at a 1% level of significance for each of the two time periods. This provides evidence that Colonies and Non-colonies differ in the average behavior of changes in IPRs.

Table 2: **Mean changes in the IPRs index**

Developing countries	1960-1990	1990-2000
Colonies	.104	.144
Non-colonies	-.022	.319
Difference	.126***	-.175***

Note: The data is in log point changes; *** denotes 1% significance level;
Means comparison test: H_0: difference= 0, H_1: difference$\neq$ 0.

To make sure that the means are not driven by a few extreme values, I look at the entire distribution of changes in Figure 2. The figure confirms my earlier conclusion about the changes in the index across Colonies and Non-colonies.[8]

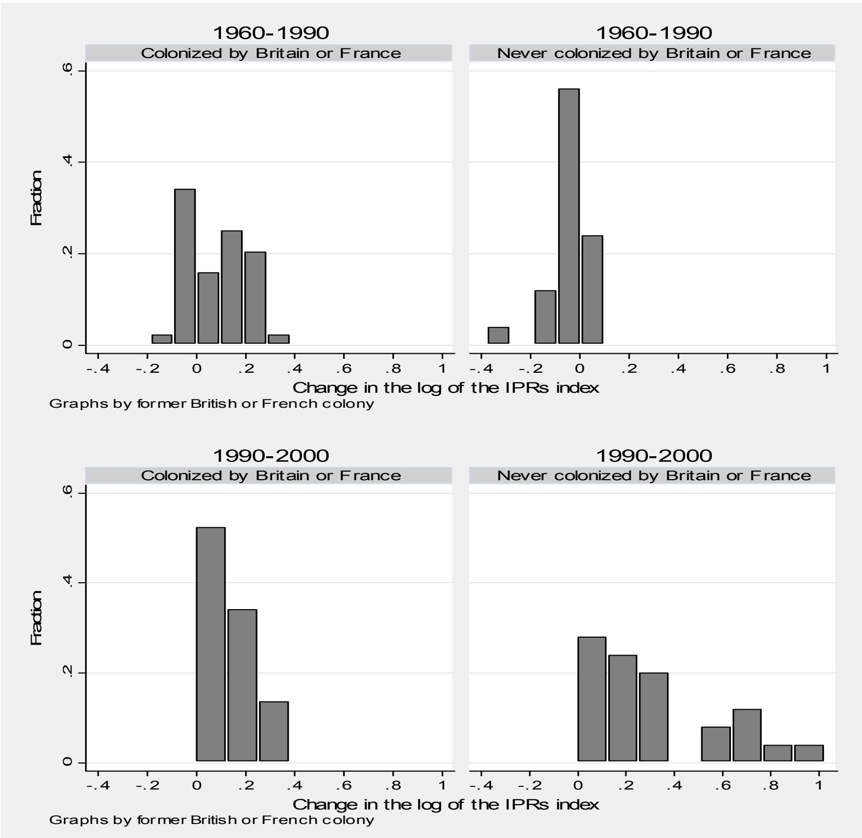

Figure 2: **The pattern of changes in IPRs**

[8]For the 1960-1990 period, the median changes for Colonies and Non-colonies are 0.94 and 0.00. For the 1990-2000 period, they are 0.13 and 0.26. I also perform a Kolmogorov-Smirnov test for equality of distributions of Colonies and Non-colonies. The null hypothesis that these distributions are equal is rejected for both periods. For the earlier period, the cumulative fraction plot of Colonies lies below that of Non-colonies 95% of the time. For the later period, the cumulative fraction plot of Non-colonies lies below that of Colonies 98% of the time.

In addition, to ensure that the magnitudes of changes and their statistical significance are not driven by aggregation over time, the changes in the index in Colonies and Non-colonies are analyzed for each five-year time interval from 1960 to 2000. As is shown in Table 3, Colonies increased their IPRs relatively more in each period from 1960 to 1990. Moreover, this difference is significant at 1% for 1965, at 5% for 1970 and 1980, and at 10% for 1985. Non-colonies increased their IPRs relatively more in the last two intervals. This difference is significant at 1% for 1995.

Table 3: **The mean changes in the IPRs index**

	1965	1970	1975	1980	1985	1990	1995	2000
Colonies	.034	.015	.005	.031	.018	.001	.032	.112
Non-colonies	.007	-.043	.004	.005	.004	.000	.195	.124
Difference	.027***	.058**	.001	.026**	.014*	.001	-.163***	-.012

Note: ***, **, and * denote 1%, 5%, and 10% significance level.

The relative progress of Colonies in strengthening IPRs before the 1990s is probably a consequence of the British or French colonial relations. Many researchers have argued that colonizers affected the formation and successive development of their colonies' institutions of law and private property (Barro, 1996; Porta et al., 1999; Hall and Jones, 1999). This initial colonial base could then provide a fertile environment for a developing country to strengthen IPRs slowly over time.

Britain in France, in particular, had well developed patent systems which had a strong influence on their colonies during the 19th century (Khan, 2004). In addition, during the late 19th and early 20th centuries, when the importance of intellectual property became well recognized among industrialized countries, British and French colonies were still dependent on their colonizers (most of them received independence only after 1945). Unlike Britain and France, Spain, for example, was less developed, had a lower per capita rate of patenting, and was dependent on foreign technologies during the 19th century. It's patent system was constructed to profit from foreign innovation rather than stimulate domestic innovation (Khan, 2004). Spain could not have much influence on patent institutions of its colonies because all Spanish colonies, save Philippines, became independent by 1826. This is long before the Paris Convention for the Protection of Industrial Property, which is the first major international intellectual property treaty, entered into force in 1884.

In contrast to the pre-1990 period, the relative progress of Non-colonies in strengthening IPRs during the 1990s is a consequence of the TRIPs agreement signed on April 15, 1994. TRIPs is an international agreement that sets down minimum standards of IPR protection. Unlike the previous intellectual property conventions (Paris Convention, Berne Convention, Rome Convention, and treaty on integrated circuits), the TRIPs agreement deals with the effective enforcement of IPRs standards. For example, trade disputes over IPRs can be pursued through the World Trade Organization (WTO) dispute settlement system. The agreement was designed to achieve universal standards of intellectual property laws, which necessarily required asymmetric increases in the strength of IPRs across the world (Gaisford and Richardson, 2000). Its ratification is a compulsory requirement of WTO membership. To enact the strong standards mandated by TRIPs, countries with weak intellectual property laws, such as Non-colonies, were asked to strengthen their IPRs relatively more, leading to the two very different episodes we see in Figure 1.

III. Industry Sensitivity to IPRs

Having described the changes in the IPRs index and their correlation with colonial status of developing countries, I proceed with describing the data used for the analysis.

The export data are by 3-digit ISIC (Rev.2) industry and available for each year from 1962 to 2000.[9] The value of exports (measured in nominal US dollars) into each devel-

[9] I aggregate the original NBER-UN world trade data, available at 4-digit SITC level, into 2-digit levels and then, use industry concordances to obtain data by 3-digit ISIC codes (Rev.2). The original NBER-UN world trade data comes from Feenstra et al. (2004) and is available at www.nber.org/data. The industry concordances come from Maskus (1989) and are available at

oping country from Appendix A is aggregated over all developed countries available in the data set. The industries analyzed are classified according to their sensitivity (or lack thereof) to IPRs. The classification is presented in Table 4, where professional and scientific equipment, medicinal and pharmaceutical products and other chemicals, industrial chemicals, and non-electrical machinery are categorized as IPR-sensitive industries; non-ferrous metals, non-metallic mineral products, and electrical machinery are categorized as IPR-insensitive industries.

Table 4: **Industry classification**

IPR-sensitive industries	IPR-insensitive industries
Medicinal and pharmaceutical products (subdivision of Other chemicals)	Non-ferrous metals (subdivision of Basic Metals)
Professional and scientific equipment	Non-metallic mineral products
Other chemicals	Electrical machinery
Industrial chemicals	
Non-electrical machinery	

In the analysis, I evaluate the behavior of exports in IPR-sensitive industries relative to that in IPR-insensitive industries. Consequently, it is particularly important to classify industries correctly. I only consider industries that fall into one of the two categories. IPR-sensitive category consists of industries which have the highest effectiveness of patents in protecting "competitive advantage" from patented inventions. IPR-insensitive category consists of industries which have the lowest patent effectiveness, and which are not covered by other categories of IPR protection.

The classification I adopt draws on several sources to make sure that an industry's sensitivity to different categories of IPRs is accounted for. The ranking of industries by the effectiveness of patent protection is documented in Cohen et al. (2000), which is displayed in Appendix C. In this ranking, publishing, printing and reproduction of recorded media industry is indicated to have the lowest patent effectiveness. However, the publishing industry is covered by copyright protection. Next in the ranking is the food

http://www.macalester.edu/research/economics/page/haveman/Trade.Resources/tradeconcordances.html.

industry. However, this industry is protected by plant variety rights and geographical indications (Maskus, 2006). The textile industry is also ranked very low, but it is covered by trademark protection (Keenan et al., 2004). The steel industry is ranked low in Cohen et al. (2000), but is ranked high in Levin et al. (1987). Therefore, I am unable to classify all these industries as insensitive to IPRs.

Initially, I perform the analysis on the aggregate industry groups. Following this analysis, I disaggregate the industry groups and analyze the growth rates of exports in individual industries. This extra step serves two purposes. First, it is used to verify that the grouping of industries does not bias the results. Second, it allows comparing estimates across individual industries to make sure that they are sensible and quite intuitive.

IV. Empirical Strategy

This section describes the empirical strategy I employ to evaluate the impact of strengthening IPRs on developed countries' exports. The analysis in section 2 demonstrated that the changes in IPRs during the 1960-1990 and the 1990-2000 periods followed a very different pattern, characterized by IPR strengthening in Colonies during the former period, and IPR strengthening in Non-colonies during the latter period.

The value of exports into Colonies is partially a consequence of the relationships established through colonization itself. For example, colonies could be geographically proximate, connected to their colonizers by direct trade routes, or share common tastes and customs. These factors lead to permanent differences in exports across Colonies and Non-colonies. If left unaccounted for, they would interfere with my evaluation of the impact of strengthening IPRs. To effectively control for these factors, which are specific to each country group and do not vary with time, *over time variation* of exports can be used. Specifically, the mean growth rates, as opposed to the mean values, of exports into Colonies and Non-colonies can be compared.

Even if we focus on export growth exclusively, potential problems with the approach remain. The stringency of IPRs in a country is but one of several factors that determine export growth. For example, domestic reforms designed to stimulate economic development or trade are all expected to go together with a policy of strengthening IPR protection. Nonetheless, as long as these reforms have an impact common to all industries within a country, they can be accounted for by using *across industry variation* in sensitivity to IPR protection. Specifically, the difference in the growth rate of exports across IPR-sensitive and IPR-insensitive industries can be examined for each country.

Some policy reforms, such as the global movement towards liberalized trade, affect industries differentially. Nonetheless, because these reforms are common to Colonies and Non-colonies, they are accounted for when the growth rates of exports between the two country groups are compared.

Finally, even if we focus on the comparison of the mean growth rates of exports in IPR-sensitive (relative to IPR-insensitive) industries in Colonies and Non-colonies, it might be that the stringency of IPRs is endogenously determined by trade. For example, an initially high growth rate of high-tech exports from developed countries could have provided incentives for Colonies to strengthen their IPRs in order to promote further growth. In this case, the positive association between the variables could bias the causal inference about the impact of strengthening IPRs on export growth.

The endogeneity problem is a serious concern in the pre-TRIPs period, when it was an individual choice of each country to what extent, if any, to regulate its IPRs. However, it is likely absent in the post-TRIPs period, when country-level regulation of IPRs was internationally mandated by the TRIPs agreement. During the 1990-2000 period, Non-colonies strengthened their IPR protection the most across all country groups (see Figure 1). The changes of IPRs in these countries was unlikely to be driven by their intrinsic economic factors. Unlike Colonies, Non-colonies did not strengthen their IPRs during the earlier period, perhaps because an environment conducive to strengthening IPRs was not established in these countries. For example, important complementary factors, such as developed institutions of law and private property, were absent in Non-colonies. In the 1990s, however, when the global movement towards strong universal standards of IPR protection began, Non-colonies strengthened their IPRs. Since a vast majority of countries in the Non-colony group are WTO members, they were required to comply with strong standards of IPRs imposed by the TRIPs agreement. As a result, the overall push to strengthen IPRs in Non-colonies during the 1990s was exogenously imposed.

Countries targeted by the TRIPs agreement were not selected randomly. These were the countries with weak IPRs, which in turn were determined by a range of historical factors, potentially affecting trade as well. By using colonial status to categorize countries into two groups – Non-colonies, which strengthened their IPRs in the 1990s relatively more (treatment group) and Colonies, which strengthened their IPRs in the 1990s relatively less (comparison group), – I am able to descern the pattern of changes in IPRs brought about by the TRIPs agreement. Next, by comparing the mean growth rates of exports in IPR-sensitive (relative to IPR-insensitive) industries in Non-colonies and Colonies, I am able to account for confounding factors which potentially could bias the results.

I perform individual empirical analyses for the pre-TRIPs and the post-TRIPs periods. The later period is of particular importance because it allows me to assess whether the results for the earlier period are contaminated by an endogeneity problem.

The statistical model for the industry-level value of exports into a developing country is specified as follows:

$$X^i_{jt} = \beta^i IPR_{jt} + \alpha_j + \alpha_{jt} + \gamma^i + \gamma^i_t + \varphi_t + u^i_{jt}, \tag{1}$$

where X^i_{jt} is the log of the aggregate value of exports into developing country j in industry i over period t; IPR_{jt} is the log of the stringency of IPRs in country j at time t; the coefficient β^i measures the sensitivity of exports to a change in IPRs, which varies across industries but is constant across importing countries; α_j denotes constant country factors, such as factor endowments, transportation costs, distance to exporting markets, etc; α_{jt} denotes country factors that vary with time, such as income levels, market and institutional environments, openness, R&D activity, etc; γ^i denotes constant industry factors, such as fixed factor requirements; γ^i_t denotes industry factors that vary with time, such as factor productivity, technological progress, and international trade policy measures; φ_t denotes common time trends, such as global macroeconomic shocks; u^i_{jt} is the stochastic error term.

To remove possible level effects, represented by α^i and γ^i, the data can be transformed into growth rates. In this case, specification (1) simplifies to:

$$\Delta X^i_{jt} = \beta^i \Delta IPR_{jt} + \delta_{jt} + \tau^i_t + \theta_t + \varepsilon^i_{jt}, \tag{2}$$

where ΔX^i_{jt} denotes the log change in the aggregate value of exports and ΔIPR_{jt} denotes the log change in stringency of IPRs over period t. The rest of the variables are defined as follows: $\delta_{jt} = \Delta\alpha_{jt}$, $\tau^i_t = \Delta\gamma^i_t$, $\theta_t = \Delta\varphi_t$, and $\varepsilon^i_{jt} = \Delta u^i_{jt}$.

In theory we could evaluate the impact of IPRs on exports by estimating specification (1) or (2) for each individual industry (or industry group) i. In fact, this evaluation has been done previously, including an estimate of a model in the first difference form in Rafiquzzaman (2002), and a panel data model estimate in Co (2004). This approach, however, is problematic. First, estimation of (1) or (2) requires the full control of factors that vary with time and affect export growth differently across importing countries. In specification (2), the set of these factors is represented by δ_{jt} and, among others, it includes variables that are correlated with the changes in the stringency of IPRs in a country (e.g. domestic reforms of institutional and market environment, political freedom, openness, etc.). Because a lot of these factors are unobservable, they are left unaccounted for, leading to a potential bias in the OLS estimator.

Second, the stringency of IPRs is potentially measured with significant errors which again produce a biased OLS estimator. Under the reasonable assumption that the measurement error is less positively autocorrelated than the true (unmeasured) explanatory variable, then first differencing and fixed effects transformation of the data actually exacerbates measurement error bias (Solon, 1985; Griliches and Hausman, 1986). This data transformation removes some of the noise in the measurement error, but it removes relatively more of the signal in the true explanatory variable. As a result, the noise-to-signal ratio for the true explanatory variable increases, magnifying measurement error bias.

Estimation of (1) or (2) requires a strictly exogenous measure of IPRs. Without exogeneity, the difficulties mentioned above are much harder to resolve. Unfortunately, there is no guarantee that the IPRs index is exogenous to trade. In contrast, it is very likely that the values (changes) of IPRs index are predetermined by the values (growth rates) of exports.

In this paper, specification (2) is estimated. The approach adopted attempts to overcome the problems mentioned above by using three dimensions of data variation. The first dimension of variation is that industries exhibit different sensitivity to changes in IPRs. This industry variation can be utilized to ensure that time-varying shocks to export growth which are common to all industries within a country, represented by δ_{jt}, are not confounded with strengthening IPRs. For example, if strengthening IPRs coincided with other domestic policy reforms promoting overall growth of exports into the country, then industry variation in sensitivity to IPRs can be used to ensure that growing rates of exports are not falsely attributed to the impact of stronger IPRs.

The second dimension of variation is the variation in the changes of IPRs across Colonies and Non-colonies. This country variation can be used to overcome the problem of measurement errors in the IPRs index. In particular, former colonial status of a country can be used to instrument the changes in the stringency of IPRs over time.

The third dimension of variation is time variation. This variation is especially important for identification purposes. It permits analysis of the data over two distinct periods (before and after the TRIPs agreement was implemented) in order to assess whether the results for the pre-TRIPs period suffer from endogeneity. Furthermore, it allows analysis of the growth rate of exports over longer time periods. This is important since the growth rates of exports are unlikely to respond immediately to a change in IPRs. Thus, longer time periods are required to be able to cover their full adjustment. These three variations together serve to identify the impact of strengthening IPRs on export growth.

Let ΔX^i_{jT} be defined as the average annual log change in the aggregate value of developed countries' exports into developing country j in industry i over period T:

$$\Delta X^i_{jT} \equiv \begin{cases} (\ln X^i_{j,1994} - \ln X^i_{j,1962})/(1994 - 1962) & \text{for} \quad T = T_1, \\ (\ln X^i_{j,2000} - \ln X^i_{j,1994})/(2000 - 1994) & \text{for} \quad T = T_2; \end{cases} \tag{3}$$

where $T = T_1$ is the pre-TRIPs 1962-1994 period;[10] and $T = T_2$ is the post-TRIPs 1994-2000 period.

By differencing the data over long time periods, I completely remove the time series variation of the data within each period. The rationale for the use of this technique is outlined in Bertrand et al. (2001) and Griliches and Hausman (1986). Bertrand et al. (2001) examined the problem of serial correlation in the context of the difference-in-difference estimation. In order to remove the bias in the estimated standard errors that serial correlation introduces, collapsing the time series dimension of the data by averaging over the longest periods possible was recommended. Griliches and Hausman (1986) examined the problem of measurement errors in panel data. It was concluded that the long differencing estimator is often the optimal estimator which minimizes inconsistency.[11]

To evaluate the impact of strengthening IPRs on export growth, a simple mean comparison analysis is employed in this paper. The growth rates of exports are differenced along two dimensions: (*i*) IPR-sensitive versus IPR-insensitive industry group; and (*ii*)

[10] The export data is available only from 1962 to 2000.

[11] The long differencing estimator is the optimal estimator if there is no autocorrelation in the measurement error or the disturbance error. In the presence of autocorrelation, it is optimal if both the measurement error and the disturbance error follow AR1 processes and the measurement error is less positively autocorrelated than the true (unmeasured) explanatory variable.

Colonies versus Non-colonies. The resultant difference-in-difference measure compares the difference in the average behavior of the growth rates of exports in the IPR-sensitive relative to IPR-insensitive industry group for Colonies with that of Non-colonies. Because this measure is related to the difference in the mean changes in IPRs across Colonies and Non-colonies, its sign can be used to infer the direction of the impact of strengthening IPRs on export growth.

Let $i = s$ stand for the IPR-sensitive industry group and $i = n$ stand for IPR-insensitive industry group. Then, the difference in the growth rates of exports across the two industry groups is given by $\Delta X_{jt}^{s/n} \equiv \Delta X_{jt}^{s} - \Delta X_{jt}^{n}$. This difference eliminates δ_{jt} as well as θ_t from equation (2). In long difference form, the equation for the outcome variable is now specified as follows:

$$\Delta X_{jT}^{s/n} = (\beta^s - \beta^n)\Delta IPR_{jT} + \tau_T^{s/n} + \varepsilon_{jT}^{s/n}, \tag{4}$$

where the following notation has been used: $\tau_T^{s/n} = \tau_T^s - \tau_T^n$ and $\varepsilon_{jT}^{s/n} = \varepsilon_{jT}^s - \varepsilon_{jT}^n$. The outcome variable $\Delta X_{jT}^{s/n}$ approximates the growth rate of exports in IPR-sensitive relative to IPR-insensitive industry group over the long period T. For each period T, the impact of strengthening IPRs on the relative growth rate of exports can be estimated from equation (4) using cross-sectional variation. However, this approach may produce an inconsistent estimator. It may be that the changes in IPRs are correlated with unobserved determinants of the relative growth rates of exports, i.e. $corr(\Delta IPR_{jT}, \varepsilon_{jT}^{s/n}) \neq 0$. In this case, we will not recover the causal effect. Thus, an alternative approach is needed.

The approach adopted in this paper uses colonial status as an instrument for the change in IPRs. It recovers the causal effect of strengthening IPRs on export growth under two key assumptions. First, I assume that strengthening IPRs does not impact export growth in IPR-insensitive industries, i.e. $\beta^n = 0$. Second, I assume that colonial status does not directly determine the growth rate of exports in IPR-sensitive relative to IPR-insensitive industry group. It only affects $\Delta X_{jT}^{s/n}$ indirectly by affecting ΔIPR_{jT}.

That is, I assume $E[\varepsilon_{jT}^{s/n}|j=c]=E[\varepsilon_{jT}^{s/n}|j=nc]$, where $j=c$ index Colony and $j=nc$ index Non-colony.

The second assumption would fail if the decision to strengthen IPRs was determined partly as a function of export growth. For example, the relatively high growth rate of high-tech exports into Colonies, compared to Non-colonies, could provided incentives for Colonies to strengthen their IPRs in order to further promote export growth. While this is the serious concern in the pre-TRIPs period, it is likely absent in the post-TRIPs period for reasons given earlier.

Under the two assumptions stated above, the estimate of the impact of strengthening IPRs on export growth in IPR-sensitive industries is given by:

$$\hat{\beta}^s=(\overline{\Delta X}_T^{s/n,c}-\overline{\Delta X}_T^{s/n,nc})/(\overline{\Delta IPR}_T^{c}-\overline{\Delta IPR}_T^{nc}) \quad \text{for} \quad T=T_1, \tag{5}$$

$$\hat{\beta}^s=(\overline{\Delta X}_T^{s/n,nc}-\overline{\Delta X}_T^{s/n,c})/(\overline{\Delta IPR}_T^{nc}-\overline{\Delta IPR}_T^{c}) \quad \text{for} \quad T=T_2; \tag{6}$$

where $\overline{\Delta X}_T^{s/n,c}$ is the sample average of $\Delta X_{jT}^{s/n}$ over the part of the sample where $j=c$ and $\overline{\Delta X}_T^{s/n,nc}$ is the sample average of $\Delta X_{jT}^{s/n}$ over the part of the sample where $j=nc$. Similarly, $\overline{\Delta IPR}_T^{c}$ and $\overline{\Delta IPR}_T^{nc}$ are the sample averages of ΔIPR_{jT} over the part of the sample where $j=c$ and $j=nc$ respectively.

$\hat{\beta}^s$ can be obtained from equation (4) by differencing the variables along the colony dimension. This differencing eliminates $\tau_T^{s/n}$. The estimate is derived under the critical assumption that unobserved determinants of $\Delta X_{jT}^{s/n}$ are the same for Colonies and Non-colonies. In other words, after the changes in IPRs in Colonies and Non-colonies were taken into account, colonial status should have no impact on export growth in IPR-sensitive relative to IPR-insensitive industry group.

$\hat{\beta}^s$ is the Wald estimator obtained by using colonial status to instrument ΔIPR_{jT}. It is equivalent to an instrumental variable estimator, where the change in IPRs is instrumented by binary colonial status. I use the first-stage F statistic to test whether colonial status is a weak instrument. The F statistic equals 19.68 in the regression $\Delta IPR_{jT_1} = \alpha + \beta c + \varepsilon^{s/n}_{jT_1}$, where c is the dummy that equals one if $j = c$. The F statistic equals 13.26 in the regression $\Delta IPR_{jT_2} = \alpha + \beta nc + \varepsilon^{s/n}_{jT_1}$, where nc is the dummy that equals one if $j = nc$. Following Stock et al. (2002), I conclude that colonial status is a strong instrument.

In this paper, the estimation of the impact of strengthening IPRs on export growth consists of two steps. To begin with, I compute the difference in the mean growth rate of exports in IPR-sensitive relative to IPR-insensitive industry group in Colonies and Non-colonies. I use the simple difference in means test to obtain the next measure:

$$DD_T \equiv \begin{cases} \overline{\Delta X}^{s/n,c}_T - \overline{\Delta X}^{s/n,nc}_T & \text{for} \quad T = T_1, \\ \overline{\Delta X}^{s/n,nc}_T - \overline{\Delta X}^{s/n,c}_T & \text{for} \quad T = T_2; \end{cases} \tag{7}$$

The DD_T, which I refer to as the difference-in-difference measure, is the simple treatment versus control measure. For the pre-TRIPs period, Colony is the treatment group and Non-colony is the control group. For the post-TRIPs period, Non-colony is the treatment group and Colony is the control group.[12]

The sign of the DD_T measure I obtain for each period can be used to infer the direction of the impact of strengthening IPRs on exports growth from equations (5) and (6). It was already shown that during the pre-TRIPs period Colonies strengthened their IPRs more than Non-colonies and during the post-TRIPs period Non-colonies strengthened their IPRs relatively more. Therefore, $\overline{\Delta IPR}^c_{T_1} - \overline{\Delta IPR}^{nc}_{T_1} > 0$ and $\overline{\Delta IPR}^c_{T_2} - \overline{\Delta IPR}^{nc}_{T_2} < 0$. It follows from equations (5) and (6) that if the sign of the DD_T measure is positive in both the pre-TRIPs and the post-TRIPs periods, strengthening IPRs promotes export growth. In contrast, if this sign is negative in both periods, strengthening IPRs hampers export growth. Further, if this sign differs across the two periods, then the endogeneity of IPRs to trade is likely to bias the estimator for the earlier period and thus, only the

[12] Alternatively, DD_T can be obtained from dummy variable regressions: $DD_1 = \beta_1$ in the regression $\Delta X^{s/n}_{jT} = \alpha + \beta_1 c + \varepsilon^{s/n}_{jT}$ and $DD_2 = \beta_2$ in the regression $\Delta X^{s/n}_{jT} = \alpha + \beta_1 nc + \varepsilon^{s/n}_{jT}$.

DD_T measure for the later period is reliable.

I then compute β^s from equations (5) and (6). Unfortunately, the IPRs index is available only for five-year time periods. As a result, the changes in IPRs over the periods of 1962-1994 and 1994-2000 are unavailable. Therefore, to compute β^s, an additional assumption is needed. Specifically, I assume that all of the changes in IPRs in the 1990s were brought about by the TRIPs agreement. As such, the change in the export growth over the 1994-2000 period is related to the change in IPRs over the 1990-2000 period. In the same way, the change in the export growth over the 1962-1994 period is related to the change in IPRs over the 1960-1990 period. As a result, the computed β^s coefficients provide only a rough measure of the impact of strengthening IPRs.

V. Empirical Results

I analyze the growth rates of exports over two periods: before and after the TRIPs agreement was signed in 1994. For each of these periods, I perform the comparison of means analysis, where the average growth in exports in IPR-sensitive (relative to IPR-insensitive) industries in Colonies is compared with that of Non-colonies. I obtain DD_T measure defined in equation (7), and use its sign to infer the direction of the impact of strengthening IPRs on exports growth.

A. Stronger IPRs and Growth in Exports

Table 5 shows the results for the pre-TRIPs period. Column 1 shows the mean growth rates of exports in the IPR-sensitive industry group into Colonies (row 1), into Non-colonies (row 2), and across the two country groups (row 3). Column 2 shows the mean growth rates of exports in the IPR-insensitive industry group. The means across the two industry groups are compared in column 3.

Inspection of row 1 and 2 provides a comparison of the growth rates of exports in

Colonies and Non-colonies. It is apparent that exports into Colonies (the treatment group for this period) increased less than exports into Non-colonies (the comparison group) in both industry groups. In the IPR-sensitive industry group, the growth rate of exports into Colonies was .0167 points lower, and in the IPR-insensitive industry group, it was .0313 points lower. By itself this may suggest that strengthening IPRs has a negative impact on exports. But this across-country disparity in the average annual growth rates was smaller for the IPR-sensitive industries than for the others, implying in fact that there are industry specific effects. Across the two groups of industries, exports in IPR-sensitive industries increased more for Colonies but increased less for Non-colonies. Column 3 reports that the growth rate of exports in IPR-sensitive (relative to the IPR-insensitive) industries was equal to .0075 points in Colonies and -.0071 points in Non-colonies. As a result, the difference-in-difference measure for this period is positive and statistically different from zero. Table 5 reports that $DD_{T_1} = 0.0146$ log point changes, which is about 1.86% per year.[13] The null hypothesis of the equality of means is rejected at the 1% level of significance.[14]

Table 5: **Average annual growth in exports over 1962-1994**

Countries	$\overline{\Delta X}^{i,j}_{T_1}$		
	$i=s$	$i=n$	$i=s/n$
Colonies			
$j=c$	.0714	.0639	.0075
Non-colonies			
$j=nc$	.0881	.0952	-.0071
Difference			
$\overline{\Delta X}^{i,c}_{T_1} - \overline{\Delta X}^{i,nc}_{T_1}$	-.0167*	-.0313***	.0146***

Note: *** and * denote 1% and 10% significance levels. The data is in log point changes.

In summary, the comparison of the mean growth rates of exports into Colonies and Non-colonies for the pre-TRIPs period indicates that the DD_T measure is positive. This

[13] To convert DD_{T_1} from log point change into percent change the next formula should be used: $[\exp(DD_{T_1} \times 32) - 1]/32 \times 100$.

[14] $H_0 : DD = 0, H_1 : DD \neq 0; p - value = .002$. I use two-sample t test with unequal variances; under the two-sample t test with equal variances the results are the same.

implies that strengthening IPRs promotes exports. The analysis in Table 5 also points to the importance of using industry variation. If the growth rates of exports between Colonies and Non-colonies are compared at the individual industry level, the misleading conclusion that strengthening IPRs hampers exports is more likely to be reached.

To ensure that the sign of the DD_T measure for the pre-TRIPs period sign was not driven by the endogeneity problem, I perform the same analysis for the post-TRIPs period. The results are reported in Table 6.

Table 6: **Average annual growth in exports over 1994-2000**

Countries	$\overline{\Delta X}_{T_2}^{i,j}$		
	$i = s$	$i = n$	$i = s/n$
Non-colonies			
$j = nc$	-.0587	-.0640	.0053
Colonies			
$j = c$	.0039	.0424	-.0385
Difference			
$\overline{\Delta X}_{T_2}^{i,nc} - \overline{\Delta X}_{T_2}^{i,c}$	-.0626**	-.1064***	.0438*

Note: ***, **, and * denote 1%, 5%, and 10% significance level.

It is apparent that over this period, exports into Non-colonies (the treatment group) fell while exports into Colonies (the comparison group) grew in both industry groups. In IPR-sensitive industries, exports grew .0626 points less for Non-colonies than for Colonies. In IPR-insensitive industries, exports increased .1064 points less for Non-colonies than for Colonies. As before, this result suggests that strengthening IPRs has a negative impact on exports, and is similarly misleading. It is evident from column 3, where the growth rates of exports are differenced across the two industry groups, that exports in IPR-sensitive (relative to IPR-insensitive) industries increased in Non-colonies and fell in Colonies. The relative growth rates of exports were equal to .0053 in Non-colonies and -.0385 in Colonies. The difference-in-difference measure for this period is also positive and statistically different from zero. Table 6 reports that $DD_{T_2} = 0.0438$ log point changes, which is about 5.01% per year.[15] The null hypothesis of the equality of means is rejected

[15]To convert DD_{T_2} from log point change into percent change the next formula should be used:

at the 10% level of significance.[16]

Therefore, the findings suggest that the strengthening IPRs promoted developed countries' high-tech exports. This impact is stronger for IPR-sensitive industries as opposed to others. The direction of the impact is consistent across the two distinct periods. In addition, it is unaffected by the change of the treatment group (i.e. in the pre-TRIPs period, Colonies is the treatment group, but in the post-TRIPs period, Non-colonies is the treatment group).

B. Sensitivity Test 1: Industry Variation

In this section, I examine the sensitivity of the results to my classification of industries into IPR-sensitive and IPR-insensitive group. I redo the mean comparison analysis by dividing up the IPR-sensitive industry group. This analysis serves two purposes. First, it is used to confirm that the positive sign of the DD measure obtained in the previous section has not been unduly influenced by the grouping of industries adopted but holds at the industry level as well. Second, it is used to explore the statistical significance of the result. The industry-level results for the pre- and post-TRIPs periods are displayed in Table 7.

Table 7: **Growth in exports: Industry variation**

Industries	1962 − 1994		1994 − 2000	
	DD_{T_1}	st.er.	DD_{T_2}	st.er.
IPR-sensitive industry group	.0146***	.004	.0438*	.022
Medicinal and pharmaceutical products	.0276***	.007	.0679**	.032
Professional and scientific equipment	.0200***	.005	.0614**	.025
Other chemicals	.0160**	.007	.0432*	.025
(incl. medicinal and pharmaceutical products)				
Industrial chemicals	.0074	.006	.0701**	.032
Non-electrical machinery	.0157***	.004	.0315	.025

Note: Growth in exports relative to the IPR-insensitive industry group.
***, **, and * denote 1%, 5%, and 10% significance level.

$[\exp(DD_{T_2} \times 6) - 1]/6 \times 100$.

[16] $H_0 : DD = 0, H_1 : DD \neq 0; p - value = .056$.

In line with the previous findings, the DD measures are positive. They show that the impact of stronger IPRs on exports varies across industries. This industry variation is sensible and quite intuitive. Across the two periods, the strongest response was observed for medicinal and pharmaceutical products, for which the DD measures equal to .0276 for the pre-TRIPs period and .0679 for the post-TRIPs period. Professional and scientific equipment follows next, for which the respective measures are .0200 and .0614. The weakest response in the both periods was observed for non-electrical machinery, for which the respective measures are .0157 and .0315.[17] Most of the measures are statistically different from zero for both periods.

The difference in the results across the two periods may be due to two reasons. First, it may be due to endogeneity in IPRs for the earlier period, which results in overestimation of the impact of strengthening IPRs. In this case, the results for the later period are more reliable. However, it is also possible that the later period is not long enough for exports to adjust fully to strengthened IPRs. In this case, the impact is underestimated for the later period.

C. Sensitivity Test 2: Time Periods Aggregation Bias

To verify whether the results for the post-TRIPs period are sensitive to my choice of time intervals, I redo the analysis over three new intervals. I redefine the post-TRIPs period to be 1995-2000, 1996-2000, or 1997-2000. The results, displayed in Table 8, largely confirm the previous findings. Strengthening IPRs has a positive impact on exports.

Moreover, the results indicate that the magnitudes of the DD measure and their statistical significance increase as the growth rates of exports are differenced over the shorter periods of time. For IPR-sensitive industry group, for example, the DD measure increases from .0535 for the 1995-2000 period to .0692 for the 1996-2000 period and then, to .1074 for the 1997-2000 period. Its significance level, in turn, increases to 1%. This

[17] I also redo the mean comparison analysis by dividing up the IPR-insensitive industry group. These results are provided in Appendix D.

Table 8: **Growth in exports: Time variation**

Industries	1995 − 2000		1996 − 2000		1997 − 2000	
	DD_T	st.er.	DD_T	st.er.	DD_T	st.er.
IPR-sensitive industry group	.0535**	.025	.0692**	.026	.1074***	.036
Medicinal and pharmaceutical products	.0456	.034	.0906**	.039	.1950***	.056
Professional and scientific equipment	.0734**	.029	.0766**	.034	.1199***	.042
Other chemicals	.0210	.028	.0773**	.032	.1573***	.043
(incl. medicinal and pharmaceutical products)						
Industrial chemicals	.0809**	.039	.1340***	.044	.2098***	.060
Non-electrical machinery	.0626**	.027	.0534	.034	.0759**	.038

Note: Growth in exports relative to the IPR-insensitive industry group.
***, **, and * denote 1%, 5%, and 10% significance level.

finding may be due to a lag between the time when a change in IPRs occurs and the time when its trade impact is manifested. However, it may also be due to the problem of a positive autocorrelation in the error term. This auto-correlation (if combined with auto-correlation in the independent variable) causes under-statement of standard errors. As a result, the null hypothesis of no effect is rejected more often (Bertrand et al., 2001). In the presence of this problem, the differencing of the data over the longest periods possible is recommended.

VI. Economic Significance

In the previous section the mean growth rates of the value of exports in IPR-sensitive (relative to IPR-insensitive) industry group between Colonies and Non-colonies have been compared. In this section, I compute the elasticity of the value of exports in IPR-sensitive industries, β^s, from equations (5) and (6). Following that, I evaluate the economic significance of the results.

The computed coefficients β^s, as well as the economic significance of the impact of stronger IPRs, are summarized in Table 9. Consider the pre-TRIPs period first. Over the 1960-1990 period the average annual rate of increase in the IPRs index in Colonies was 0.45% higher than that in Non-colonies. As a result of this difference, exports in IPR-sensitive (relative to IPR-insensitive) industry group into Colonies were growing more than these exports into Non-colonies over the 1962-1994 period. The DD_{T_1} measure in section 5.1 indicates that the average annual increase in the value of exports in IPR-sensitive (relative to IPR-insensitive) industry group into Colonies was 1.86% higher than that into Non-colonies. As such, it can be computed from the equation (5) that $\beta^s = 4.1$. This implies that for each 1% increase in the IPRs index the value of developed countries' exports in IPR-sensitive industries increased by 4.1% per year during the pre-TRIPs period. With the total the value of exports in IPR-sensitive industries into Colonies of $7.8 billion (1994 US dollars) in 1962, 4.1% translates into over $320 million per year (1994 US dollars).

Table 9: **The impact of a 1% increase in the IPRs index**

Industries	β^s pre-TRIPs	β^s post-TRIPs	Additional exports into Colonies in 1962	Additional exports into Non-colonies in 1994
IPR-sensitive industry group	4.1	2.6	$323,017	$993,516
Medicinal and pharmaceutical products	9.9	4.4	$83,773	$66,408
Professional and scientific equipment	6.2	3.9	$28,243	$97,001
Other chemicals (incl. medicinal and pharmaceutical products)	4.7	2.6	$64,661	$83,808
Industrial chemicals	1.9	4.5	$29,490	$360,888
Non-electrical machinery	4.5	1.8	$159,761	$412,382

Note: Exports are in thousands of 1994 US dollars.

Now consider the post-TRIPs period. Over the 1990-2000 period the average annual rate of increase in IPRs in Non-colonies was 1.92% higher than in Colonies. In response, the average annual increase in the value of exports in IPR-sensitive (relative to IPR-insensitive) industry group into Non-colonies was 5.01% higher than that into Colonies. This implies that for each 1% increase in the IPRs index the value of developed countries' exports in IPR-sensitive industries increased by 2.6% per year during the post-TRIPs period, i.e. $\beta^s = 2.6$. With the total value of exports in IPR-sensitive industries into Non-colonies of $38 billion in 1994, 2.6% translates into about $1 billion per year (1994 US dollars). Non-colonies increased their IPRs by over 50% during the 1990s. This added about \$50 billion (1994 US dollars) to the annual value of IPR-sensitive exports into these developing countries. Given that over 65% of all exports in these industries into developing countries were directed into Non-colonies in 1994, it is clear why developed countries were pushing for strengthening IPRs in these regions.

For most of the industries, the β^s coefficients are higher in the pre-TRIPs period than in the post-TRIPS period. As is discussed earlier, because of potential endogeneity in IPRs, the impact of strengthening IPRs could be overestimated for the earlier period. It may also be true that because of the short time interval for the post-TRIPs period, the impact could be underestimated for the later period. Consequently, the estimates of the impact of strengthening IPRs provided in this paper should be interpreted with caution. Nonetheless, the β^s coefficients computed for the pre-TRIPs period and the post-TRIPs period provide reasonable upper and lower bounds, respectively, for the true measure of the impact of strengthening IPRs.

VII. Quantity vs. Price

The TRIPs agreement was largely opposed on the grounds that strengthening IPRs increases the price of high-tech products and hence, limits developing countries' access to new technologies. The potential effect of TRIPs on product prices has been specifically recognized as the most troubling effects of granting, strengthening, or extending intellectual property protection. The analysis employed in this paper has shown that the value of developed countries' exports in IPR-sensitive industries increased in response to a strengthening of IPRs in developing countries. It is unclear, however, whether the increase in the value of exports was driven by a quantity or a price increase. In this section, I examine how the price of high-tech exports into developing countries has been affected by their strengthening of IPRs.

It is important to note that, by differencing the export data along country and industry dimensions, we can be sure that the increase in the export value was not driven by a relative increase in the overall price index in treated countries, or a relative increase in the price of IPR-sensitive products. First, an increase in country's overall price index does not contribute to the difference in the value of exports across IPR-sensitive and IPR-insensitive industries. Second, a relative increase in the price of IPR-sensitive products does not contribute to the difference in the value of exports across Colonies and Non-colonies. It is possible, however, that the value of high-tech exports into the treated countries has risen because of an increase in prices which is specific to high-tech industries in these countries.

As before, the NBER-UN world trade data is employed for the analysis. I keep the data disaggregated and organized by the 4-digit Standard International Trade Classification. Price (or unit value) is computed for each developing country from the data on value and quantity of developed countries' aggregate exports. Prices are measured in nominal US dollars. Unfortunately, the data on quantity are not complete, and hence I examine prices for the post-TRIPs 1994-2000 period only.

The change in price is computed for each 4-digit commodity as the difference in the log of price over the 1994-2000 period. I classify 4-digit commodities into corresponding industries. Industrial chemicals, for example, is composed of 43 commodities, which are the varieties of dyeing, tanning and coloring materials, organic chemicals, inorganic chemicals, and fertilizers. For each industry, such as industrial chemicals, I compute an index of price changes over the 1994-2000 period. It is a weighted sum of changes in export prices across four-digit commodities within a given industry, calculated as follows:

$$\Delta P^i_{jt} = \sum_{k \in i} w^k_{jt} \Delta p^k_{jt},$$

$$\text{where} \qquad w^k_{jt} = p^k_{jt} q^k_{jt} / \sum_{k \in i} p^k_{jt} q^k_{jt} \qquad \text{and} \qquad \Delta p^k_{jt} = log(p^k_{jt,2000}) - log(p^k_{jt,1994})$$

where Δp^k_j is the change in the price of a commodity k exported to a country j over the

1994-2000 period. q_j^k is the quantity of exports of commodity k into a country j. The weight w_j^k is the share of a commodity k in the total value of exports in an industry i in the initial year, i.e. 1994.

The changes in these industry-specific export price indices are summarized in Table 10. Column 2 shows the mean value of the index for Non-colonies, i.e. $\sum_{j \in nc} \Delta P_j^i / N$, where N is the number of Non-colonies. Similarly, column 3 shows the mean value of the index for Colonies.[18] The difference in means across the two country groups is displayed in column 4. It is apparent that the index of export price changes differs across the two groups of countries. This difference depends on industry. For professional and scientific equipment and non-metallic mineral products, the change in the price index is on average lower for Non-colonies than for Colonies. For the other industries, the index is on average higher for Non-colonies than for Colonies. The difference in means is significantly different from zero for other chemicals and electrical machinery.

Table 10: **The index of price changes**

	obs.	Non-colonies	Colonies	Difference	st.er.
IPR-sensitive industries					
Medicinal and pharmaceutical products	64	-.214	-.268	.054	.13
Professional and scientific equipment	60	-.069	-.044	-.025	.17
Other chemicals	63	-.026	-.228	.202*	.11
Industrial chemicals	59	.049	-.115	.164	.11
Non-electrical machinery	64	-.150	-.209	.060	.08
IPR-insensitive industries					
Non-ferrous metals	49	.062	-.086	.148	.19
Non-metallic mineral products	57	-.272	-.103	-.169	.15
Electrical machinery	64	.033	-.290	.323**	.13

Note: ***, **, and * denote 1%, 5%, and 10% significance level.

To ensure that the results in Table 10 are influenced by price changes specific to Non-colonies (as opposed to Colonies), I now compare the changes in prices across industries with different sensitivity to IPRs. This comparison is performed by measuring the index of price changes for each IPR-sensitive industry relative to the index of price changes

[18]The negative sign of the index implies prices have on average fallen over the 1994-2000 period. This may be a result of an appreciation in the US dollar over this period.

in the group of IPR-insensitive industries. The following formula is used $\Delta P_j^i/\Delta P_j^n = \sum_{k\in i} w_j^k \Delta p_j^k/\Delta P_j^n$, where ΔP_j^n is the IPR-insensitive index of price changes constructed for each developing country as follows:

$$\Delta P_j^n = \sum_{k\in n} w_j^k \Delta p_j^k, \qquad \text{where} \qquad w_j^k = p_j^k q_j^k / \sum_{k\in n} p_j^k q_j^k,$$

that is, ΔP_j^n is a weighted sum of changes in export prices across four-digit commodities in the IPR-insensitive industry group. The weights are given by commodities' shares in the total value of exports in IPR-insensitive industries in 1994.

The difference in the relative price changes across Non-colonies and Colonies is shown in Table 11. For all IPR-sensitive industries, except for other chemicals, the difference in means is negative. For all IPR-sensitive industries, the difference is not significantly different from zero. As such, the data suggest that the relative changes in the price of IPR-sensitive products do not differ significantly across the two country groups during the 1994-2000 period.

Table 11: **The index of price changes relative to the IPR-insensitive price index**

IPR-sensitive industries	obs.	Difference	st. er.
Medicinal and pharmaceutical products	64	-.165	.19
Professional and scientific equipment	60	-.193	.17
Other chemicals	63	.003	.15
Industrial chemicals	59	-.063	.14
Non-electrical machinery	64	-.159	.14

The data show that the price of products in IPR-sensitive industries (relative to that in IPR-insensitive industries) did not increase in Non-colonies (the treatment group) relative to Colonies (the comparison group) in response to strengthening IPRs. This suggests that the earlier finding that stronger IPRs increase the value of exports into developing countries was driven by a quantity, rather than a price, increase. This seems to indicate that strengthening IPRs does not limit developing countries' access to innovative products and technologies by leading to higher prices.

VIII. Conclusion

This paper is a contribution to a long standing and still active debate over trade related aspects of intellectual property rights. For over twenty years economists have been debating the likely consequences of strengthening protection in the developing world. While the large and still growing theoretical literature has been useful in identifying a series of links between stronger IPR protection and trade flows, there are few general results. This is not surprising since the relevant theory requires models of imperfect competition and at least temporary monopolistic power arising from IPRs. Theory is further complicated by investments in R&D, a consideration of long run growth, and the possibility of active efforts at imitation.

The existing empirical evidence linking IPRs and trade is also fragmentary. The results range from a finding of no impact of IPRs on trade flows to both significant negative and positive effects. While some variance in results is expected from studies that consider different time periods, employ different methods, and consider different industry aggregates, this literature has also struggled with the econometric issues of endogeneity, measurement error and unobserved heterogeneity across both countries and industries. This paper combines and extends the methods employed in the existing empirical literature in an attempt to address these issues. It examines only one important aspect of the TRIPs debate - the link between IPR protection and exports into the developing world - by employing a difference-in-difference estimation that links stronger IPRs in developing countries to the differential growth in high-tech exports from the developed world.

The results are striking. For both the 1960-1994 and 1994-2000 periods, the results show a strengthening of IPRs in developing countries raised the value of developed countries' exports in IPR-sensitive industries. This effect is the strongest for industries that rely heavily on patent protection, such as medicinal and pharmaceutical products and professional and scientific equipment. The results are consistent across the two distinct periods, and robust to two sensitivity tests altering the industry group and time period definitions. Further, the data for the 1994-2000 period suggest that stronger IPRs increased the value of exports into developing countries by increasing the quantity, rather than the price, of exports. This seems to indicate that strengthening IPRs does not limit developing countries' access to innovative products and technologies by leading to higher prices. Using my empirical results and assuming that a change in IPRs should have no effect on exports in IPR-insensitive industries, I calculate that for each 1% increase in the IPRs index in developing countries, the value of developed countries' IPR-sensitive exports into an "average" non-colony increased by 2.6% during the 1990s. This amounts to approximately $1 billion per year (1994 US dollars). Therefore, these empirical results support the view that IPRs are indeed trade relevant. Changes in IPR protection have real, measurable and economically significant effects on trade flows.

A. Country Groups

Developed countries	Countries formerly colonized by Britain or France	Countries not colonized by Britain or France
Australia	Algeria (1962)	Angola
Austria	Bangladesh (1947)	Bolivia
Belgium	Benin (1960)	Burundi
Canada	Botswana (1966)	Colombia
Denmark	Burkina Faso (1960)	Congo Dem Republic (Zaire)
Finland	Burma (Union of Myanmar) (1948)	Costa Rica
France	Cameroon (1960)	Ecuador
Germany	Central African Republic (1960)	El Salvador
Greece	Chad (1960)	Ethiopia
Iceland	Congo Republic (1960)	Guatemala
Ireland	Dominican Republic (1844)	Honduras
Italy	Egypt (1922)	Indonesia
Japan	Fiji (1970)	Iran
Luxemburg	Ghana (1957)	Liberia
Netherlands	Grenada (1974)	Mozambique
New Zealand	Guyana (1966)	Nepal
Norway	Haiti (1804)	Nicaragua
Portugal	India (1947)	Panama
Spain	Iraq (1932)	Papua New Guinea
Sweden	Ivory Coast (1960)	Paraguay
Switzerland	Jamaica (1962)	Peru
Turkey	Jordan (1946)	Philippines
UK	Kenya (1963)	Rwanda
USA	Madagascar (1960)	Thailand
	Malawi (1964)	Venezuela
	Mali (1960)	
	Mauritania (1960)	
	Morocco (1956)	
	Niger (1960)	
	Nigeria (1960)	
	Pakistan (1947)	
	Senegal (1960)	
	Sierra Leone (1961)	
	Somalia (1960)	
	Sri Lanka (1948)	
	Sudan (1956)	
	Swaziland (1968)	
	Syria (1946)	
	Tanzania (1964)	
	Togo (1965)	
	Tunisia (1956)	
	Uganda (1962)	
	Zambia (1964)	
	Zimbabwe (1980)	

Note: In brackets is the year of independence from Britain or France.

B. IPRs Index: Descriptive Statistics

	1960	1965	1970	1975	1980	1985	1990	1995	2000
Developed countries (24 observations)									
Mean	2.60	2.77	2.90	2.91	3.25	3.30	3.38	3.75	4.01
Std. Deviation	0.49	0.53	0.53	0.54	0.69	0.74	0.77	0.78	0.64
Min	1.65	1.65	1.80	1.80	1.80	1.80	1.80	1.80	2.71
Max	3.86	3.86	3.86	3.86	4.24	4.52	4.52	4.86	5.00
Developing countries formerly colonized by Britain or France (44 observations)									
Mean	1.99	2.09	2.14	2.15	2.26	2.32	2.33	2.43	2.84
Std. Deviation	0.64	0.64	0.66	0.65	0.68	0.71	0.72	0.73	0.75
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.71
Developing countries not colonized by Britain or France (25 observations)									
Mean	1.73	1.75	1.65	1.67	1.69	1.70	1.70	2.22	2.57
Std. Deviation	0.88	0.91	0.94	0.96	0.98	1.00	1.00	0.96	0.90
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	3.19	3.19	3.19	3.19	3.32	3.32	3.32	3.86	4.00

C. Patent Effectiveness

ISIC code Rev.3	Manufacturing Industries	Effectiveness
3311	Medical Equipment	54.7
2423	Drugs	50.2
2920	Special Purpose Machinery	48.8
3430	Autoparts	44.4
3010	Computers	41.0
2429	Miscellaneous Chemicals	39.7
2800	Fabricated Metal Products	39.4
3410	Car and Truck	38.9
2411	Basic Chemicals	38.9
2910	General Purpose Machinery	38.8
3230	TV and Radio	38.8
2400	Chemicals and Chemical Products	37.5
2100	Paper and Paper Products	36.9
2922	Machine Tools	36.0
3100	Electrical Machinery and Apparatus	34.6
2320	Petroleum	33.3
2413	Plastic Resins	33.0
3530	Aerospace	32.9
2500	Rubber and Plastics Products	32.7
2610	Glass	30.8
2695	Concrete, Cement, Lime	30.0
3314	Search and Navigational Equipment	28.7
3211	Semiconductors and Related Equipment	26.7
3312	Precision Instruments	25.9
3220	Communications Equipment	25.7
3110	Motor and Generator	25.2
2710	Steel	22.0
3210	Electronic Components	21.4
2600	Non-metallic Mineral Products	21.1
1700	Textiles	20.0
2700	Basic Metals	20.0
1500	Food Products	18.3
2200	Publishing, Printing and Reproduction of Recorded Media	12.1

Note: Effectiveness: Average percentage of product innovations for which patents are effective. Source: Cohen et al. (2000). The codes 3220, 3110, and 3210 in ISIC Rev.3 correspond to the codes 3831 and 3832 in ISIC Rev.2. Therefore, Communications Equipment, Motor and Generator, and Electronic Components are subdivisions of Electric Machinery.

D. Sensitivity Analysis to Industry Classification

Growth rates of exports	1962 – 1994		1994 – 2000	
	DD_T	st.er.	DD_T	st.er.
Relative to non-ferrous metals				
IPR-sensitive industry group	.0113*	.006	.0311	.026
Medicinal and pharmaceutical products	.0249***	.009	.0461	.031
Professional and scientific equipment	.0165**	.007	.0559*	.032
Other chemicals	.0126	.008	.0231	.030
(incl. medicinal and pharmaceutical products)				
Industrial chemicals	.0023	.006	.0471	.031
Non-electrical machinery	.0123*	.007	.0240	.029
Relative to non-metallic mineral products				
IPR-sensitive industry group	.0104	.006	-.0110	.034
Medicinal and pharmaceutical products	.0233***	.008	.0131	.034
Professional and scientific equipment	.0158**	.006	.0065	.039
Other chemicals	.0118*	.007	-.0117	.027
(incl. medicinal and pharmaceutical products)				
Industrial chemicals	.0031	.007	.0153	.041
Non-electrical machinery	.0144	.007	-.0233	.039
Relative to electric machinery				
IPR-sensitive industry group	.0141**	.005	.0419*	.025
Medicinal and pharmaceutical products	.0277***	.008	.0524	.034
Professional and scientific equipment	.0193***	.006	.0674***	.024
Other chemicals	.0154**	.008	.0302	.030
(incl. medicinal and pharmaceutical products)				
Industrial chemicals	.0051	.007	.0579*	.034
Non-electrical machinery	.0151***	.005	.0411	.026

Note: $*$, $**$, and $***$ denote 1%, 5%, and 10% significance level.

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