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INTELLECTUAL PROPERTY PROTECTION AND THE GEOGRAPHY OF TRADE*

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This paper investigates how the implementation of intellectual property rights in developing countries under the 1995 TRIPS agreement affected trade in knowledge-intensive goods. We compare trade in knowledge-intensive goods with trade in other types of goods for 158 members and observers of the World Trade Organization from 1993–2009. Trade in knowledge-intensive goods increased relative to a control group after TRIPS implementation. The increase in imports by developing countries was driven by exchange with high-income countries and was concentrated in the information and communications technology sector. Our findings suggest that the effect of TRIPS on promoting knowledge diffusion from high-income to developing countries varies by sector.

I. INTRODUCTION

The international framework of legal institutions for intellectual property (IP) protection changed significantly with the establishment of the World Trade Organization (WTO) in 1995. The primary purpose of the WTO is to facilitate international trade. Signed on April 15th, 1994, the agreement to form the WTO included an important provision called Annex

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1C, which obligated member countries—including developing and least-developed countries—to implement IP protection for knowledge-intensive products such as biopharmaceuticals, computers, and telecommunications equipment under a policy that has become known as 'TRIPS' (trade-related aspects of intellectual property rights). Many of the developing and least-developed countries did not have a history of strong IP protection when they joined the WTO, and were thus obligated to strengthen their IP laws. This requirement was controversial because of the potential costs to poor countries,[1] but rationalized as follows:[2]

> 'The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations.'

We study the relationship between trade in knowledge-intensive products and IP protection to assess whether one of the objectives of TRIPS was fulfilled. Prior studies of TRIPS have reported different findings regarding the effects of the policy on trade. Ivus [2010] finds evidence of increased growth in exports of high-tech products from advanced economics into those developing countries that had previously been colonies of the exporters; Maskus and Penubarti [1995] and Rafiquzzaman [2002] have similar conclusions.[3] However, a number of other papers find on average either a negative or insignificant relationship between IP protection and trade (Fink and Primo Braga [1999], Smith [1999], Co [2004]).

We use a differences-in-differences approach that compares trade in knowledge-intensive goods with trade in a control group to evaluate the impact of TRIPS. We examine whether developing countries increased their trade in knowledge-intensive goods following TRIPS implementation. Based on previous findings that relate trade to knowledge flows (e.g., MacGarvie [2006]), we interpret increased trade in these knowledge-intensive products as evidence of knowledge diffusion and focus on how the

[1] Poor countries and others were concerned that the dynamic benefits of patent protection (i.e., to stimulate innovations) would not outweigh the static costs, which include the high prices that could arise from the monopoly rights of patent holders (Taylor [1993, 1994], Kumar [2003]).

[2] Part 1, Article 7 of Annex 1C of the Marrakesh Agreement to establish the World Trade Organization, available at *http://www.wto.org/english/docs_e/legal_e/27-trips_03_e.htm* (accessed April 25, 2013).

[3] Maskus and Penubarti [1995] find a significant increase in manufacturing exports from OECD into developing countries. Rafiquzzaman [2002] finds greater Canadian exports into countries with stronger patent protection, but this effect is smaller for low-income countries.

value of exports and imports of these products changed relative to other sectors that rely less on IP (such as consumer goods with low IP intensity, which we refer to as the 'control group'), though we cannot directly assess whether technology transfer has occurred. We are especially interested in the influence of TRIPS on the transfer of knowledge from rich to poor countries, and thus we consider a third difference: that between country income levels. We employ two specifications, one using multilateral trade between a country and the world, and the other using aggregate trade flows (i.e., aggregate imports from high-income innovative countries received by developing countries).

The data are drawn from the United Nations Commodity Trade Statistics database (UN Comtrade) as screened and developed by the International Cluster Competitiveness Project (ICCP) at the Institute for Strategy and Competitiveness at Harvard University. Our dataset covers imports and exports between 158 countries from 1993 to 2009. We use several approaches to define when particular countries became TRIPS compliant, including the WTO's original compliance schedule, the Ginarte-Park Index of Patent Rights, updated by Park [2008], and a more recent IPR index by Hamdan-Livramento [2009]. A question arises regarding the endogeneity of the adoption of IPR's. The TRIPS agreement provides a natural experiment of sorts, because most developing countries were reluctant to make this policy change: it was not an endogenous response to domestic innovation or other activity. WTO rules were applied uniformly across countries within certain categories, and countries were limited in their ability to change the deadlines for the implementation of IPR's and their enforcement. In our empirical analysis, we observed no pre-TRIPS patterns suggesting a serious endogeneity issue. In addition, our differences-in-differences approach allows us to address unobserved country-level changes that might also drive the adoption of IPR's.

We find several interesting patterns in multilateral trade. TRIPS implementation is associated with an increase in trade in high-IP product groups, compared to the control group of products that are not IP-intensive. We find differences between imports and exports, between country income groups, and between IP-intensive sectors. The analysis suggests that TRIPS implementation positively influenced the exports of high-IP products (those with high-patent, high-trademark or high-copyright intensity) relative to the control group for both developing and high-income countries. This increase in exports is largely explained by biopharmaceutical and information and communications technology (ICT) products. Imports were also affected by TRIPS, but the effect differed across country income levels. High-income countries significantly increased their biopharmaceutical imports after becoming TRIPS compliant. In contrast, the main increase in imports in developing countries is for ICT.

The trade flow analysis suggests that developing countries that implemented TRIPS experienced a significant increase in their high-IP products imports from high-income innovative countries relative to the control group. Importantly, we find that TRIPS implementation in developing countries is associated with a significantly higher increase in ICT than in biopharmaceutical imports. This finding is consistent with the fact that TRIPS-required protection of biopharmaceutical products was subject to more exceptions (especially for less advanced countries) than that of ICT products.[4] We also find that lower middle and low-income countries increased their high-IP products imports, in particular their ICT imports. This suggests that technology-rich products may be reaching poorer countries, although more research is required to assess whether the increase in dollar value of imports arises from price increases or from quantity increases.

The rest of the paper proceeds as follows. We first provide a summary of the TRIPS agreement and details on its implementation. Section .III explains the main hypotheses for the relationship between IP protection and changes in trade by sector and country-type. Section IV discusses the empirical approach. Section V explains the data, and we discuss the results in Section VI. We conclude in Section VII.

II. TRIPS: BACKGROUND

The TRIPS Agreement requires WTO member states to protect and enforce intellectual property rights with the stated goal of promoting innovation and transferring and disseminating technology. The agreement covers multiple aspects of IP protection: patents, copyrights, trademarks, industrial designs, topographic layouts of integrated circuits, trade secrets, and geographical indications. The most economically significant aspect of the policy was the phased implementation, initially scheduled to end by 2005, of patent protection lasting at least 20 years in all WTO member states. While TRIPS potentially applies to any product or service whose value depends on invention or design, two product categories that were especially affected were biopharmaceuticals and ICT.

In 1994, when the WTO was formed with TRIPS as a condition of membership, few developing and least-developed countries had implemented the same legal and enforcement protections for intellectual property as developed countries. Historically, some countries have used IP laws as a tool of protectionism, and one reason for the inclusion of IP require-

[4] These exceptions, which were negotiated during the 2002 Doha Round to assure access by developing countries to essential drugs during health emergencies, allow developing countries to issue compulsory licenses to domestic pharmaceutical manufacturers for essential medicines, later expanded to include manufacturers located in other countries.

ments in the WTO was to remove a potential barrier to trade. However, the optimal level of IP protection is likely to vary with a country's level of development. Many developing countries resisted the adoption of IP protection, fearing that the monopoly power granted by IP rights would reduce access to knowledge-based products and particularly to critical pharmaceuticals. For example, India did not grant pharmaceutical product patents prior to 2005, and many firms there specialize in the production of generic (unpatented) drugs. Membership in the WTO and integration into global trade provided an incentive for these countries to accept TRIPS. A difference between the adoption of IP required by TRIPS and the voluntary adoption of IP observed beforehand is that it is less likely to raise concerns about the endogeneity of IP policy and the innovative capacity of domestic firms. We also address the possibility of pre-TRIPS trends in the production of knowledge-intensive goods in our empirical analysis.

However, developing and least-developed countries did negotiate for some important exceptions. Countries that joined the WTO at the time of its formation were provided with a transition period for implementation of intellectual property laws and enforcement mechanisms.[5] Advanced countries were given one year (until January 1, 1996) to ensure that their laws and practices conformed to TRIPS requirements, although many already had such systems in place. Countries that declared themselves to be 'developing' upon joining the WTO were given an extension of five years (until January 1, 2000) to comply with TRIPS. Sixty-nine nations, including some high-income countries such as Israel and Korea, designated themselves as developing (see Table A1a).[6]

Subsequently, the WTO granted additional extensions. Developing countries that did not provide product patent protection in a particular area of technology by January, 2000, were granted up to five more years to comply, to January, 2005. However, pharmaceutical and agricultural chemical products that were sold during the transition period could enjoy exclusive marketing rights for five years (or until a product patent was granted).[7] Finally, least-developed countries (as defined by the UN) had until January, 2006, to implement TRIPS. The transition period was extended to 2016 for pharmaceutical patents (and undisclosed information, including trade secrets) during the 2002 Doha round negotiations, and extended to 2013 for all other categories. These compliance requirements

[5] See Data Section. Detailed information on TRIPS obligations and the transition periods can be accessed at *http://www.wto.org/english/theWTO_e/whatis_e/tif_e/agrm7_e.htm.*

[6] The list of 'developing' countries can be accessed at *www.wto.org/english/tratop_e/trips_e/intel8_e.htm.*

[7] For pharmaceutical and agricultural chemical products, countries had to accept the filing of patent applications from January, 1995, though they were not required to grant the patents until the end of the transition period (see *http://www.wto.org/english/theWTO_e/whatis_e/tif_e/agrm7_e.htm*).

mean that countries implemented TRIPS in different years, a feature that improves our identification by creating variation across years and country.

III. HYPOTHESES

If innovators are better able to appropriate the value of their ideas in the presence of IP protection, then they should be more willing to sell their products in countries that are TRIPS compliant than in countries that do not offer IP protection. Of course, the profitability of these markets for innovators depends not only on the ability of consumers to pay, but also on complementary products, services and infrastructure: for example, new computers depend on reliable power sources and are more valuable in areas with broadband access, while the distribution of new pharmaceuticals may depend on local clinics, medical personnel, pharmacies, diagnostic devices, delivery systems and insurance. Although the effect of TRIPS may be limited by the absence of complementary products and services in poorer countries, we nonetheless expect the implementation of TRIPS to have a positive effect on imports of knowledge-intensive products by developing countries, and particularly imports from high income countries.

We assume that trade in such goods is associated with the gradual transfer of the underlying knowledge between the trading countries. Several researchers have established the relationship between the transfer of knowledge into a country and trade using microeconomic data. MacGarvie [2006] investigated a group of French firms in knowledge-intensive industries and found that cross-border patent citations were greater among importers as compared to non-importers. Branstetter [2006] similarly noted the importance of exporter direct investments for knowledge spillovers, and thereby isolated knowledge flows as an important facet of exportation that could explain the superior survival rates of exporters over non-exporters in a group of Japanese firms that invested in the United States. This research complemented prior findings reported by Bernard and Jensen [1999] and Hallward-Driemeier *et al.* [2002] associating trade with productivity and knowledge flows. Subsequent researchers have focused on China to reaffirm the importance of learning through trade (Bloom *et al.* [2009], Park *et al.* [2010]). Researchers studying trade flows within specific industries or countries have tied trade flows to knowledge diffusion (Padoan [1998]; Keller [2002a, 2002b]; Eaton *et al.* [2004]).

A large body of literature associates corporate innovation with trade and documents various mechanisms of knowledge transfer, including the importation and exportation of knowledge-based products (Grossman and Helpman [1991, 1994]; Eaton and Kortum [1996, 2002]; Bretschger [1997]; Keller [1998, 2002a, 2002b]; Branstetter [2001]; Saggi [2002]; Furman *et al.* [2002]). TRIPS can also influence investment and production in knowledge-intensive products through foreign direct investment, and thus compound the knowledge transfer that occurs through trade (Branstetter [2006]). In particular, the implementation of patent protections may induce the *location or relocation of manufacturing activities* of knowledge-intensive products to TRIPS-compliant developing countries by patent holders. While we lack the data to examine relocation decisions directly, we can test for this possibility indirectly by investigating whether there is an increase in multilateral *exports* from developing countries after TRIPS implementation. We are particularly interested in whether exports of developing countries were greater in the biopharmaceutical and ICT sectors as compared to the control sector after TRIPS implementation.

While IP may facilitate the transfer of knowledge and the development of markets for ideas, patents by design are legal monopolies of fixed duration. The purpose of these monopolies is to provide risk-taking innovators with incentives to invent through high *ex-post* profits that are usually driven by high prices. Higher prices may lead to lower quantities sold as compared to what would occur if patent protection did not exist. The lower quantity sold under IP protection as compared to what would be obtained under the competitive process can be interpreted as reducing access to new technologies, particularly by the poor. Our data are not ideal for assessing whether an increase in the value of trade is driven by increased prices or increased quantities, and this remains an important question for future research.

The changes in trade flows that took place with the implementation of TRIPS may have occurred gradually for several reasons. First, enforcement mechanisms may have been slow to develop, and thus patent protection may have become effective only after some time. Second, several years may have been required for the establishment of complementary products and services (such as the provision of electricity for ICT and the availability of fully-staffed clinics, pharmacies and insurance for biopharmaceuticals). As these complementary products and services developed, the markets for IP-protected, knowledge-intensive imports would have emerged over time. Finally, exporters may have required time to learn about the potential for export into foreign countries. Our analysis examines these post-TRIPS dynamics by using a measure of a country's accumulated years of TRIPS implementation.

Our expectations about the effect of TRIPS on trade in biopharmaceuticals in particular are moderated because of specific exceptions to the policy to ensure that countries with health emergencies would have access to essential medicines. For example, TRIPS weakened biopharmaceutical protection by allowing 'compulsory licenses' in countries with public health emergencies. Because most countries have few local pharmaceutical firms that could serve as licensees, the WTO in the 2002 Doha Round implemented an additional exception for parallel importing of essential medicines manufactured abroad. The Canadian generic firm Apotex is able to export an AIDS treatment to developing countries using a compulsory license under this exception, and South Africa has exercised the option of parallel importation of HIV/AIDS treatments from generic manufacturers in India. While rarely used in practice, the use of compulsory licensing, or the threat to do so, could still have important consequences for firm behavior. For example, Abbott Laboratories threatened to withdraw all of its products from Thailand after the Thai government issued several compulsory licenses on Abbott drugs. In response to the threat of compulsory licensing, pharmaceutical firms may have preemptively licensed their products voluntarily or have reduced the prices of their products. Either action would likely reduce the value of exports from the high-income countries, where most pharmaceutical firms are based, to developing countries.

Another reason that the impact of TRIPS on trade in biopharmaceutical products may be observed only with a lag is that TRIPS compliance does not involve retroactive patents. Products first patented elsewhere prior to a country's TRIPS compliance would not generally qualify for patent rights following compliance. Since development times in biopharmaceuticals are 5–10 years on average, this means that the set of biopharmaceutical products in our dataset with TRIPS-compliant patents in developing countries is very small. In contrast, products with shorter lifecycles, such as electronics other ICT, have more recent patents and related IP. Thus, we expect that TRIPS may have a smaller effect on biopharmaceutical trade than on trade in ICT and other IP-intensive sectors, and particularly for developing country biopharmaceutical imports from high-income countries.[8]

To summarize, we examine the following. First, to assess whether TRIPS is associated with the relocation of manufacturing of knowledge-intensive goods to developing countries, we test whether there is a larger change in multilateral exports of such goods from TRIPS-compliant developing countries relative to a control group of products. Second, to assess whether TRIPS is associated with knowledge transfer, we examine whether the value of knowledge-intensive imports, multilateral and particularly imports from high-income countries, increased following the implementation of TRIPS in developing countries. We also focus on differences between particular IP-intensive sectors in the magnitude and direction of changes.

IV. EMPIRICAL APPROACH

This paper examines trade between 1993 and 2009 for 158 WTO member and observer countries that vary by income levels and in the timing of

[8] Many countries that did not grant pharmaceutical product patents prior to TRIPS did permit process patents, so we would not necessarily expect TRIPS to have much an effect on generic competition through a change in process patent law. If these process patents provided sufficient protection from generic competition, then the effect of additional product patent protection may not be significant.

TRIPS compliance. We consider country trade in various groups of high-IP products and a control group of low-IP intensive products, which we detail in the following section. We are interested in how the effect of TRIPS implementation varies by product group ('sector') and country income group (high-income and developing) over time.

IV(i). *Multilateral Trade*

We first examine multilateral trade, and compare a country's *total* exports (or imports) in high-IP sectors to a control sector. We estimate the following equation using OLS, pooling all the sectors:

$$\begin{aligned} \ln(\text{Trade})_{ist} = {} & \alpha_0 + \gamma_1 \text{Post-TRIPS}_{it} + \gamma_2 \text{HIC*High-IP*Post-TRIPS}_{it} \\ & + \gamma_3 \text{DC*Post-TRIPS}_{it} + \gamma_4 \text{DC*High-IP*Post-TRIPS}_{it} \\ & + \beta_1 \ln(\text{GDP}_{it}) + \beta_2 \text{High-IP*}\ln(\text{GDP}_{it}) + \alpha_{gst} + \varepsilon_{ist} \end{aligned} \tag{1}$$

where *i* indexes country, *s* indexes sector (Control and High-IP),[9] *t* indexes year (1993–2009), and *g* indexes country income group (high-income, developing, or least-developed). The dependent variable, ln(Trade), is the natural log of the total dollar value of sector exports (or imports) by country *i* in year t to all countries; Post-TRIPS is a dummy variable indicating whether country *i* has implemented TRIPS in year *t* (i.e., this dummy is equal to one the year the country implements TRIPS and all the subsequent years); HIC and DC are dummies for high-income and developing countries, respectively; the natural log of real GDP is included as a control for market size (whose coefficient vary by sector); and α_{gst} are income group-sector-year (triplet) fixed effects.[10] Since sector trade is correlated within a country over time, we cluster the standard errors by country.[11]

Equation 1 allows the coefficient on Post-TRIPS to vary by sector and by high-income and developing country, but not by least-developed countries since these countries are never TRIPS compliant during our time period.[12] We are especially interested in the effect of TRIPS on the trade by developing countries. For example, if TRIPS removed the fear of having technology appropriated by imitators in poorer countries, we would expect an

[9] In Equation 1, there are two mutually exclusive sectors. In other specifications, there are seven mutually exclusive sectors: the control group and six high-IP clusters. Further details are provided in the data section.

[10] That is, we include a total of 102 dummies (2 sectors by 17 years by 3 income groups) that control for income-group-sector specific trends in trade.

[11] In the sensitivity analysis, we include country fixed effects to further control for country-level factors that could influence the implementation of TRIPS and trade (e.g., institutions, colonial past, and ability to imitate), though these may absorb relevant post-TRIPS variation. Our findings are robust to the inclusion of the country fixed effects.

[12] The omitted category of country income group-sector dummy is High-Income-Control.

increase in high-IP imports in developing countries after the implementation of TRIPS, relative to imports of the control sector ($\gamma_4 > \gamma_3$). We can also test whether the effect of TRIPS on trade in high-IP goods is higher for developing countries than high-income countries (in absolute terms ($\gamma_4 > \gamma_2$) or relative to the control sector (γ_4-$\gamma_3 > \gamma_2$)). In the case of high-IP imports, the TRIPS effect may be limited by the absence of complementary products and services and the lower ability of consumers to pay in developing countries. The expected effect of TRIPS on high-IP imports would then be lower for developing countries. In contrast, if production of high-IP goods was mainly relocated to TRIPS-compliant developing countries, the increase in multilateral exports could be higher for these countries. Finally, an additional comparison is the effect of TRIPS on the trade of the control sector (low-IP goods). We do not expect TRIPS to increase the trade of the control sector in high-income (γ_1) or developing countries ($\gamma_1 + \gamma_3$).

IV(ii). *Trade Flows: Total Imports Received by Developing Countries from High-Income Countries*

The multilateral analysis discussed above allows us to test whether TRIPS-compliant developing countries increased their *total* imports of knowledge-intensive products. To assess the progress toward the goal of dissemination of technology from richer to poorer countries, we also examine changes in imports received by TRIPS-compliant developing countries from high-income countries.

We specify trade openness models to evaluate whether developing countries receive more imports of knowledge-intensive products from high-income innovative countries after the implementation of TRIPS. We examine aggregate imports received from 20 high-income countries with the highest number of 1993 USPTO patents.[13] One important advantage of examining aggregate imports from high-income countries (as opposed to analyzing bilateral imports) is that we do not have to deal with a large number of country-pair observations with no trade. A potential limitation is that we cannot examine country-pair attributes that facilitate trade in knowledge-intensive products (such as colonial ties, distance, free trade agreements, etc.), although we do not expect the influence of these factors to change with TRIPS implementation.

To test for differences in the response by sector to TRIPS implementation, we estimate the following equation using OLS estimation and the sample of 80 developing countries:

[13] A similar approach is used in Ivus [2010], which examines the growth rate in total imports received from high-income countries by a subset of developing countries in response to increased IPR protection.

$$\ln(\text{Imports})_{ist} = \alpha_0 + \gamma_1\text{Post-TRIPS}_{it} + \gamma_2\text{High-IP*Post-TRIPS}_{it} + \beta_1 \ln(\text{GDP}_{it}) + \beta_2\text{High-IP*}\ln(\text{GDP}_{it}) + \alpha_{st} + \varepsilon_{ist} \quad (2)$$

where the dependent variable is the natural log of the aggregate value of sector imports from high-income innovative countries received by developing country *i* in year t; α_{st} are sector-year fixed effects; and the rest of explanatory variables are the same as in equation 1. As before, we cluster the standard errors in equation 2 by country. This model tests whether developing countries that implemented TRIPS experienced a significant increase in their imports of high-IP products relative to the control group ($\gamma_2 > \gamma_1$).

We supplement this analysis by examining differences between two types of developing countries: upper-middle income countries ('DC-high') and lower-middle and low-income countries ('DC-low'). To test whether the effect of TRIPS implementation on trade flows varies by developing-country income group and sector, we estimate the following equation using OLS:

$$\begin{aligned}\ln(\text{Imports})_{ist} = {} & \alpha_0 + \gamma_1\text{Post-TRIPS}_{it} \\ & + \gamma_2\text{DC-high*High-IP*Post-TRIPS}_{it} \\ & + \gamma_3\text{DC-low*Post-TRIPS}_{it} \\ & + \gamma_4\text{DC-low*High-IP*Post-TRIPS}_{it} \\ & + \beta_1\ln(\text{GDP}_{it}) + \beta_2\text{High-IP*}\ln(\text{GDP}_{it}) + \alpha_{gst} + \varepsilon_{ist}\end{aligned} \quad (3)$$

The dependent variable is the same as in equation 2; *g* indexes developing country income group (DC-high and DC-low); α_{gst} are income group-sector-year fixed effects; and the rest of explanatory variables are the same as in equation 2.[14] Using equation (3), we test whether poorer developing countries that implemented TRIPS experienced a significant increase in their high-IP imports ($\gamma_4 > \gamma_3$).

V. DATA

The panel dataset for the analysis is based on the United Nations Commodity Trade Statistics database (UN Comtrade). This database provides the nominal value of country trade by product categories in U.S. currency. We convert the figures into 2005 dollars using the U.S. Price Deflator for Gross Domestic Product,[15] and we exclude the value of re-exports from the export figures.[16]

[14] In equation (3) the omitted country income group-sector dummy category is DC-high-Control.

[15] We use this aggregate deflator because no appropriate price deflators are available for our traded product groups.

[16] In the UN Comtrade database, trade that is imported and then re-exported from a country is generally identified separately and has been excluded. For example, steel imported to the U.S. only for transit to Canada is excluded.

For each country, we create two complementary datasets from the UN Comtrade data: one of exports and the other of imports, based on SITC Rev.3 definitions. In each dataset, we capture information on the trading partners for each country by product and by year. We use the reported imports to estimate exports and follow Feenstra *et al*. [2005] to reconcile the data if the reported exports from one country into another do not coincide with the imports reported by the receiving country.[17] The dataset includes only those countries that were members or observers of the WTO by 2009. The result is a country-level panel that describes the imports and exports between 158 countries from 1993 to 2009 (see Table A1a in the Appendix).[18] To study the changes in trade by country income level, we create three income groups. High-income countries are those currently classified as such by the World Bank. Least developed countries are those identified by the United Nations in 2009. We categorize the remaining countries as developing. In the sensitivity analysis, we consider finer distinctions between country income groups.

V(i). *Knowledge-Intensive Products*

Our analysis requires the definition of product sectors that vary in the relevance of IP. This section details the construction of these product sectors.

High-IP products. Ideally, we would group products according to the IP intensity of each product category in the Comtrade data. Unfortunately, measures of IP intensity are available only at the industry level, so we must link products to industries. We start with a list of industries with high IP-intensity described in a recent report by the Economics and Statistics Administration (ESA) and the USPTO.[19] This report provides a list of broad industries (4-digit NAICS code) with above average IP intensity in the U.S. (based on patents, trademark or copyrights). To define the high-IP group of traded products, we match the NAICS industries to the Comtrade product categories (Standard International Trade Classification, Revision 3 (SITC Rev. 3)). There is no direct bridge between NAICS codes and Comtrade SITC product codes. Instead, we build a somewhat noisy and indirect concordance from NAICS to ISIC to SITC. We primarily use the detailed NAICS industry definitions and SITC definitions to create the final match. Further details are provided in the Appendix.

[17] The export/import data are reported independently by administrations of two different countries and thus differences can arise from time lags, CIF imports versus FOB exports, and the inclusion or exclusion of goods for redirection to third countries.

[18] There are 155 countries for which we have data in all years. For a country-year that is not available in the data, we estimate both their exports and imports using other countries' reported imports from and exports into the country. We drop a few countries that never reported trade during the 1993–2009 period.

[19] ESA-USPTO Report, U.S. Department of Commerce, 2012.

The resulting high-IP group accounts for 45.6% of the dollar value of global imports of goods in 2009.[20] We also disaggregate the high-IP products into the overlapping subcategories of products with high-patent, high-trademark and high-copyright intensity products for our sensitivity analysis.[21] These forms of IP protection tend to be complementary (especially between trademark and patenting), as suggested by the significant overlap between high-patent and high-trademark intensive industries in the ESA-USPTO Report. In our data, the high-copyright group is very small since this form of protection is most prevalent in service industries, which are outside the scope of the Comtrade database.

High-IP clusters. The high-IP group is very broad and based on a somewhat coarse mapping. To enhance the analysis, we define particular subcategories of high-IP products (e.g., biopharmaceuticals or ICT), and examine the patterns of trade in these particular product groups. To define subsets of our high-IP product group, we use a clustering approach to create groups (called 'clusters') in such a way that objects in the same cluster are more similar to each other than to those in other groups. In our case, the objects are narrowly defined industries or traded products (NAICS or SITC). The cluster approach allows more refined mapping of related traded products into meaningful groups of high-IP intensity.[22]

We use two cluster databases: the *industry cluster* data from the U.S. Cluster Mapping Project (USCMP, Porter [2003]); and the *traded-products cluster* data from the International Cluster Competitiveness Project (ICCP).[23] Industry clusters are groups of industries related by knowledge, skills, inputs, demand and other linkages in a region (Porter [2003]). The main method in the USCMP of creating these groups is the correlation of employment between industries across regions within the U.S. For example, the computer hardware and software industries are in the same Information and Communication Technology cluster because employment in each industry is strongly co-located.[24] Similarly, the ICCP defines 36

[20] The ESA-USPTO Report classification of high-IP is based on aggregated industry codes that match many traded products, and some of these products may have low IP. To define a better high-IP group, we supplemented the analysis with a cluster database (explained below); and we exclude a small set of products that belong to clusters with very low-IP.

[21] High-Patent, High-Trademark and High-Copyright groups account for 37%, 35% and 0.4% of world good imports in 2009, respectively.

[22] A noisier alternative to defining particular groups would be to select aggregated NAICS codes with high-IP, and map them into broad SITC codes.

[23] Additional information on the USCMP and ICCP can be accessed at *http://www.clustermapping.us/* and at *http://data.isc.hbs.edu/iccp*, respectively.

[24] Delgado, Porter and Stern [2013] show that these cluster definitions capture many types of inter-industry linkages discussed in the economies of agglomeration literature, rather than focusing on any specific type. Other clustering and network studies at firm-level focus on specific linkages, such as the technology and market proximity (see e.g., Bloom *et al.*, [2012]). For this paper the goal is to capture meaningful groups of industries (and products) that are highly related among themselves in various dimensions (technology, skills, input-output).

clusters of related traded products (SITC Rev. 3) in countries, drawing on the methods described in Porter [2003].[25]

We use the USCMP to assess which clusters have high-patent intensity in the U.S. and then find the matching cluster in the ICCP database to define our high-IP clusters of traded products. The (mutually exclusive) clusters with the highest IP intensity are biopharmaceuticals, medical devices, analytical instruments, chemicals, ICT and production technology (PT).[26] The products in these clusters are a sub-set of the broad high-IP group.[27] Overall they account for 25% of world imports in 2009, with size varying by cluster: 1.8% in medical devices, 2.3% in analytical instruments, 3.5% in biopharmaceuticals, 3.7% in production technology, 4.2% in chemicals, and 10% in ICT. Further details are provided in the appendix.

Control Group: Non-IP-Intensive Products. Central to our analysis is a comparison of trade in IP-intensive products to those that rely less on IP and that should be less affected by TRIPS implementation, which we refer to as a control group. This provides a benchmark that captures how trade between countries changed independently of TRIPS. For example, imagine that trade between the U.S. and China increases both within high-IP and low-IP products due to other factors, such as changes in each country's business environment or relative wages. It would be reasonable to consider that an increase in high-IP trade would have occurred in parallel to low-IP trade even if TRIPS had not been implemented. We therefore focus on the difference in trade in the high-IP products with trade in the control group before and after TRIPS.

We define a control group of low-IP products using the cluster databases and the categorization of industries by IP intensity in the ESA-USPTO Report described above. First, we identify the set of clusters with the lowest IP intensity. While a cluster may have an overall low-IP intensity, it may include some high-IP products. To correct for this, we then exclude a few products in these clusters that have high-IP, based on our mapping of the ESA-USPTO Report. By construction, the product categories included in

[25] Correlation of exports of two products across countries is used as the main criterion to designate SITC product codes to meaningful clusters. The resulting clusters include products that share multiple types of linkages.

[26] The ESA-USPTO Report identifies as high-patent intensive, industries with five, or more patents per 1,000 workers per year. We then look for industry clusters that have a patent intensity above this value. We recognize that this measure is imperfect since some industries may have fewer but more valuable patents. ICT and analytical instruments have the highest patent intensity (with 22 and 19 patents per 1,000 workers, respectively) followed by biopharmaceuticals, medical devices and chemicals (each with around 11 patents per 1,000 workers). See Delgado *et al.* [2012].

[27] Within high-IP clusters, there may be some products with low IP-intensity. We correct this by dropping a few products that have low-IP based on the ESA-USPTO Report. The SITC's included in the final clusters are listed in the Appendix.

the control group have a significantly lower IP intensity than in the high-IP groups. The control group includes mainly consumable and unprocessed (semi-processed) products, and accounts for 34% of world good imports in 2009 (see Appendix).

To be a suitable control group for the effect of TRIPS, we must assume that TRIPS should have no effect on this group, and that differences between the control group and the high-IP groups are not varying over time. We test that the control group is not subject to positive Post-TRIPS trends in trade in Section 6.[28]

V(ii). *Measuring the Strength of Intellectual Property Protection*

The strength of IP protection at the country and sector level involves many related policies (e.g., patents, secrecy, trademarks and copyrights), and the most effective type of IP protection varies across industries (Cohen *et al.* [2000]; Bilir [2011]). Countries' patent laws may exclude some invention categories from patents, thus making the law subject to complex interpretations (Ginarte and Park [1997]). To test the effect of TRIPS implementation, we rely on several different indicators of IP protection to define a 'treatment' year for each country. Our core TRIPS-implementation variable is a dummy variable that is equal to one the year t a country is compliant and all the subsequent years (Post-TRIPS) and the number of years of TRIPS compliance as of year t (Post-TRIPS Years). The main criteria for computing these variables are the WTO transition periods for compliance described in Section II, supplemented by corrections based on the degree of implementation in patent protection as reported in Ginarte and Park [1997], Park [2008] and Hamdan-Livramento [2009]. Details on the classification criteria are provided in the Appendix (Table A1b).

The resulting Post-TRIPS variable has a mean of 0.45 across all countries during 1993–2009, with some countries never compliant (including the LDC's and 13 developing countries). The average value for Post-TRIPS Years is 5.3 for high-income countries and 2.6 for developing countries (See Table 1). Our two variables are highly correlated with the measures of patent enforcement and coverage provided by Ginarte and Park [1997] and Park [2008], but their measures are missing for 48 countries in our dataset and only vary at 5-years intervals. Thus, our analysis focuses on the Post-TRIPS and Post-TRIPS Years variables.

An obvious concern is that the adoption of IPR's is an endogenous policy choice by countries. As described above, policy changes due to TRIPS were not determined at the country level, but rather by an external body. The

[28] Trade in the control group could be correlated to TRIPS if (poorer) countries were able to negotiate lower tariff rates for their exports (e.g., for primary products) in exchange for better IP protection. We do not believe that this negotiation influences our results since we do not observe a significant Post-TRIPS effect for the control group.

Table 1
Descriptive Statistics

	All countries N=2656		High-Inc. N=770		Developing, DC N=1332	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Imports from High-Income Innovative countries into developing country i in year t (US$ 2005)						
Ln High-IP $imports_{it}$					20.894	2.044
Ln Bio $imports_{it}$					17.815	2.117
Ln ICT $imports_{it}$					18.873	2.166
Ln Control $imports_{it}$					1.903	1.828
Multilateral trade: $Exports_{it}$ to or $Imports_{it}$ from any other country (US$ 2005)						
Ln High-IP $exports_{it}$	20.154	3.241	22.974	2.558	19.950	2.604
Ln Bio $exports_{it}$	15.718	4.436	19.287	3.342	15.465	3.583
Ln ICT $exports_{it}$	17.429	3.782	20.723	3.116	17.024	3.159
Ln Control $exports_{it}$	21.553	2.380	23.049	1.888	21.615	2.118
Ln High-IP $imports_{it}$	21.608	3.345	23.516	1.980	21.445	1.936
Ln Bio $imports_{it}$	18.583	2.343	20.285	2.230	18.405	1.933
Ln ICT $imports_{it}$	19.566	2.604	21.732	2.233	19.326	2.178
Ln Control $imports_{it}$	21.446	2.142	23.083	1.875	21.304	1.785
Strength of IPR Protection Variables						
$Post\text{-}TRIPS_{it}$	0.448	0.497	0.738	0.440	0.466	0.499
Post-TRIPS $Years_{it}$	2.837	4.007	5.338	4.727	2.570	3.475
Ln GDP_{it} (bill US$, 2005)	2.957	2.332	4.676	2.099	2.776	2.048

Notes: Trade data is sourced from UN Comtrade database. Real GDP data is sourced from IMF. IPR protection variables are computed by the authors based on multiple sources (see Section 5).

changes in IPR due to TRIPS, in contrast to voluntary policy changes made prior to 1995 that have been studied in other academic work, may be less problematic from an econometric standpoint.[29] Our use of difference-in-difference analysis alleviates some concerns. However, we confirm that there were no trends in trade prior to TRIPS that would suggest a serious endogeneity problem, and verify that our control group is a valid one.

VI. EMPIRICAL RESULTS

The results of our analysis are presented in Tables 2 through 5. We first examine how multilateral trade—exports or imports—between a focal country and all other countries changed with the implementation of TRIPS in the focal country, and discuss whether these patterns are consistent with increased access to or production of knowledge-intensive products in TRIPS-compliant countries. We then study changes in imports received by developing countries from high-income innovative countries after TRIPS implementation.

[29] Authors of earlier work have taken different approaches. Branstetter *et al.* [2006] argue that the endogeneity of IPR's can be ignored for their empirical analysis. Others use an instrument such as colonial origin (e.g., Ivus [2010]) or create a matched sample of 'treated' and 'untreated' countries. We did not find the latter approaches to be useful in our context, so we emphasize the differences across sectors.

Table 2
Country Multilateral Trade and IPR Protection: High-IP Products
(OLS Estimates, N = 5,312)

	Exports to world		Imports from world	
	1	2	3	4
Post-TRIPS	–0.344*	–0.532*	–0.039	–0.007
	(0.139)	(0.262)	(0.088)	(0.129)
High-IP*Post-TRIPS	0.996**		0.172**	
	(0.275)		(0.058)	
HIC*High-IP*Post-TRIPS		0.967**		0.034
		(0.357)		(0.093)
DC*Post-TRIPS		0.265		–0.045
		(0.300)		(0.178)
DC*High-IP*Post-TRIPS		1.273**		0.184
		(0.384)		(0.160)
DC, Post-TRIPS:		8.08**		8.93**
High-IP vs. Control (F-test)		(0.005)		(0.003)
Ln(GDP)	0.926**	0.930**	0.828**	0.827**
	(0.038)	(0.037)	(0.017)	(0.018)
High-IP*Ln(GDP)	0.134*	0.134*	0.066**	0.069**
	(0.059)	(0.060)	(0.016)	(0.016)
R-squared	0.883	0.883	0.945	0.945

Notes: Y= Ln(country-year real dollar value of export/import in sectors). All specifications include intercept and income group-sector-year fixed effects. Standard errors in parentheses are clustered by country. In Models 1 and 3 the, omitted category of dummy variable is the Control sector. In Models 2 and 4, HIC and DC are dummies for High-Inc. and Developing countries; and the omitted category of Income group-Sector dummy is High-Income-Control sector. '*DC, Post-TRIPS: High-IP vs. Control*' reports the F-test of the difference in the estimated coefficients of *DC*High-IP*Post-TRIPS vs. DC*Post-TRIPS.*
**Significant at the 1% level, *significant at the 5% level.

VI(i). *Multilateral Trade: Evidence on Increase in Trade of Knowledge-Intensive Goods Post-TRIPS*

We expect an increase in the total trade (exports to and imports from the world) of high-IP products relative to the control group of low-IP products following TRIPS implementation. We expect no changes Post-TRIPS for the trade in the control group.

To validate our empirical approach, we first confirm that the control group is not subject to positive Post-TRIPS trends in trade, and that there is no pre-treatment trend in high-IP products as compared to the control group. This analysis is presented in Tables A2a and A2b. We estimate a modified version of equation 1 using pre- and post-TRIPS trend dummies.[30] The results confirm that there was no statistically significant pre-TRIPS or post-TRIPS effect for multilateral imports or exports of the control group. In addition, there was no positive pre-TRIPS trend (relative

[30] The TRIPS trends are estimated by including a series of dummy variables for years 1-to-3 after (before) TRIPS, years 4-to-6, years 7-to-9, and 10 or more years after (before) TRIPS; and the omitted variable is the year of TRIPS implementation. For example, *Post-TRIPS Years 1–3* variable is a dummy equal to 1 if a country has been compliant for 1 to 3 years as of year *t*. This analysis is implemented for countries that became TRIPS compliant during our sample period.

TABLE 3A
COUNTRY MULTILATERAL EXPORTS AND IPR PROTECTION: HIGH-IP SECTORS
(OLS ESTIMATES, N = 18,592)

	Exports to world in:						
	Control	Bio	Med	Analytical	Chem	ICT	Production Tech (PT)
Post-TRIPS	–0.532* (0.262)						
HIC*Sector*Post-TRIPS		1.726** (0.654)	1.985** (0.546)	1.326** (0.472)	0.437 (0.393)	1.561** (0.597)	2.047** (0.417)
DC*Post-TRIPS	0.265 (0.300)						
DC*Sector*Post-TRIPS		1.854** (0.490)	1.075 (0.549)	1.100* (0.422)	1.163** (0.401)	1.640** (0.492)	0.869* (0.426)
DC, Post-TRIPS: Sector vs. Control (F-test)		10.61** (0.001)	2.27 (0.134)	4.92* (0.028)	6.85** (0.010)	8.30** (0.005)	2.27 (0.134)
R-squared				0.844			

Notes: Y = Ln(country-year real dollar value of export in sectors). Specification includes intercept, Ln GDP (interacted by sector) and income group-sector-year fixed effects. The omitted category of Income group-Sector dummy is High-Income-Control sector. Standard errors in parentheses are clustered by country. *DC, Post-TRIPS: Sector vs. Control* reports the F-test of the difference in the estimated coefficients of *DC*Sector*Post-TRIPS vs. DC*Post-TRIPS.*
**Significant at the 1% level, *significant at the 5% level.

TABLE 3B
COUNTRY MULTILATERAL IMPORTS AND IPR PROTECTION: HIGH-IP SECTORS
(OLS ESTIMATES, N = 18,592)

	Imports from world in:						
	Control	Bio	Med	Analytical	Chem	ICT	PT
Post-TRIPS	–0.007 (0.129)						
HIC*Sector*Post-TRIPS		0.553* (0.276)	0.407** (0.150)	0.080 (0.179)	0.089 (0.084)	0.212 (0.203)	–0.184 (0.120)
DC*Post-TRIPS	–0.045 (0.179)						
DC*Sector*Post-TRIPS		0.154 (0.201)	0.187 (0.207)	0.155 (0.193)	0.215 (0.167)	0.485** (0.181)	–0.017 (0.199)
DC, Post-TRIPS: Sector vs. Control (F-test)		2.13 (0.147)	4.06* (0.046)	3.11 (0.080)	9.23** (0.003)	22.85** (0.000)	0.05 (0.825)
R-squared				0.938			

Notes: Y = Ln(country-year real dollar value of import in sectors). See notes in Table 3a.
**Significant at the 1% level, *significant at the 5% level.

to the control) in high-IP exports or imports (Table A2a), or in Bio and ICT exports or imports (Table A2b).[31]

[31] Similarly, there was no positive Pre-TRIPS trend (relative to the control) for the other high-IP clusters (medical devices, analytical instruments, chemicals or production technology). Results with individual year dummies are similar. We also conduct placebo tests for countries that never complied with TRIPS, and find no significant trend in their trade patterns before and after an artificial 'treatment' of TRIPS in 2000.

TABLE 4A
HIGH-IP IMPORTS BY DEVELOPING COUNTRIES FROM HIGH-INCOME INNOVATIVE COUNTRIES AND IPR PROTECTION (OLS ESTIMATES, DC COUNTRIES, N = 2,664)

	Imports from High-Inc. Innovative countries into DC:	
	1	2
Post-TRIPS	–0.033 (0.189)	
High-IP*Post-TRIPS	0.297* (0.113)	
Post-TRIPS Years		0.002 (0.030)
High-IP*Post-TRIPS Years		0.042* (0.018)
R-squared	0.869	0.869

Y = Ln(country-year real dollar value of sector imports from High-Inc. Innovative countries). Standard errors in parentheses are clustered by country. Specifications include intercept, Ln GDP (interacted by sector), and sector-year fixed effects. The omitted category of dummy variable is the Control sector.
**Significant at the 1% level, *significant at the 5% level.

TABLE 4B
HIGH-IP IMPORTS BY DEVELOPING COUNTRIES FROM HIGH-INCOME INNOVATIVE COUNTRIES AND IPR PROTECTION (OLS ESTIMATES, DC COUNTRIES, N = 2,664)

	Imports from High-Inc. Innovative countries into DC-high and DC-low	
	1	2
Post-TRIPS	–0.036 (0.230)	
DC-High*High-IP*Post-TRIPS	0.219 (0.175)	
DC-Low*Post-TRIPS	–0.012 (0.360)	
DC-Low*High-IP*Post-TRIPS	0.316 (0.310)	
DC-Low, Post-TRIPS: High-IP vs. Control (F-test)	4.850* (0.031)	
Post-TRIPS Years		0.008 (0.034)
DC-High*High-IP*Post-TRIPS Years		0.023 (0.026)
DC-Low*Post-TRIPS Years		–0.020 (0.059)
DC-Low*High-IP*Post-TRIPS Years		0.038 (0.049)
DC-Low, Post-TRIPS Years: High-IP vs. Control (F-test)		4.440* (0.038)
R-squared	0.872	0.872

Notes: See notes in Table 4a. Specifications include intercept, LnGDP (interacted by sector), and income group-sector-year fixed effects. The omitted dummy category is DC-high-Control sector. There are 39 DC-high and 41 DC-low countries.

Table 5a
High-IP Sector Imports by Developing Countries from High-Income Innovative Countries and IPR Protection (OLS Estimates, DC countries; N = 9,324)

	Imports from High-Inc. Innovative countries into DC-high and DC-low						
	Control	Bio	Med	Analytical	Chem	ICT	PT
Post-TRIPS	–0.033 (0.189)						
Sector*Post-TRIPS		0.186 (0.191)	0.243 (0.197)	0.312 (0.180)	0.334* (0.131)	0.626** (0.147)	0.139 (0.171)
R-squared				0.884			

Notes: The omitted dummy category is Control sector. Specification includes sector-year fixed effects. See Notes in Table 4.

Table 5b
High-IP Sector Imports by Developing Countries from High-Income Innovative Countries and IPR Protection (OLS Estimates, DC countries, N = 9,324)

	Imports from High-Inc. Innovative countries into DC-high and DC-low						
	Control	Bio	Med	Analytical	Chem	ICT	PT
Post-TRIPS	–0.036 (0.230)						
DC-High*Sector*Post-TRIPS		–0.131 (0.223)	–0.066 (0.160)	0.239 (0.222)	0.377 (0.231)	0.658** (0.237)	–0.030 (0.213)
DC-Low*Post-TRIPS	-0.012 (0.360)						
DC-Low*Sector*Post-TRIPS		0.435 (0.366)	0.426 (0.361)	0.280 (0.362)	0.276 (0.333)	0.535 (0.333)	0.249 (0.369)
DC-Low, Post-TRIPS: Sector vs. Control (F-test)		2.710 (0.104)	1.910 (0.171)	1.080 (0.301)	4.350* (0.040)	8.060** (0.006)	1.060 (0.306)
R-squared				0.889			

Notes: See notes at Table 5a. Model includes income group-sector-year fixed effects. DC-high-Control is the omitted dummy.

We next study the aggregate effect of TRIPS-implementation in multilateral trade using all countries. We examine first the overall post-TRIPS effect on trade in high-IP products by estimating equation 1. Our main specifications use the TRIPS implementation dummy (Post-TRIPS) as the main indicator of IP protection. Table 2 shows the estimated Post-TRIPS effect across all countries for High-IP exports (Model 1) and imports (Model 3), with the estimates of the Post-TRIPS effect by income group in Models 2 and 4.

We find that TRIPS implementation was associated with higher exports in high-IP products relative to the control. The *High-IP*Post-TRIPS* variable in Model 1 has a positive and significant coefficient of 0.996, meaning that the value of high-IP exports saw double the increase of the control group following TRIPS compliance. TRIPS implementation also increased imports in high-IP products relative to the control, but to a lower extent than exports, with a positive and significant coefficient of 0.172 in Model 3.

These findings are robust to the inclusion of country fixed effects, and to using a continuous variable for the number of elapsed post-TRIPS years (*Post-TRIPS Years*).[32] Thus, we find clear evidence that the implementation of TRIPS is tied to greater multilateral trade in high-IP goods.

Post-TRIPS Effects by Income Group and Sector. We next look for evidence that trade in knowledge-intensive goods has increased for developing countries after TRIPS implementation. To test this, we estimate equation 1, allowing for income group-sector differences in the post-TRIPS effect. Models 2 and 4 of Table 2 contain the results of this analysis for exports and imports of high-IP products, respectively. We then examine specific sectors, with results in Tables 3a and 3b.

We begin with a discussion of exporting patterns. The exports of high-IP products increased after TRIPS relative to the control group for high-income countries: *HIC*High-IP*Post-TRIPS* has a statistically significant coefficient of 0.967. Exports of high-IP products also increased for developing countries relative to the control as indicated by the positive and significant difference in the estimated coefficients of *DC*High-IP*Post-TRIPS* and *DC*Post-TRIPS* (the reported F-test of the difference is 8.08). There are no significant differences between the income groups in the effect of TRIPS on high-IP exports.

Table 3a contains results for exports of the high-IP clusters. Exports of biopharmaceuticals, analytical instruments and ICT increased significantly Post-TRIPS for both country income groups relative to the control group. There are also some significant differences across income groups. Exports of medical devices increased for high-income countries, but not for developing countries. Exports of chemicals increased for developing countries only.

The increase in exports in high-IP products and in biopharmaceuticals, analytical instruments, chemicals and ICT is consistent with the hypothesis that production of some high-IP goods has been relocated to TRIPS-compliant developing countries. Future work needs to bring hard evidence on the effect of TRIPS compliance on the inflow of FDI in high-IP sectors and the subsequent export behavior, and to examine how this relationship relates to the complexity of manufacturing and the importance of complementary infrastructure.

Imports of high-IP products were also affected by TRIPS, but the post-TRIPS changes vary across income groups. Results from Model 4 in Table 2 show that only developing countries increased their high-IP imports, both in absolute terms and relative to the control group. There is a positive and significant difference between the estimated coefficients of *DC*High-IP*Post-TRIPS* (0.184) and *DC*Post-TRIPS* (0.045). We also

[32] The same findings also hold for the imports and exports in the sub-categories of high-patent, high-trademark, and high-copyright relative to the control group (not reported).

find interesting differences in imports across high-IP clusters, as shown in Table 3b. In developing countries, TRIPS compliance is associated with an increase in ICT, chemicals and medical devices imports. This positive Post-TRIPS effect is significantly higher for ICT than for their imports of any other cluster (the estimated coefficient of *DC*ICT*Post-TRIPS* is 0.485). In contrast, the main increase in imports in high-income countries is for biopharmaceuticals.

These findings on the Post-TRIPS effects on multilateral trade by income group and sector are robust to including country fixed effects, and to using the number of years of TRIPS implementation (*Post-TRIPS Years*) as the measure if IPR protection. Results using only developing countries or excluding least-developed countries are qualitatively similar as well.

VI(ii). *The Effect of TRIPS on Developing Country Imports from High-Income Innovative Countries*

The multilateral analysis has shown that TRIPS-compliant developing countries' increased their *total* imports of high-IP products. We now examine whether their aggregate imports from high-income innovative countries also increased with TRIPS implementation. As noted earlier, we identify innovative high-income countries as those that were ranked in the top 20 by USPTO patents as of 1993. These countries are host to almost all multinational companies that generate patentable innovations, and so an increase in imports from these countries into TRIPS-compliant developing countries is evidence of progress toward the goal of dissemination of technology. As before, we first confirm that there are no pre- and post-TRIPS trends that would invalidate the analysis, and the results are contained in Table A3.[33]

Tables 4a and 5a present the results of estimating equation 2 using OLS. Table 4a shows that imports of high-IP products increased significantly with TRIPS implementation relative to the control group. *High-IP*Post-TRIPS* has a statistically significant coefficient of 0.297 in Model 1. The absolute effect of Post-TRIPS for high-IP products is also positive and significant, with an estimated effect of 0.264. The findings are robust to using the number of years of TRIPS implementation. *High-IP*Post-TRIPS Years* has an estimated coefficient of 0.042 in Model 2. We have the same findings when we examine the effect of TRIPS implementation in imports in the overlapping high-IP sub-categories of high-patent, high-trademark and high-copyright goods (not reported).

[33] This analysis estimates equation 2, using pre- and post-TRIPS dummies as in Table A2. Table A3a shows that there are no statistically significant pre-TRIPS or post-TRIPS effect for imports of the control group. In addition, there was no positive pre-TRIPS trend (relative to the control) in high-IP imports (Table A3a), or in Bio and ICT imports (Table A3b) or in any of the other high-IP clusters (not reported). Tables A2, A3 and A4 may be referenced on The Journal's website, or from the authors.

We then examine developing countries' imports of specific high-IP clusters in Table 5a. The effect of TRIPS implementation varies by product cluster. The largest positive and significant effect is for ICT imports, with an estimated *ICT**Post-TRIPS* coefficient of 0.626, followed by Chemicals (0.334). The other clusters have no significant post-TRIPS effects. In addition, the imports of ICT increased significantly more than the imports of biopharmaceutical products. These findings are consistent with those reported for multilateral imports above.

Differences Across Developing Country Groups. We are also interested in examining whether the effect of TRIPS implementation on trade flows varies with the income level of developing countries. We estimate equation 3, allowing for different TRIPS effects for DC-high (upper middle-income countries) versus DC-low (lower middle and low-income countries). Table 4b reports the results for all high-IP imports, and Table 5b for the specific high-IP clusters.

We find that DC-high countries did not experience a significant increase in high IP imports relative to the control after TRIPS implementation. In contrast, DC-low countries experienced a significant increase in imports of high IP products. The difference in the estimated coefficient of *DC-Low*High-IP*Post-TRIPS* and *DC-Low*Post-TRIPS* (Control) is positive and significant at the 5% level in Model 1 of Table 4b (the F-test is 4.85). The same findings hold when using *Post-TRIPS-Years* (Model 2). In additional analyses that are not included, we find DC-low countries also experienced an increase in high-patent and high-trademark imports. The effect, while positive, is insignificant for DC-high countries.

Table 5b reports the changes in imports for the specific high-IP clusters. Both types of developing countries realized an increase in ICT imports from high-income innovators after TRIPS implementation, in absolute terms and relative to the control;[34] imports of chemicals also increased for DC-low countries.

The inclusion of country fixed effects does not change the qualitative results reported in Tables 4 and 5. Overall these findings are encouraging evidence that technology-rich products may be reaching poorer countries—although more research is required to assess whether the increase in dollar value of imports arises from price increases, which could disadvantage the poor, or from quantity or quality increases, which could benefit the poor. The positive effect of TRIPS is greater for ICT and chemicals imports. The effect is smaller for biopharmaceuticals, as expected, due either to product life cycle differences or to TRIPS exceptions for pharmaceuticals.

[34] There are no significant differences between the developing income groups in the effect of TRIPS in ICT imports.

VII. DISCUSSION AND CONCLUSION

The TRIPS agreement, implemented in 1995 as a condition of WTO membership, had as one of its principal objectives the 'transfer and dissemination of technology' to enhance social welfare through the trade in knowledge-intensive goods. The results reported here identify a positive effect of TRIPS implementation on the dollar value of trade in IP-intensive products relative to a control group of non-IP-intensive products. This finding is consistent with Rose [2004, 2006], which shows a small effect of GATT/WTO membership on trade. The empirics also show that the effect of TRIPS varied across high-IP sectors. TRIPS implementation by developing countries was tied to greater increases in trade in high-IP products compared to the control group, but the most robust increase is for the ICT sector. These findings suggest that the effect of TRIPS on promoting knowledge diffusion from high-income to developing countries varies by sector.

A limitation of our analysis is that we cannot identify whether TRIPS led to increases in the quantity of product traded or in the prices of products. If the dollar value of trade between high-income and poorer countries increased only because IP-owners increased prices on their products, then it is not clear that TRIPS met its policy objective of transferring knowledge-intensive products from richer to poorer countries. Prior studies have provided evidence that the extension of patent protection may not benefit developing and least-developed countries (Deardorff [1992]; McCalman [2001, 2005]; Chaudhuri *et al.* [2006]). Since this issue is particularly salient in the case of pharmaceuticals, it is worth emphasizing one point. Only very recent pharmaceuticals have post-TRIPS patents in developing countries, since TRIPS did not require retroactive patents. That is, any product that was first patented in the U.S. in 1999 would never enjoy patent protection in developing countries that complied with TRIPS after 2000. The price effect of TRIPS in developing should only be evident for these very recent product introductions, since they are the only ones with TRIPS-compliant patents in developing countries. Therefore, the change in the value of traded biopharma goods that we observe probably reflects a change in quantity, rather than price. However, the price effect may well dominate going forward. For other sectors, particularly those with shorter product lifecycles (so that trade post-TRIPS involves trade in products with post-TRIPS patent, trademark or copyright dates), it is impossible to say with our analysis.

An area for future research is to examine the relationship between IP protection and the ability of developing countries to begin trading particular high-IP products, i.e. the extensive margin rather than the intensive margin that is our focus here. This new trade could then spur subsequent increases in trade in other related products. Understanding these dynamics will help develop better policies to improve the diffusion of technology from richer countries to poorer countries.

Our analysis does not address other possible changes related to TRIPS during this period. Intra-national manufacturing capacity and the interactions between trade and investment are not captured in the analysis because of data limitations. If leading producers of IP-intensive goods, headquartered principally in advanced countries, built manufacturing capacity in poorer countries, or if they transferred technology to locally headquartered firms in poorer countries, then the objectives of TRIPS for technology dissemination may have been met. To assess whether TRIPS has been effective at stimulating the dissemination of technology into developing and least-developed countries, much additional research is required. Future work might explore whether differences between high-IP sectors in exports and imports is related to the types of investments and trade, including the stage of the value chain, complexity of manufacturing or importance of complementary infrastructure. Unfortunately, our data does not allow us to explore such questions.

The response to TRIPS is still in its infancy, and the impact of new activity may not yet be evident in trade flows. Trade may not respond immediately if investment in distribution, logistics or retail outlets for IP-intensive products is required and occurs only gradually. In addition, since TRIPS does not require IP protection for previously existing products, we might only observe an impact on trade in relatively new products that qualified for TRIPS-compliant protections, a set that may still be a small share of total trade. The statistical analysis reported in this paper deals with trade flows only through 2009, and more time may be needed for the full effect of these agreements to be evident in trade flows.

The limitations in our data do not allow us to make a conclusive statement on whether TRIPS stimulated the transfer and dissemination of knowledge in a 'manner conducive to social and economic welfare' which was one of the primary goals of the policy. However, the estimated changes in trade patterns of high-IP goods in response to TRIPS are consistent with the promotion of technology transfer. Importantly, the analysis suggests that the effect of TRIPS varies by sector. In sectors such as ICT, TRIPS stimulated exports and imports of developing countries. However, in sectors such as biopharmaceuticals, which were subject to more exceptions (especially for less advanced countries) and which depend on the availability of complementary resources, TRIPS did not have as great an impact in increasing imports by poorer countries. Further research would be significantly enhanced by improved data that accounts for the specific natures of the technologies embedded in such goods as well as the detailed composition of the trade and of the complementary resources required to deliver trade in developing countries.

APPENDIX

Table A1a
List of Countries by Country-Type

High-Income (46 Countries)		*Developing (DC)*		*Least Developed (LDC)*
Top-20		Upper-middle Inc.	Lower-middle & low-Inc.	
Innovative**	Other High-Inc.	(DC-High, 39 countries)	(DC-Low, 41 countries)	(33 countries)
Australia	*Antigua and Barbuda*	Algeria	Albania	Bangladesh
Austria	Bahamas	*Argentina*	Armenia	Benin
Belgium	*Bahrain*	Belarus	Azerbaijan	Bhutan
Canada	*Barbados*	Bosnia Herzegovina	*Belize*	Burkina Faso
China, Hong Kong	*Brunei Darussalam*	*Botswana*	*Bolivia*	Burundi
Denmark	Croatia	*Brazil*	*Cameroon*	Cambodia
Finland	*Cyprus*	Bulgaria	*China*	Cape Verde
France	Czech Rep.	*Chile*	*Congo*	Central African Rep.
Germany	*Estonia*	*Colombia*	*Côte d'Ivoire*	Comoros
Israel	Greece	*Costa Rica*	Ecuador	Ethiopia
Italy	Hungary	*Dominica*	*Egypt*	Gambia
Japan	Iceland	*Dominican Rep.*	*El Salvador*	Guinea
Netherlands	Ireland	*Fiji*	*Ghana*	Lesotho
Rep. of Korea	*Kuwait*	*Gabon*	Georgia	Madagascar
Norway	Luxembourg	*Grenada*	*Guatemala*	Malawi
Spain	*Malta*	*Jamaica*	*Guyana*	Maldives
Sweden	New Zealand	Kazakhstan	*Honduras*	Mali
Switzerland	Oman	Latvia	*India*	Mauritania
United Kingdom	Portugal	Lebanon	*Indonesia*	Mozambique
USA	*Qatar*	Lithuania	Iran	Myanmar
	Saudi Arabia	*Malaysia*	Jordan	Nepal
	Singapore	*Mauritius*	*Kenya*	Niger
	Slovakia	*Mexico*	Kyrgyzstan	Rwanda
	Slovenia	*Namibia*	Mongolia	Samoa
	Trinidad and Tobago	Panama	*Morocco*	Sao Tome and Principe
	United Arab Emirates	*Peru*	*Nicaragua*	Senegal
		Poland	*Nigeria*	Sierra Leone
		Romania	*Pakistan*	Sudan
		Russian Federation	*Papua New Guinea*	Togo
		Saint Kitts and Nevis	*Paraguay*	Uganda
		Saint Lucia	*Philippines*	United Rep of Tanzania
		Saint Vincent and the Grenadines	Rep. of Moldova	Yemen
		Seychelles	*Sri Lanka*	
		South Africa	*Swaziland*	
		Suriname	Tajikistan	
		TFYR of Macedonia	*Thailand*	
		Turkey	Tonga	
		Uruguay	*Tunisia*	
		Venezuela	Ukraine	
			Viet Nam	
			Zimbabwe	

Notes: High-Income countries based on The World Bank classifications (*http://go.worldbank.org/D7SN0B8YU0*). Countries in *Italics* are countries self-designated as 'developing' when they joined WTO. The list of Least-developed countries can be accessed at http://www.un.org/special-rep/ohrlls/ldc/list.htm. Cape Verde and Maldives moved from LDC to developing in 2004 and 2007, respectively.
**Top-20 high-Income innovative countries in terms of USPTO patents as of 1993.

TABLE A1B
CLASSIFICATION CRITERIA FOR A COUNTRY'S TRIPS COMPLIANCE

1. *WTO member countries in 1995 not self-designated as developing:*
   The estimated compliance year is 1995 for most countries; and 1996 for Portugal, Iceland, Slovakia and the Czech Republic (based on Ginarte and Park [1997] and Park [2008]).
2. *WTO member countries* after *1995:*
   Their estimated compliance year is their membership date, in accordance with WTO rules.
3. *WTO member countries in 1995 that self-designated as developing:*
   The estimated year of compliance is 2000. There are some exceptions since TRIPS granted extensions for countries that did not provide product patent protection in a particular area of technology as of 2000 (see discussion in Section 2). We draw on Park [2008] and Hamdan-Livramento [2009] to identify countries that may be using these exceptions or are not compliant by their deadlines. Based on Hamdan-Livramento [2009], eleven countries achieved TRIPS compliance after 2000 (Brazil, Kenya and Uruguay are compliant in 2001; Mauritius in 2002; Ghana and Sri Lanka in 2003; Chile, India, Pakistan, and Paraguay in 2005; and Egypt in 2006). Using Park [2008] we identify three additional countries that did not have TRIPS compliance by 2005 (Nicaragua, Papua New Guinea, and Tunisia) and the Post-TRIPS variable is corrected accordingly.
4. *LDC countries:*
   They are classified as non-compliant for the entire period of analysis. Initially, LDC countries were required to comply by 2006. This deadline was extended to 2016 for biopharmaceutical products and 2013 for all others after the Doha declarations. Park [2008] and Hamdan-Livramento [2009] confirm that most of these countries either do not have patent laws or that their systems for patent enforcement are not in compliance with TRIPS

Notes: The main criteria are the WTO transition periods for compliance described in Section 2. Countries self-designated as 'developing' are listed in Table A1a. Ginarte and Park's [1997] Index of Patent Rights measures the strength of IP protection and enforcement in 121 countries at 5-year intervals updated through 2005 (Park, [2008]). We use two components of the index: the strength of enforcement of patent protection and the patent-coverage. Hamdan-Livramento [2009] investigates the TRIPS implementation of 53 countries based on various types of IP protection, and reports estimates of the date of compliance.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table A2a: Pre- and Post-TRIPS Trends in Multilateral Trade: High-IP Products Relative to Control (OLS Estimates, High-Income and developing countries, N=3,728)

Table A2b: Pre- and Post-TRIPS Trends in Multilateral Trade: Bio, ICT Relative to Control (OLS Estimates, High-Income and developing countries, N=5,592)

Table A3a: Pre- and Post-TRIPS Trends in Imports by Developing Countries from High-Income Innovative Countries: High-IP Products Relative to Control (OLS Estimates; DC countries; N=2,222)

Table A3b: Pre- and Post-TRIPS Trends in Imports by Developing Countries from High-Income Innovative Countries: Bio and ICT Relative to Control (OLS Estimates, DC countries, N=3333)

Table A4a: Definition of High-IP Group (SITC Rev. 3 Labels and Codes)

Table A4b: Definition of High-IP Clusters (SITC Rev. 3 Codes)

Table A4c: Definition of Control Group of Low-IP Products (SITC Rev. 3 Labels and Codes)