Intellectual Property-Related Preferential Trade Agreements and the Composition of Trade*

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Abstract

We study how preferential trade agreements (PTAs) with chapters covering intellectual property rights (IPRs) affect the trade of member countries, defining treatment PTAs as those in which one partner is the United States, the European Union, or the European Free Trade Association. While effects on total trade are relatively limited, we show that the inclusion in PTAs of IPRs chapters with elevated standards causes significant increases in bilateral exports of biopharmaceutical goods and other IP-sensitive sectors to markets outside the PTAs, while generally reducing trade in sectors less reliant on IP protection. These impacts suggest that "behind the border" regulations within PTAs do influence trade.

JEL codes: F14, F15, O34

Keywords: trade agreements, intellectual property rights, high-technology trade

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1 Introduction

The international framework for protecting intellectual property rights (IPRs) has evolved considerably in recent decades, with these changes amounting to the most dramatic globalization of exclusive ownership rights in knowledge goods in history (Maskus, 2012). A systematic negotiating effort, primarily led by the United States and the European Union (EU), has instituted significant changes in how developing and emerging countries regulate the rights to use industrial knowledge assets and creative works through IPRs, meaning patents, copyright and related rights, trademarks, and similar constructs. The basis of this campaign was the multilateral Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), a foundational component of the World Trade Organization (WTO). TRIPS requires WTO member countries to provide minimum standards of protection and coverage for comprehensive aspects of IPRs.

These WTO rules are just part of the story, however. In the period since TRIPS was ratified, the United States, the European Free Trade Association (EFTA), and the EU increasingly have demanded even stronger protection for IPRs in their bilateral and regional preferential trade agreements (PTAs).[1] For example, the United States has concluded PTAs with Jordan, Peru, Australia, South Korea, and other countries that feature elevated patent protection for pharmaceuticals and chemicals, stronger regulations governing copyrights in digital goods, and expanded penalties for trademark infringement. Thus, these agreements generally provide far-reaching and specific coverage requirements that were not considered at the WTO. The recently concluded 11-country Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) added further rules, including for the protection of trade secrets.[2] In 2014 The European Union and Canada ratified their bilateral Comprehensive Economic and Trade Agreement, which features an extensive chapter on intellectual property. All of this suggests that the role of PTAs in determining how the international intellectual property environment takes shape will expand even further.

The TRIPS Agreement has received considerable attention in the empirical literature regarding the effects of changes in international IPRs policy on such economic outcomes as trade, FDI, and knowledge transfer. Equally, PTAs have been widely studied for their impacts on trade patterns. The role of PTAs that feature strong IPRs rules has been largely neglected, however. These agreements, which have grown steadily in number since the mid-1990s, are an important means by which IPRs policy is set at the international level. In turn, they are a potentially significant determinant of trade and investment patterns, innovation activities, and other important economic outcomes. As such, they deserve systematic study, which we undertake in this paper. Specifically, we consider the impact of national membership in PTAs with substantive chapters governing IPRs regulation, where one partner is the US, the EU, or EFTA, on the value and composition of member countries' aggregate and bilateral trade, controlling for compliance with TRIPS standards.

As discussed in Section 3 below, the relationship between strengthened IPRs and the volume and composition of trade, both imports and exports, is ambiguous for numerous reasons. Put simply, rules governing IPRs are different from import barriers. A cut in a particular import tariff is effectively a reduction in trade costs, implying higher trade. Much the same may be said about across-the-board reductions in trade taxes, which expand trade overall even as there may be some unanticipated decreases in imports of some goods due to product-interaction effects. Tariff cuts generally expose domestic firms to competition, destroying market power. Intellectual property rights, however, create temporary monopolies in the use, including trade, of particular technologies and goods. The exclusive rights offered by patents, copyrights, and trademarks permit rights-holders to decide where, when, and how they will produce and sell protected products and license patented technologies and digital goods.

Because multiple and contradictory theoretical predictions about potential effects of IPRs on trade, foreign direct investment (FDI), licensing, and pricing are possible, the issue is ultimately empirical. In this context, numerous studies, beginning with Maskus and Penubarti (1995), have analyzed the impacts on either aggregate or broad sectoral imports, focusing mainly on simple cross-country and temporal variations in indexes of legal patent protection. While the results of early studies, using data prior to TRIPS, were mixed (Co, 2004; Smith, 2001), they found evidence that countries with stronger patent rights attracted increased imports of high-technology goods, especially in emerging countries with a notable ability to absorb and imitate international technologies. Using micro-level data on the affiliates of US multinational enterprises, Branstetter et al. (2011) detected significantly positive impacts of domestic patent reforms in several emerging economies on local R&D, employment, and exports at the extensive margin.

More recent papers have focused on the effects of TRIPS. Thus, Ivus (2010) found that one group of developing countries, which were obliged by the WTO agreement to adopt stronger patent reforms than a similar group, experienced significantly higher import growth in high-technology products. Using a more comprehensive sample, Delgado et al. (2013) studied the dates at which developing countries implemented the TRIPS patent rules and discovered a significant causal effect of reforms on imports of particular patent-intensive goods. Maskus and Yang (2018) found a significantly positive effect of patent reforms in the TRIPS era on the growth and composition of R&D-intensive sectoral exports in both emerging and developed economies. There was also evidence that this export expansion was associated with sectoral inflows of patent applications and intra-firm trade, which may have had spillover effects on the growth in productivity.

Thus, an evidentiary consensus is emerging around the proposition that strengthening IPRs, particularly as associated with the TRIPS Agreement, has the effect of increasing both imports and exports among developed and middle-income emerging economies, especially in high-technology and IPRs-sensitive goods. As noted above, however, this question has rarely been studied in the context of the additional strengthening of IPRs associated with high-protection preferential trade agreements. Indeed, it is possible that these estimated WTO impacts on trade are actually some combination of outcomes from both multilateral (TRIPS) and IP-related regional agreements. In this context, the United States, the EU, and EFTA expend considerable negotiating and political capital to convince their trading partners within PTAs to adopt so-called "TRIPS-Plus" standards for IPRs, arguing that doing so will expand innovation, trade, and inward flows of technology through FDI. Because these entities push far more than other nations for such rules, the IP-related agreements featuring one of them as a partner offer an important laboratory for studying their trade effects.

To date, the claim that TRIPS-Plus chapters stimulate trade is based solely on qualitative analysis and anecdotes, for there is little systematic evidence on this question. This is the empirical gap we hope to begin filling with this paper.[3] Specifically, we ask whether PTAs with chapters requiring IPRs standards that exceed TRIPS expectations have some additional impact on the trade of member countries, over and above that of TRIPS. We also ask whether these effects vary by countries broken down into income groups (development levels) and specific industries that are highly sensitive to intellectual property protection. Following Delgado et al. (2013), we pay particular attention to trade in pharmaceuticals, chemicals, and information and communication technologies, for these are the areas in which protective IPRs chapters set down particularly rigorous standards. Pharmaceuticals are particularly contentious in this context, given the potential for stronger patents to limit generic competition, thereby raising prices and limiting access to new drugs (Chaudhuri et al., 2006; Duggan et al., 2016). The latter effect might arise in part due to endogenous decisions of drug companies to limit exports to PTA partner markets.

Thus, our paper contributes to the empirical literature on how “behind the border” regulatory regimes may affect economic activity, including international trade. Until recently this literature has paid no attention to how PTAs that incorporate such regulations might augment or diminish trade. However, Falvey and Foster-McGregor (2017) recently found a non-monotonic relationship between the regulatory breadth (measured by an index of how many regulatory provisions are included) of a PTA and trade among member countries. PTAs with an intermediate number of provisions seem to expand within-agreement trade flows, while those with few or many rules have no effects on trade. They did not study IPRs specifically, however.

Our analysis also fits into the literature on the economic effects of PTAs, which certainly can differ from those of basic WTO membership. For example, Rose (2004) asked whether membership in the WTO actually increased a member’s trade, finding evidence that it did not and stimulating a literature contesting this result. Whether PTAs, such as NAFTA, actually increase or decrease trade, couched in terms of trade creation or trade diversion, has long been a subject of theoretical and empirical research (Bagwell and Staiger, 1997; Romalis, 2007; Baier and Bergstrand, 2007). More recent literature suggests that PTAs generally have positive trade effects, controlling for endogeneity of selection into agreements, but the impacts are strongly heterogeneous (Baier and Bergstrand, 2009; Baier et al., 2019).

Note that traditional studies of PTAs consider reductions in trade barriers between members to be the main policy impact of free trade agreements. These cuts are necessarily discriminatory in their treatment of members versus non-members. Thus, such studies naturally focus on bilateral or within-agreement trade effects, accounting also for trade diversion from outside. When considering IPRs, however, the logic is different in at least one critical way, arising from the inherent spillover effect created by national IPR regimes. Specifically, when a country strengthens its IPRs as a result of provisions in a PTA, by, for example, enhancing patent protection or bolstering its IPRs enforcement, it must extend this treatment to all WTO members. That is, it cannot discriminate in its treatment of rights-holders from PTA members versus others. Legally, this proscription comes from TRIPS, which demands of any WTO member that its IPRs regulations must be subject to the most-favored nation and national treatment principles. In practical terms, it makes little sense to discriminate across the origins of applications for intellectual property protection. Thus, in principle, rights-holders from countries not party to a PTA are affected legally under the same terms as their counterparts from member countries. This fact suggests that the effects of IPRs chapters in PTAs are spread beyond the agreements' members *de jure*, though it does not preclude the possibility of *de facto* discrimination, an item left for future research.

In this paper we study the effects of membership in IP-related PTAs, negotiated with strong demandeur countries, on trade in goods that intensively use intellectual property, accounting for levels of per-capita income. We estimate impacts on member nations' aggregate trade in IP-intensive sectors, using a difference-in-differences approach comparing treatment agreements with a control group. We then consider bilateral trade flows in these sectors in a gravity context. We adopt successively more rigorous specifications to deal with endogenous selection into such agreements. In general, we find that the trade effects are modest. However, there is robust evidence of a trade-expanding impact on specific IP-intensive sectors, such as pharmaceuticals, chemicals, and information technology products, particularly in higher-income emerging countries. Perhaps most strikingly, we find clear evidence that developing countries that join such agreements see significant reductions in their trade in goods that are not IP-intensive, relative to countries that do not join them. These findings imply that strong IP chapters exert a sorting effect, shifting trade from low-IP to high-IP industries.

The remainder of the paper is organized as follows. Section 2 provides historical background on the development of PTAs with strong intellectual-property chapters, which we call IP-related PTAs, and gives an overview of their scope and coverage. Section 3 briefly revisits the ambiguous theory surrounding intellectual-property protection and its effects on trade. Section 4 describes the empirical framework and provides estimates of the effects of IP-related PTAs on aggregate and bilateral imports and exports at the sectoral level. Section 5 discusses some implications of the results and presents concluding remarks.

2 Background

The nature and focus of PTAs have changed considerably in recent decades. Their traditional purview was almost exclusively to reduce barriers to trade and expand market access between member countries. This scope was broadened considerably in the mid–1990s, with the creation of the North American Free Trade Agreement (NAFTA) and the negotiation of multiple bilateral treaties between the European Free Trade Association and individual countries, such as Estonia, Latvia, and Mexico. One primary novelty of these trade agreements was to pay greater attention to IPRs. A decade later, the EU followed suit with its own "new trade policy," asking for stringent protection of patents, copyrights, geographical indications and other elements of IPRs in its proliferating PTAs with countries in Eastern Europe and the Middle East, and, more recently, the Caribbean, Latin America, Canada, and Japan.

NAFTA was the first multi-country, large-scale PTA that went far beyond tariff-cutting to set minimum standards, if not harmonization, in key regulatory areas, including nearly every aspect of IPRs. In the patents area NAFTA requires, among other things, minimum patent duration, confidentiality for pharmaceutical trial data, and extensions in patent length to compensate for administrative delays in granting protection. It also requires a minimum copyright length and stipulates what types of works must be protected, including with various neighboring rights. NAFTA calls for protection of geographical names through an effective equivalence with trademarks and collective marks, as well as automatic recognition of internationally well-known marks. The agreements made by the EU and EFTA have similar requirements, though they vary in certain areas of emphasis. These agreements, and those concluded by the United States, also require members to join various international treaties on IPRs.

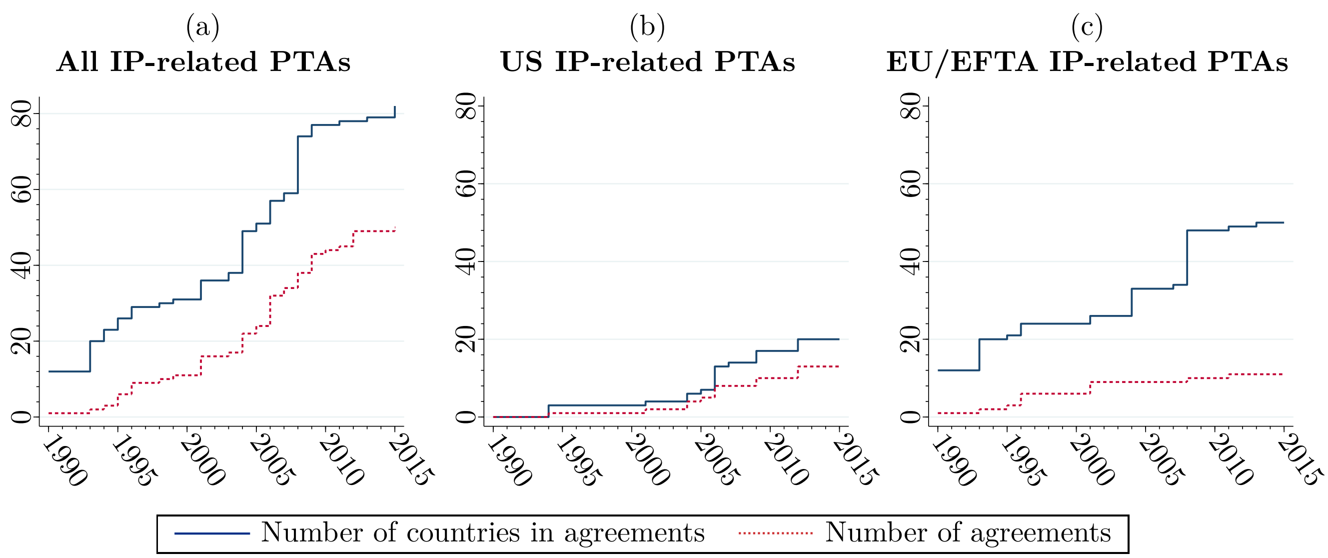
The evolution of PTAs beyond their traditional scope accelerated after 2000, with subsequent agreements reached by the United States or the EU including strong IPR provisions as a matter of negotiating priority. To be sure, other newly created trade agreements, which do not involve those countries or regions, have been reached by Mexico, Japan, Australia, South Korea, and Chile, among others. These PTAs also include chapters on IPRs, though generally with less rigorous standards in key areas. Figure 1a illustrates the persistent growth after 1993 in the number of PTAs that are "IP-related" according to the definition set out in Dür et al. (2014) and the corresponding expansion in membership. This definition simply requires the existence of an IPRs chapter, no matter how limited or comprehensive, to qualify. As of 2015, 50 such agreements were in place, with 82 different countries claiming membership in at least one of them. Figures 1b and 1c, in contrast, show the growth in IP-related PTAs involving the US, the EU, or EFTA. There were 24 such agreements by 2015, involving 70 countries.[4] Owing to the high degree of standards harmonization in IPRs, we classify the EU and EFTA themselves as being IP-related trade agreements in our sample.[5] As noted, these PTAs involve more extensive expectations about standards and enforcement. Thus, we focus our analysis on these PTAs, thinking of them as a policy treatment group with respect to potential trade impacts.

It is important to note that while many different trade agreements cover IPRs, they do not treat all elements of intellectual property in the same way, nor do they operate with the same degree of depth. In principle, countries joining PTAs make different decisions about IPRs and other policies based on their own political-economic interests. Japan and South Korea, for example, are concerned about extending patent rights, while Australia prefers weaker standards governing copyrights. Developing countries might be expected to place more importance on sustaining access to international technologies and information, including the rights to diffuse such knowledge widely through imitation or other means. In this context, it is perhaps surprising that these countries increasingly agree to strong IPRs chapters in PTAs, a point we exploit in our econometric analysis. The point here is that different countries likely negotiate agreements to emphasize particular aspects of IPRs.

For its part, the United States places great emphasis on assuring patent and copyright protection for its own nationals' inventions and creative works in foreign markets and negotiates its international agreements accordingly. The EU and EFTA do so as well but emphasize even more the protection of geographical indications, which protect the rights to use place names in wines, spirits, and other products. Figure 2 sheds light on specific provisions found in IP-related trade agreements reached by these entities, cumulated across them.[6] Nearly all of these PTAs specifically mention national treatment, or non-discrimination with respect to the treatment of the intellectual property of foreign nationals. American agreements require administrative extensions for delays in the patent approval process, linkage rules requiring that the originators of a product be notified when a potential producer of an identical generic product applies for marketing approval, and requirements for test data confidentiality for pharmaceuticals and chemicals. These are key components of the "TRIPS-Plus" requirements of IP-related PTAs. The EU and EFTA have begun to demand similar rules. To be sure, there are exceptions to strong patent scope. A small number of US-involved PTAs allow parties to exempt from patentability plants and animals, surgical or therapeutic procedures, or inventions that disrupt *ordre public*. The EU and EFTA agreements are relatively more lenient in this regard and also tend to exempt microorganisms from patent eligibility, reflecting their domestic legal systems.

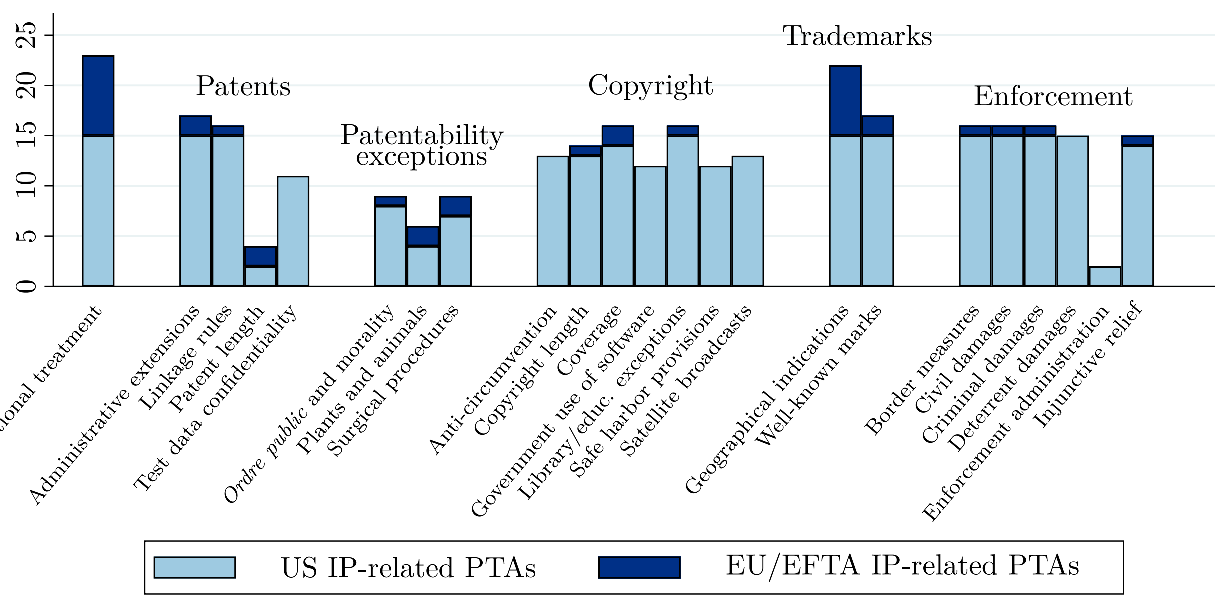
With regard to copyrights, the breadth of coverage varies considerably. Most agreements stipulate minimum durations for copyright (generally the author's lifetime plus 70 years, which is in excess of the TRIPS standard of life plus 50 years) and specify what types of works must be eligible for coverage. Inevitably, with the rise of the digital economy, rules preventing circumvention of digital rights management and ending government use of illegally-acquired software have become major concerns. In trademarks, the vast majority of these PTAs require the protection of geographical indications in some fashion, with the EU and EFTA being particularly strict in this area, and recognition of well-known marks. Finally, with regard to enforcement, US-brokered agreements require both criminal and civil penalties for infringement, special border customs measures for dealing with infringing material, injunctive relief, and establishment of within-PTA enforcement administrations or committees. Again, these provisions exceed TRIPS standards. Recent EU agreements have begun to take on similar provisions. All told, there is an increasingly broad scope of IP-related agreements covering a comprehensive range of often controversial issues. This trend suggests that both domestic and foreign rights-holders in countries that are party to US-, EU-, or EFTA-partnered PTAs operate under IPRs regimes that are notably more stringent than those of countries unconnected to such agreements.

Figure 1: Number of IP-related Trade Agreements and Number of Countries with Membership in One or More IP-related Trade Agreements by Year, 1990 to 2015



Source: Based on data from Dür et al. (2014)

Figure 2: Number of IP-related Trade Agreements by Presence of Specific Provisions



Source: Authors' construction, based on data from Dür et al. (2014)

3 Ambiguous Effects of IP Protection on Trade

Within this complex framework it is worth reconsidering how IPRs, which may seem only indirectly related to comparative advantage, might affect the volume and composition of countries' trade. Even at the simplest level the anticipated effects of IPRs policy revisions are theoretically ambiguous. As discussed by Maskus and Penubarti (1995), stronger domestic protection of intellectual property creates several cross-cutting effects. First, the market-expansion effect, associated with reducing imitative competition in local markets, would increase imports if foreign rights-holders can more easily safeguard their intellectual property. This should especially be the case in those sectors most reliant on IPRs. Second, the market-power effect from strengthened IPRs might lead to rights-holders engaging in monopolistic behavior, restricting sales (including imports from such firms) and raising prices in destination markets. Third, a cost-reduction effect could emerge as firms find it less necessary to disguise the technical aspects of their products or become more willing to ship advanced-technology inputs.

At the same time, the impacts of patent reforms could interact with international firms' choice of modes with which they serve foreign markets. Again, stronger patents, trade secrets and trademarks could lower the fixed costs of entering a market via local production, whether due to reduced legal costs or a more favorable bargaining position with local intermediate suppliers. This should raise the relative level of inward FDI and technology licensing in the market, perhaps at the expense of imports (Vishwasrao, 1994; Nicholson, 2007). Nonetheless, it is possible for both imports and inward FDI to increase as the destination country's market becomes more attractive due to stronger IPRs. Such trade-offs make it difficult to state confident hypotheses about how policy reforms could expand or contract trade and the mechanisms driving those disparate outcomes.

These scenarios refer to reasons why IPRs reforms in destination markets could alter the exports of goods from technology-leading nations to both similar countries and emerging economies. It is also possible for domestic policy changes to affect exports of local firms. On the one hand, the technology access implicit in greater imports can build domestic capacities through adoption, adaptation, and learning spillovers, eventually leading to technology-oriented exports (Branstetter and Saggi, 2011; He and Maskus, 2012). On the other hand, stronger IPRs potentially limit the ability of local firms to imitate and copy technologies, diminishing their possibilities for exporting domestic versions of advanced or even lower-technology goods. In another vein, stronger patent rights may either incentivize more innovation on the part of domestic firms or raise the costs of follow-on R&D. Available evidence is mixed on this point, though it suggests innovation in emerging countries may be enhanced subject to certain threshold effects in education and competition (Chen and Puttitanum, 2005; Qian, 2007).

Models focused on firm-level heterogeneity paint a more subtle picture. For example, as noted by Lai et al. (2019) strengthened patent rights should have several qualitative effects on behavior. Domestic firms in an environment of weaker IPRs tend to favor imitation of imported goods over formal licensing, permitting them to produce for the local market. However, with the implementation of stronger patents those firms observe a higher marginal cost of imitation, set against lower marginal costs of licensing, itself subject to a fixed entry cost. Under these circumstances, stronger IPRs, ceteris paribus, force less productive firms out of the market and reduce the productivity cut-offs for exporting and licensing for higher-productivity enterprises. This effect is accentuated under the reasonable assumption that stronger patents reduce the fixed costs of licensing from abroad. In turn, such effects could reduce both the variable and fixed costs of exporting to particular markets, with a potential increase in both the intensive and extensive margins of trade. Such logic offers a microeconomic foundation for the claim that patent reforms may be pro-export in high-technology sectors in emerging countries.

There remains the question of why PTAs with strong IPRs chapters may exert an additional influence, positive or negative, on the imports and exports of member nations relative to what could happen under unilateral patent reforms or TRIPS expectations. To some degree the answer is simply that such agreements increase IPRs protection above the global baseline of TRIPS and also impose stricter standards than might be adopted unilaterally by emerging countries. Thus, any primary trade effects could be magnified. Also important, however, are potential interactions of IPRs with the market-size impacts of PTAs. By establishing larger areas within which both trade is liberalized and key elements of intellectual property protection are enhanced, IP-related PTAs could have a dual impact on trade within the region. This effect should arise particularly in goods that intensively rely on various forms of IPRs, a hypothesis we test statistically and for which we find specific and robust evidence.

4 Empirical Framework and Estimation Results

Given the extensive changes in national IPRs policy wrought by bilateral and multilateral trade agreements, and the potential mechanisms outlined above through which such reforms could affect trade flows, our objective in the empirical analysis is to uncover what effects membership in IP-related trade agreements has had on countries' aggregate and bilateral imports and exports, including at the detailed sectoral level. Regarding aggregate trade, we adopt a treatment-control econometric framework, where we first compare separately countries' aggregate imports or exports across two sectors: an IP-intensive group of commodities (High-IP), and a group of products classified as less reliant on IPRs (Low-IP). Here, treatment countries are those that are in a US, EU, or EFTA IP-related PTA at any point during the sample, and control countries are all others. We take our definition of IP-intensive and less IP-intensive commodities from Delgado et al. (2013). They classify the traded commodity codes in the Standard International Trade Classification (SITC), Revision 3, into high-IP or low-IP sectoral classifications based on a similar categorization of the Standard Industrial Classification (SIC) codes in the Economics and Statistics Association of the US Patent and Trademark Office's 2012 report on intellectual property.[7] Finally, because the effects of changes in IPRs regimes might vary by countries' comparative development levels, we allow for any effect of membership in IP-related trade agreements to vary by discrete income groups.

As detailed in Section 2, IP-related PTAs cover multiple aspects of IPRs and vary in their specific regulatory provisions. Therefore, to add depth to the empirical analysis we later break down the sectoral classification. Specifically, we classify goods according to specific high-IP industry clusters as noted below. In all cases we focus on trade effects in samples excluding the treatment partners, namely the United States, EU or EFTA. As discussed below, this approach excludes potential endogeneity between existing trade linkages with those partners and decisions to join such PTAs.

Turning to bilateral trade among all country pairs, we adopt a gravity specification in which we identify specific coefficients on imports and exports of IP-sensitive goods, using both the broader and more disaggregated sectoral breakdowns by product. This approach permits estimation of the particular impacts of membership in an IP-related PTA on sectoral trade with bilateral partners, both inside and outside the agreements.

Table 1 presents the characteristics of treatment ("member") vs. control ("non-member") coun-

Table 1: Sample Summary Statistics, 1995

	Member countries		**Non-member countries**		**Difference**	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	t-stat
High income (HI, 38 countries)						
GDP	499.74	648.38	825.51	2,179.54	–325.77	–0.65
High-IP trade share	0.09	0.16	0.08	0.13	0.01	0.24
Low-IP trade share	0.06	0.08	0.16	0.15	–0.10	–2.55**
Upper-middle income (UMI, 25 countries)						
GDP	24.53	38.68	158.33	225.58	–133.80	–2.11*
High-IP trade share	0.06	0.03	0.09	0.13	–0.03	–0.78
Low-IP trade share	0.11	0.11	0.12	0.10	–0.01	–0.22
Lower-middle income (LMI, 61 countries)						
GDP	22.88	34.70	41.84	79.53	–18.96	–1.03
High-IP trade share	0.08	0.07	0.07	0.08	0.01	0.35
Low-IP trade share	0.13	0.09	0.13	0.12	–0.01	–0.25
Low income (LI, 63 countries)						
GDP	2.89	1.97	25.33	108.02	–22.44	–0.36
High-IP trade share	0.08	0.02	0.05	0.05	0.04	1.15
Low-IP trade share	0.12	0.03	0.12	0.10	0.01	0.13

Notes: Data and income classifications are for the year 1995 (the beginning of the sample period). "Member countries" are those countries that enter into a post-TRIPS IPR-related PTA with the US or Europe at any point in the sample, while "Non-member countries" do not. GDP is presented in billion USD. High-IP and low-IP trade shares are the respective shares of total high-IP and low-IP trade (exports plus imports) in GDP for the respective sectors. The t-statistics in the rightmost column give the statistic on the test of common means between member and non-member countries. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

tries. These figures are broken down by World Bank income groups (with countries' classifications fixed at their 1995 values) at the beginning of the sample period. Included in the table are averages of country GDPs and average values of aggregate high-IP and low-IP exports plus imports as a percentage of GDP. Judging from the t-statistics on differences in means in the final column, countries are similar in size and trade volumes in all income groups except the UMI countries, where members are smaller than non-members. While these summary statistics contain limited information, they offer some initial assurance that countries do not enter into IP-related PTAs simply because they had initially high or low levels of trade in products that are sensitive to intellectual property protection.[8]

With this background, our identification relies on three types of variation. First, during our sample some countries entered into IP-related trade agreements, as we define them below, while others did not (note that countries rarely exit PTAs once they have joined). We also distinguish among countries at varying income levels, noting that both their membership decisions and their economic responses to such agreements may vary. Second, as already noted we distinguish between sectors in terms of their apparent relative usage of intellectual property, computing trade impacts in high-IP and low-IP industries compared to the same sectors in control countries, with increasingly specific definitions of IP-using industries as we go forward. This distinction is important, for if IP chapters matter for trade, in comparison with just the impacts of membership in an FTA generally, the effects should show up in relatively greater impacts in the high-IP set of industries. Note that while we refer to our primary regressions as "aggregate trade" the analysis is done with particular sectoral breakdowns. We use the term aggregate because we do not focus in those cases on bilateral trade impacts between country pairs. However, to sharpen the analysis, in subsequent regressions we consider the impacts of IP-related PTAs on bilateral sectoral trade. The third important element for identification is to control for TRIPS adherence. As noted above, most countries in our sample became compliant with TRIPS at some point in the period, which may have happened before or after their joining an IP-related PTA. In order clearly to isolate the PTA effect, therefore, our preferred specification defines treatment countries as those which joined an IP-related PTA only after they complied with TRIPS.[9]

An obvious challenge to this identification strategy arises if the causality between trade and IPRs works in two directions. On the one hand, IP-related PTAs might increase members' trade over and above TRIPS, the basic effect we seek to identify. On the other hand, member nations may form such agreements because they already undertake a relatively high level of trade in high-IP goods. While this is a potential concern, the threat of an endogenous relationship between high-IP trade and the formation of high-IP PTAs is limited by a critical factor in how such agreements arise. The primary purpose of PTAs is to liberalize within-agreement trade through cuts in border taxes and other trade barriers. Where strong IPRs chapters are included it is typically at the insistence of a single negotiating party. This is especially the case where IP-related PTAs involve both technologically advanced countries that have a strong comparative advantage in creating IP-intensive goods and developing or emerging countries that produce relatively little intellectual property. Indeed, this situation accurately characterizes the bulk of the IP-related PTAs in our sample, with one partner being the United States, EFTA, or the EU. Moreover, these developed partners typically bring greater bargaining power to the negotiating table. Thus, it is highly likely that low-income and middle-income countries that join PTAs with higher-income countries primarily agree to significantly stronger IPRs rules in order to obtain greater and more secure export access to major foreign markets.[10] Put differently, for such countries IPRs are second-order negotiating concessions that they would not ordinarily select as a matter of endogenous policy.[11] While this factor does not ensure that the IPRs effect we examine is necessarily exogenous to countries' trade, it is reasonable to expect that, at least for low-income and middle-income countries, the policy is effectively randomly assigned.

Despite this argument, to alleviate remaining concerns about endogenous selection we estimate specifications in which we eliminate from the sample trade with the major partner (the US, EU, or EFTA) in each of the treatment agreements, generating estimates of the trade impacts with respect to all other countries, both in the aggregate and bilaterally.[12] We regard this as the most rigorous specification, in that it extracts the possibility that the intent of the major partner was to increase trade in IP-sensitive goods with treatment countries, leaving just residual trade effects with third countries.

Trade in High-IP Goods

Equation (1) presents a fully specified regression approach designed to identify the various influences of IPA membership across sectors and income groups.[13]

$$
\begin{aligned}
\log(TR_{ist}) = {} & \alpha_1 \log(GDP_{it}) + \alpha_2\, High\text{-}IP_s \times \log(GDP_{it}) \\
& + \beta_1\, IPA_{it} + \sum_{g \neq LI} \beta_{2g}\, Group_{ig} \times IPA_{it} + \beta_3\, High\text{-}IP_s \times IPA_{it} \\
& + \sum_{g \neq LI} \beta_{4g}\, Group_{ig} \times High\text{-}IP_s \times IPA_{it} \\
& + \gamma_1\, TRIPS_{it} + \sum_{g \neq LI} \gamma_{2g}\, Group_{ig} \times TRIPS_{it} + \gamma_3\, High\text{-}IP_s \times IPA_{it} \\
& + \sum_{g \neq LI} \gamma_{4g}\, Group_{ig} \times High\text{-}IP_s \times TRIPS_{it} \\
& + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.
\end{aligned} \tag{1}
$$

The dependent variable, $\log(TR_{ist})$, represents country i's aggregate imports or exports (in million US dollars) in sector s (high-IP or low-IP in the baseline specification) in year t. To capture the continual introduction of IP-related PTAs that has occurred in recent decades as well as contemporaneous changes in IPR policy at the international level, the sample period covers the years 1995 to 2014.[14] Because of the positive relationship between economic size and trade volume, we include $\log(GDP_{it})$, country i's GDP in year t. We also allow for the trade elasticity with respect to size to vary across sectors via the inclusion of $High\text{-}IP_s \times \log(GDP_{it})$, where $High\text{-}IP_s$ is an indicator for whether a particular observation of trade is in the high-IP sector. We obtain our data on countries' yearly trade flows and national income levels from, respectively, CEPII's BACI dataset, described in Gaulier and Zignago (2010), and World Bank (2016).[15]

Our key variable is designed to incorporate cross-country differences in accession to IP-related trade agreements. For this purpose, we introduce the variable IPA_{it} (for IP-related agreement), which takes a value of 0 for the years in which country i is not party to an IP-related PTA (which has entered into force) with the US, EU, or EFTA, and 1 for each year in which they are party to at least one such agreement. With respect to the time dimension, most IPRs chapters in these agreements require specific compliance dates, upon or soon after the date of a treaty's entry into force. In this context, the binary nature of this policy variable is appropriate.

Both logic and empirical results from the literature suggest that the effects of IPRs on trade are likely to vary across levels of economic development. Thus, we also explore the role of differences in income in determining the trade of member countries by interacting group-level indicator variables (denoted $Group_{ig}$, an indicator for country i belonging to income group g) for specific income groups with IPA. We consider whether the effects of membership in IP-related PTAs, as well as TRIPS compliance, are heterogeneous across income levels in addition to the sectoral dependence on IPRs. To define income groups we take the World Bank's classification of economies as low-income (LI), lower-middle-income (LMI), upper-middle-income (UMI), and high-income (HI).[16] We assign each country to a single income group based on its 1995 level for the duration of the sample. It is important to fix each country's income level in the sample to avoid the possibility that IPRs-related changes in economic activity endogenously change national incomes over time. In this specification, policy interactions vary with income group, permitting heterogeneous coefficients across development levels. Note that in the terms involving income groups we exclude LI, making it the baseline omitted group.

Thus, β_1 represents the direct effect of the IPA variable on the low-IP trade of countries in the low-income group, while $(\beta_1 + \beta_{2g})$ represents the effect of the IPA variable on the low-IP trade of countries in the income group $g \neq LI$. Analogously, β_3 captures the difference in the effect of the IPA variable on the high-IP trade of LI countries relative to the effect on their low-IP trade, and $(\beta_3 + \beta_{4g})$ captures the difference in this effect for countries in the LMI, UMI, and HI income groups. Coefficients γ_1, γ_{2g}, γ_3, and γ_{4g} represent the corresponding effects of TRIPS compliance. Our regressions carefully define the timing of the treatment group. Specifically, we use countries that enter such an agreement only after they come into compliance with TRIPS. Our approach is thus an augmented difference-in-difference estimation, where the effects of the policy treatment are permitted to vary across both countries' levels of development and the sectoral composition of trade.

Recalling that our central question is whether IP-related PTAs have an impact on trade beyond what would be driven by multilateral IPRs reforms, each specification contains an analogous set of controls for each country's compliance with the TRIPS agreement. Note that accession to and compliance with TRIPS are generally not the same. This is because the WTO pact gave developing countries certain transition periods within which to come into TRIPS compliance after ratifying the agreement itself (Deere, 2009). Thus, we estimate the date of TRIPS compliance using the methodology employed by Delgado et al. (2013), based on Ginarte and Park (1997), Park (2008), and Hamdan-Livramento (2009). High-income countries generally implemented TRIPS in 1995 (with some exceptions, such as Portugal and Iceland, which attained compliance in 1996), while middle-income countries were generally granted extended deadlines through 2000 or later. The least-developed countries were given exemptions which effectively delayed their mandatory TRIPS compliance past 2013. Similarly, numerous low-income economies had not come into compliance by that date. These TRIPS-related controls and interactions allow us to separate the variation in aggregate trade attributable to IP-related PTAs from that attributable to TRIPS compliance.

Finally, we control for unobservable factors that may affect aggregate trade volumes and may be correlated with our IPA policy variable. First, we account for idiosyncratic variables that may exist across country development levels, IPRs intensity of goods, and time by including income group-sector-year fixed effects λ_{gst}.[17] Note that the definition of sector or commodity type s will vary with the particular specification, as discussed below. We also incorporate country time trends $\lambda_i\, t$, which control for unobservable national factors affecting trade over time. We see this case, used with the post-TRIPS treatment definition, as a rigorous specification and will rely on it in the regressions we describe next.

While the regression results from the specification in equation (1) are recoverable, it is tedious to present all of them for every specification. Because our primary interest is in the total effects of the policy variables on Group × Sector trade, we can recover them directly by suppressing the IPA, Group × IPA, TRIPS, and Group × TRIPS variables in the regressions and including the exhaustive set of income groups and sectors in the triple interactions.[18] This approach yields coefficients that indicate the total impact of a policy on the group and sector. Thus, the specification we estimate going forward is:

$$
\begin{aligned}
\log(TR_{ist}) = {} & \alpha_1 \log\left(GDP_{it}\right) + \alpha_2\, High\text{-}IP_s \times \log\left(GDP_{it}\right) \\
& + \sum_g \beta_{1g}\, Group_{ig} \times Low\text{-}IP_s \times IPA_{it} \\
& + \sum_g \beta_{2g}\, Group_{ig} \times High\text{-}IP_s \times IPA_{it} \\
& + \sum_g \gamma_{1g}\, Group_{ig} \times Low\text{-}IP_s \times TRIPS_{it} \\
& + \sum_g \gamma_{2g}\, Group_{ig} \times High\text{-}IP_s \times TRIPS_{it} \\
& + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.
\end{aligned} \tag{2}
$$

In interpreting the results of regression (2) and other regressions to follow, it is important to keep in mind that the control group is countries that are not members of an IPA. Thus, our coefficients capture the increases or decreases in trade flows for each group-sector-policy interaction relative to countries without a policy treatment. A positive coefficient, for example, implies that trade increases in treatment countries relative to what it would have been in control countries.

We report the regression results for equation (2) in Table 2 for exports and in Table 3 for imports. In all regressions we report robust standard errors, which are clustered by country. The first columns present the baseline regressions, including all countries in the sample, while the second column presents results when omitting trade with the current (or future) IP-related PTA partner from the aggregate. Because it is useful to compare the magnitudes and significance of the differences in impacts across sectors, we also present in the third column the total effects on trade in equation (1) that are implied by the coefficients in column (2) of each table. Thus, for example, in the fourth row of Table 2 the direct coefficient estimated in the second column (-0.506) is the sum of the coefficients in the third column, where $\beta_{2,LMI}$ is recovered according to the technique in Appendix 2. We list these total effects in Tables 2 and 3 to demonstrate the equivalence of equation (1) with equation (2) but focus discussion on the key coefficients in column (2).

Table 2: Aggregate Exports in High-IP vs. Low-IP Sectors

	(1) Total exports	(2) Total net of partner trade	(3) Total effects implied by estimation of equation (1)
log(GDP)	0.747***	0.718***	
	(0.101)	(0.105)	
High-IP × log(GDP)	0.152**	0.143**	
	(0.061)	(0.064)	
IPA coefficients			
Low-IP × LI	–0.331	–0.337	$\beta_1 = -0.337$
	(0.292)	(0.248)	
Low-IP × LMI	–0.552***	–0.506***	$\beta_1 + \beta_{2,LMI} = -0.337 - 0.169$
	(0.170)	(0.174)	
Low-IP × UMI	–0.622**	–0.426	$\beta_1 + \beta_{2,UMI} = -0.337 - 0.089$
	(0.313)	(0.323)	
Low-IP × HI	–0.465	–0.558*	$\beta_1 + \beta_{2,HI} = -0.337 - 0.221$
	(0.299)	(0.312)	
High-IP × LI	–0.064	0.060	$\beta_1 + \beta_3 = -0.337 + 0.396$
	(0.571)	(0.550)	
High-IP × LMI	0.358*	0.562***	$\beta_1 + \beta_{2,LMI} + \beta_3 + \beta_{4,LMI} = -0.337 - 0.169 + 0.396 + 0.672$
	(0.198)	(0.201)	
High-IP × UMI	0.619**	0.878***	$\beta_1 + \beta_{2,UMI} + \beta_3 + \beta_{4,UMI} = -0.337 - 0.089 + 0.396 + 0.908$
	(0.279)	(0.331)	
High-IP × HI	0.730***	0.830***	$\beta_1 + \beta_{2,HI} + \beta_3 + \beta_{4,HI} = -0.337 - 0.221 + 0.396 + 0.992$
	(0.269)	(0.280)	
TRIPS coefficients			
Low-IP × LI	–0.097	–0.127	$\gamma_1 = -0.127$
	(0.207)	(0.211)	
Low-IP × LMI	–0.539**	–0.584***	$\gamma_1 + \gamma_{2,LMI} = -0.127 - 0.457$
	(0.216)	(0.218)	
Low-IP × UMI	–0.721***	–0.716***	$\gamma_1 + \gamma_{2,UMI} = -0.127 - 0.589$
	(0.257)	(0.273)	
Low-IP × HI	0.104	0.066	$\gamma_1 + \gamma_{2,HI} = -0.127 + 0.192$
	(0.466)	(0.469)	
High-IP × LI	0.022	0.043	$\gamma_1 + \gamma_3 = -0.127 + 0.170$
	(0.236)	(0.235)	
High-IP × LMI	0.216	0.258	$\gamma_1 + \gamma_{2,LMI} + \gamma_3 + \gamma_{4,LMI} = -0.127 - 0.457 + 0.170 + 0.672$
	(0.213)	(0.216)	
High-IP × UMI	0.635**	0.766***	$\gamma_1 + \gamma_{2,UMI} + \gamma_3 + \gamma_{4,UMI} = -0.127 - 0.589^{*} + 0.170 + 1.312^{**}$
	(0.257)	(0.272)	
High-IP × HI	0.159	0.153	$\gamma_1 + \gamma_{2,HI} + \gamma_3 + \gamma_{4,HI} = -0.127 + 0.192 + 0.170 - 0.082$
	(0.412)	(0.414)	
Observations	7,132	7,132	7,132
Number of countries	187	187	187
R^2	0.926	0.913	0.913
Country trends	Y	Y	Y
Group-sector-year FEs	Y	Y	Y

Notes: Dependent variable is log (exports). Columns (1) and (2) present the OLS estimates of equation (2), with column (2) excluding the value of trade with the current or future IP-related PTA partner. Column (3) presents the total effects by income group and sector implied by equation (1), omitting trade with the current or future IP-related PTA partner as in column (2). Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Aggregate Imports in High-IP vs. Low-IP Sectors

		(1) Total imports	(2) Total net of partner trade	(3) Total effects implied by estimation of equation (1)
	log(GDP)	0.545***	0.528***	
		(0.045)	(0.043)	
	High-IP × log(GDP)	0.083***	0.077***	
		(0.014)	(0.016)	
IPA coefficients	Low-IP × LI	–0.443**	–0.456**	$\beta_1 = -0.456^{**}$
		(0.172)	(0.184)	
	Low-IP × LMI	–0.083	0.038	$\beta_1 + \beta_{2,LMI} = -0.456^{**} + 0.494^{**}$
		(0.091)	(0.108)	
	Low-IP × UMI	0.165	0.346*	$\beta_1 + \beta_{2,UMI} = -0.456^{**} + 0.802^{***}$
		(0.139)	(0.180)	
	Low-IP × HI	0.170**	0.277***	$\beta_1 + \beta_{2,HI} = -0.456^{**} + 0.733^{***}$
		(0.082)	(0.095)	
	High-IP × LI	–0.212**	–0.105	$\beta_1 + \beta_3 = -0.456^{**} + 0.351^{***}$
		(0.104)	(0.107)	
	High-IP × LMI	–0.137*	–0.229**	$\beta_1 + \beta_{2,LMI} + \beta_3 + \beta_{4,LMI} = -0.456^{**} + 0.494^{**} + 0.351^{***} - 0.617^{***}$
		(0.071)	(0.088)	
	High-IP × UMI	–0.000	–0.033	$\beta_1 + \beta_{2,UMI} + \beta_3 + \beta_{4,UMI} = -0.456^{**} + 0.802^{***} + 0.351^{***} - 0.723^{**}$
		(0.095)	(0.140)	
	High-IP × HI	0.116	–0.049	$\beta_1 + \beta_{2,HI} + \beta_3 + \beta_{4,HI} = -0.456^{**} + 0.733^{***} + 0.351^{***} - 0.677^{***}$
		(0.091)	(0.122)	
TRIPS coefficients	Low-IP × LI	0.065	0.074	$\gamma_1 = 0.074$
		(0.089)	(0.088)	
	Low-IP × LMI	–0.116	0.002	$\gamma_1 + \gamma_{2,LMI} = 0.074 - 0.071$
		(0.072)	(0.079)	
	Low-IP × UMI	–0.039	–0.022	$\gamma_1 + \gamma_{2,UMI} = 0.074 - 0.096$
		(0.080)	(0.082)	
	Low-IP × HI	–0.044	–0.083	$\gamma_1 + \gamma_{2,HI} = 0.074 - 0.157$
		(0.152)	(0.155)	
	High-IP × LI	0.007	0.021	$\gamma_1 + \gamma_3 = 0.074 - 0.052$
		(0.080)	(0.080)	
	High-IP × LMI	–0.058	–0.080	$\gamma_1 + \gamma_{2,LMI} + \gamma_3 + \gamma_{4,LMI} = 0.074 - 0.071 - 0.052 - 0.030$
		(0.057)	(0.061)	
	High-IP × UMI	0.137	0.043	$\gamma_1 + \gamma_{2,UMI} + \gamma_3 + \gamma_{4,UMI} = 0.074 - 0.096 - 0.052 + 0.118$
		(0.089)	(0.121)	
	High-IP × HI	0.114	0.097	$\gamma_1 + \gamma_{2,HI} + \gamma_3 + \gamma_{4,HI} = 0.074 - 0.157 - 0.052 + 0.233$
		(0.117)	(0.122)	
	Observations	7,132	7,132	7,132
	R^2	0.978	0.971	0.913
	Country trends	Y	Y	Y
	Group-sector-year FEs	Y	Y	Y

Notes: Dependent variable is log (imports). Columns (1) and (2) present the OLS estimates of equation (2), with column (2) excluding the value of trade with the current or future IP-related PTA partner. Column (3) presents the total effects by income group and sector implied by equation (1), omitting trade with the current or future IP-related PTA partner as in column (2). Robust standard errors clustered by country are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Clearly market size, given by GDP of the exporter or importer, matters greatly for trade. It is interesting that there is a significantly positive interaction of GDP with our indicator for high-IP goods, suggesting that both exports and imports are more elastic with respect to total demand than are low-IP sectors. We find in Table 2, column (2) that exports of low-IP goods are reduced among all income groups that are in a treatment IPA, though the coefficients are significant only for LMI and HI nations. Thus, these agreements seem to repress exports in goods that are less reliant on IP protection compared to other sectors. In contrast, there is a sharply positive effect on exports of high-IP goods in LMI, UMI, and HI countries. In this context, there is a clear sorting effect emerging from the inclusion of strong IP chapters in trade agreements: exports of low-IP commodities fall while exports of high-IP goods expand at nearly all levels of income.

We further find in Table 3 that the negative effect of an IPA on low-IP imports is limited to the low-income countries. It appears from these coefficients that when such countries join an IP-related PTA they tend to see diminished imports of products that are less dependent on IPRs. Interestingly, this negative impact carries over to imports of high-IP goods for both LI and LMI countries, especially in the latter case when trade with the major partner is excluded in column (2). This result, that imports of high-IP goods from third countries are diminished in developing countries, stands in contrast with prior literature, which largely considered only such imports from OECD economies in total, as opposed to those associated with PTAs, without controlling appropriately for exclusion effects.

Thus, our initial evidence suggests that, controlling for TRIPS, IP-related PTAs diminish low-IP imports and exports in poor countries but there is a stimulative effect on high-IP exports from both emerging and developed countries. Such PTAs do not significantly affect imports of high-IP goods among higher-income economies. It is notable that adherence to TRIPS has similar impacts on third-country exports and no effects on imports at any level of income. These results suggest that prior findings in the literature of TRIPS-related trade impacts may have conflated that multilateral agreement with these IP-related PTAs.

We next extend the analysis by running similar regressions on bilateral trade data for each country with all potential partner countries, put into a trade-gravity context estimated using a Poisson Pseudo-Maximum Likelihood (PPML), as suggested by Santos Silva and Tenreyro (2006). Thus, the dependent variable becomes TR_{ijst}, where subscript j refers to the bilateral partner. In the gravity context, the equation we estimate becomes

$$
\begin{aligned}
TR_{ijst} = \exp\Big\{ & \alpha_1 \log(GDP_{it}) + \alpha_2 \, High\text{-}IP_s \times \log(GDP_{it}) \\
& + \alpha_3 \log(GDP_{jt}) + \alpha_4 \, High\text{-}IP_s \times \log(GDP_{jt}) \\
& + \sum_g \beta_{1g} \, Group_{ig} \times Low\text{-}IP_s \times IPA_{it} + \sum_g \beta_{2g} \, Group_{ig} \times High\text{-}IP_s \times IPA_{it} \\
& + \sum_g \beta_{3g} \, Group_{jg} \times Low\text{-}IP_s \times IPA_{jt} + \sum_g \beta_{4g} \, Group_{jg} \times High\text{-}IP_s \times IPA_{jt} \\
& + \sum_g \gamma_{1g} \, Group_{ig} \times Low\text{-}IP_s \times TRIPS_{it} + \sum_g \gamma_{2g} \, Group_{ig} \times High\text{-}IP_s \times TRIPS_{it} \\
& + \sum_g \gamma_{3g} \, Group_{jg} \times Low\text{-}IP_s \times TRIPS_{jt} + \sum_g \gamma_{4g} \, Group_{jg} \times High\text{-}IP_s \times TRIPS_{jt} \\
& + \lambda_i \, t + \lambda_j \, t + \lambda_{(i)gst} + \lambda_{(j)gst} + \lambda_{ij} \Big\} + \nu_{ijst}.
\end{aligned} \tag{3}
$$

The key difference between this equation and equation (2) (aside from the dependent variable being in its absolute level) is that the effects are now broken down between exporter versus importer effects within the same regression.

In this specification, the variable IPA_{it} refers to the exporting country's membership in an IP-related trade agreement, while IPA_{jt} connotes the membership status of the importer in a bilateral linkage. TRIPS is likewise delineated between exporters and importers. Note that in addition to policy effects varying between exporters and importers, we now include income group-sector-year fixed effects ($\lambda_{(i)gst}$ and $\lambda_{(j)gst}$, denoting respectively the group-sector-year fixed effects for exporter i and importer j) and country-specific time trends ($\lambda_i \, t$ and $\lambda_j \, t$) that capture importer and exporter-specific factors. This achieves a comprehensive gravity specification, with the country-pair effect λ_{ij} controlling for unobserved bilateral trade costs (Head and Mayer, 2014).

The results are in Table 4, with the exporter effects in column 1 and the importer effects in column 2, the columns together forming a single gravity regression. We find that dramatically expanding the sample size in this way produces similar inferences to aggregate trade. We again unearth a distinctive separation of effects at different income groupings. Low-IP imports seem to be diminished in LI countries when they join an IP-related PTA, though the corresponding TRIPS effect is positive. Exports of low-IP goods are reduced also in middle-income countries but there are significantly positive coefficients on the interactions for these countries in high-IP exports. Again, therefore, there seems to be a bifurcation along lines of comparative advantage,

Table 4: Bilateral High-IP vs. Low-IP Trade

	(1) Exporter Effects	(2) Importer Effects
log(GDP)	0.129***	0.533***
	(0.036)	(0.032)
High-IP × log(GDP)	0.373***	0.023
	(0.033)	(0.034)
Low-IP × LI× IPA	–0.131	–0.264*
	(0.107)	(0.154)
Low-IP × LMI × IPA	–0.265***	–0.003
	(0.097)	(0.066)
Low-IP × UMI × IPA	–0.748***	–0.062
	(0.143)	(0.099)
Low-IP × HI × IPA	–0.222**	0.029
	(0.100)	(0.079)
High-IP × LI × IPA	–0.064	0.298**
	(0.215)	(0.134)
High-IP × LMI × IPA	0.388***	0.019
	(0.111)	(0.078)
High-IP × UMI × IPA	0.471***	0.258***
	(0.155)	(0.082)
High-IP × HI × IPA	0.173***	–0.031
	(0.067)	(0.068)
Low-IP × LI × TRIPS	–0.298***	0.230**
	(0.077)	(0.107)
Low-IP × LMI × TRIPS	–0.561***	0.146**
	(0.084)	(0.058)
Low-IP × UMI × TRIPS	–0.488***	–0.173**
	(0.077)	(0.078)
Low-IP × HI × TRIPS	0.451***	0.068
	(0.102)	(0.096)
High-IP × LI × TRIPS	0.595***	0.354***
	(0.115)	(0.097)
High-IP × LMI × TRIPS	1.428***	–0.079
	(0.154)	(0.049)
High-IP × UMI × TRIPS	1.130***	0.137**
	(0.163)	(0.055)
High-IP × HI × TRIPS	0.150**	0.012
	(0.074)	(0.059)
Observations		1,055,276
Country trends		Y
Group-sector-year FEs		Y
Pair FEs		Y

Notes: Dependent variable is TR_{ijst}, omitting observations of trade between current and future IP-related PTA partners. Estimation method is PPML. Columns (1) and (2) present coefficients from the same regression corresponding to equation (3). Robust standard errors clustered by bilateral pair are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

with the emerging nations shifting their exports at the margin into higher-technology goods after joining such agreements. Compliance with the TRIPS Agreement also encourages exports in high-IP sectors among developing and emerging countries, a result that is more sharply delineated with bilateral trade data. It is notable that the regressions find fewer suggestions overall that either membership in treatment IPAs or TRIPS compliance affects imports of either type of products in the disaggregated bilateral gravity model. However, high-IP imports are expanded in both LI and UMI treatment countries. The latter finding is consistent with the results of prior literature regarding TRIPS using more aggregated data (Ivus, 2010; Delgado et al., 2013).

Trade in High-IP Industry Clusters

The analysis in the previous section demonstrates how the effects of IP-related PTAs membership vary by income groups, focusing on aggregate and bilateral trade in high-IP sectors. While instructive, this approach may miss important variation at more disaggregated levels. Recall that many of the TRIPS-Plus standards and other elevated IPRs, such as test-data protection, linkage rules for chemicals and pharmaceuticals, and anti-circumvention of digital copyrights, arise in order to address issues in specific sectors. Thus, it is also interesting to examine the details of how such agreements may affect trade in detailed industries that are particularly sensitive to IPRs. Other detailed IPRs-intensive industries might not be the focus of specific standards in these agreements, but nonetheless could be affected differently.

In the next analysis, $Sector_s$ is an indicator for an observation belonging to a particular IPRs-intensive industry cluster as defined in Delgado et al. (2013), based on Porter (2003) and U.S. Department of Commerce (2012). Our high-IP industries now are the ones identified as being most reliant on IPRs, and include analytical instruments (AI), biopharmaceuticals (BIO), chemicals (CHEM), information and communications technology (ICT), medical devices (MED), and production technology (PT). We also include a category of other high-IP industries, which are the remaining sectors from our earlier definition of the high-IP classifications.Analogous to equation (2), equation (4) describes the relationship between aggregate sectoral (including low-IP goods) imports or exports and the income group- and sector-specific effects for both IPA and $TRIPS$:[19]

$$\log(TR_{ist}) = \alpha_1 \log(GDP_{it}) + \sum_s \alpha_{2s}\, Sector_s \times \log(GDP_{it}) \tag{4}$$
$$+ \sum_g \sum_s \beta_{gs}\, Group_{ig} \times Sector_s \times IPA_{it}$$
$$+ \sum_g \sum_s \gamma_{gs}\, Group_{ig} \times Sector_s \times TRIPS_{it}$$
$$+ \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.$$

The regression results for equation (4) are in Table 5 for aggregate exports, where again trade of IPA members with other partner countries is excluded. Again, these are results from a single regression, with sectoral coefficients read down the columns. In each sector there is a notably higher elasticity of exports with respect to market size. Isolating coefficients in this fashion, we find that IPA membership reduces exports of low-IP goods for LMI, UMI, and HI countries, with the effect rising with income. Low-income countries see reductions in exports of AI and PT sectors. With this specification, there is relatively little indication of export enhancements in the emerging countries from joining an IPA, although UMI nations register a significantly positive coefficient on ICT goods, which may reflect the growth of assembly and export operations in microelectronics. The most notable outcome is that high-income countries experience significant export increases in biopharmaceuticals and medical devices. This result suggests that, in fact, TRIPS-Plus standards in the medical patenting area may support higher exports from developed countries. The TRIPS agreement seems to have similar effects on exports of AI and CHEM, with the CHEM effect being particularly pronounced in UMI countries. These results are depicted visually in Figures 3a and 3b, which show 95% confidence intervals around coefficient estimates. The picture overall is one in which trade is little affected by membership in IP-related PTAs and TRIPS but there are export-enhancing effects in specific sectors and country groups.

The aggregate imports results are in Table 6. With this breakdown, aggregate imports in LI and LMI countries are diminished significantly by IPA membership in AI and PT. In contrast, BIO and MED imports are significantly raised among high-income economies, meaning that trade in both directions rises among treatment countries in medically based industries. Again, we find little evidence of an overall impact on imports across most income groups and detailed sectors in the aggregate trade. These findings are illustrated in Figures 4a and 4b.

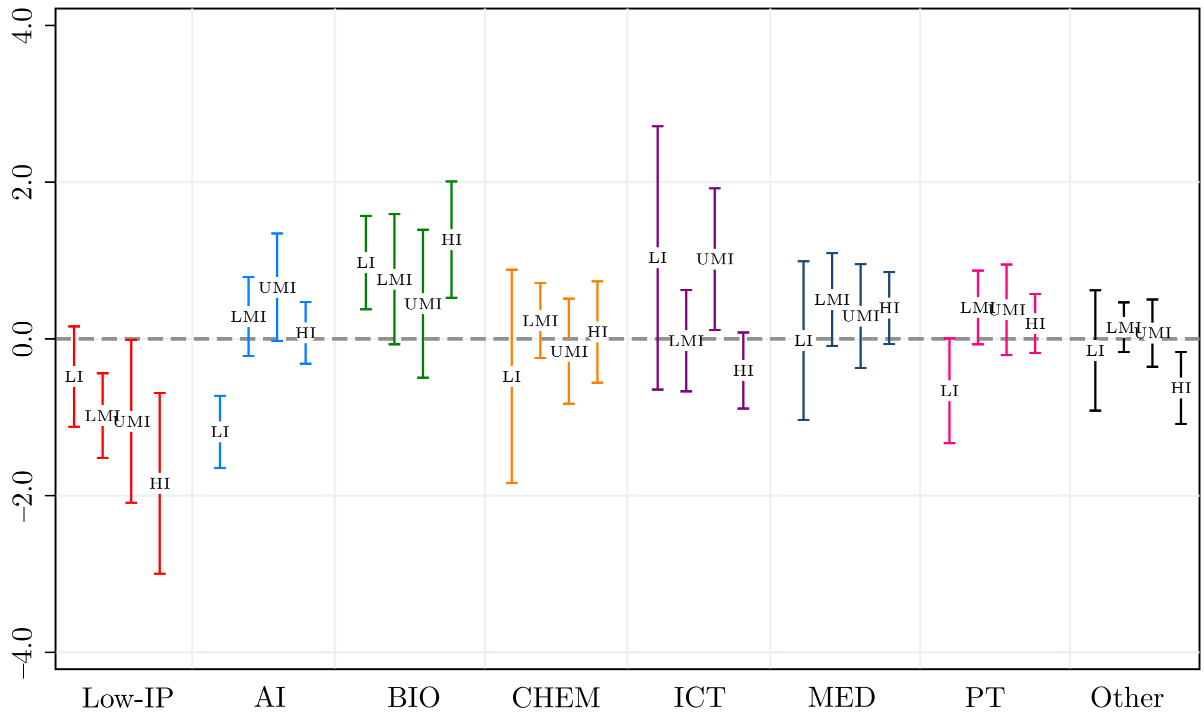
Table 5: Aggregate Exports of High-IP Clusters

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
log(GDP)	0.428***							
	(0.093)							
Sector × log(GDP)		0.138**	0.218***	0.273***	0.154*	0.223***	0.200***	0.168***
		(0.067)	(0.070)	(0.076)	(0.086)	(0.077)	(0.059)	(0.059)
Sector × LI × IPA	–0.481	–1.187***	0.974***	–0.478	1.034	–0.021	–0.663*	–0.147
	(0.324)	(0.234)	(0.302)	(0.690)	(0.852)	(0.513)	(0.339)	(0.389)
Sector × LMI × IPA	–0.979***	0.286	0.762*	0.234	–0.023	0.503*	0.401*	0.150
	(0.274)	(0.256)	(0.422)	(0.243)	(0.328)	(0.300)	(0.239)	(0.160)
Sector × UMI × IPA	–1.052**	0.659*	0.449	–0.156	1.018**	0.291	0.371	0.074
	(0.527)	(0.348)	(0.478)	(0.340)	(0.458)	(0.336)	(0.293)	(0.217)
Sector × HI × IPA	–1.843***	0.077	1.267***	0.088	–0.403	0.394*	0.197	–0.627***
	(0.585)	(0.199)	(0.376)	(0.328)	(0.246)	(0.233)	(0.190)	(0.232)
Sector × LI × TRIPS	–0.104	0.239	0.541	–0.144	0.226	0.161	0.228	0.096
	(0.361)	(0.238)	(0.336)	(0.292)	(0.234)	(0.260)	(0.209)	(0.227)
Sector × LMI × TRIPS	–0.932**	–0.166	0.432	0.267	0.062	0.120	–0.225	–0.215
	(0.375)	(0.171)	(0.363)	(0.260)	(0.276)	(0.275)	(0.184)	(0.178)
Sector × UMI × TRIPS	–1.910**	0.079	0.865**	1.167***	0.301	–0.649	0.208	–0.416
	(0.787)	(0.176)	(0.431)	(0.388)	(0.446)	(0.843)	(0.192)	(0.589)
Sector × HI × TRIPS	0.203	0.662***	–0.392	0.598	0.367	0.347	0.371	0.256
	(0.711)	(0.232)	(0.597)	(0.371)	(0.279)	(0.303)	(0.287)	(0.242)
Observations								27,950
Country trends								Y
Group-sector-year FEs								Y

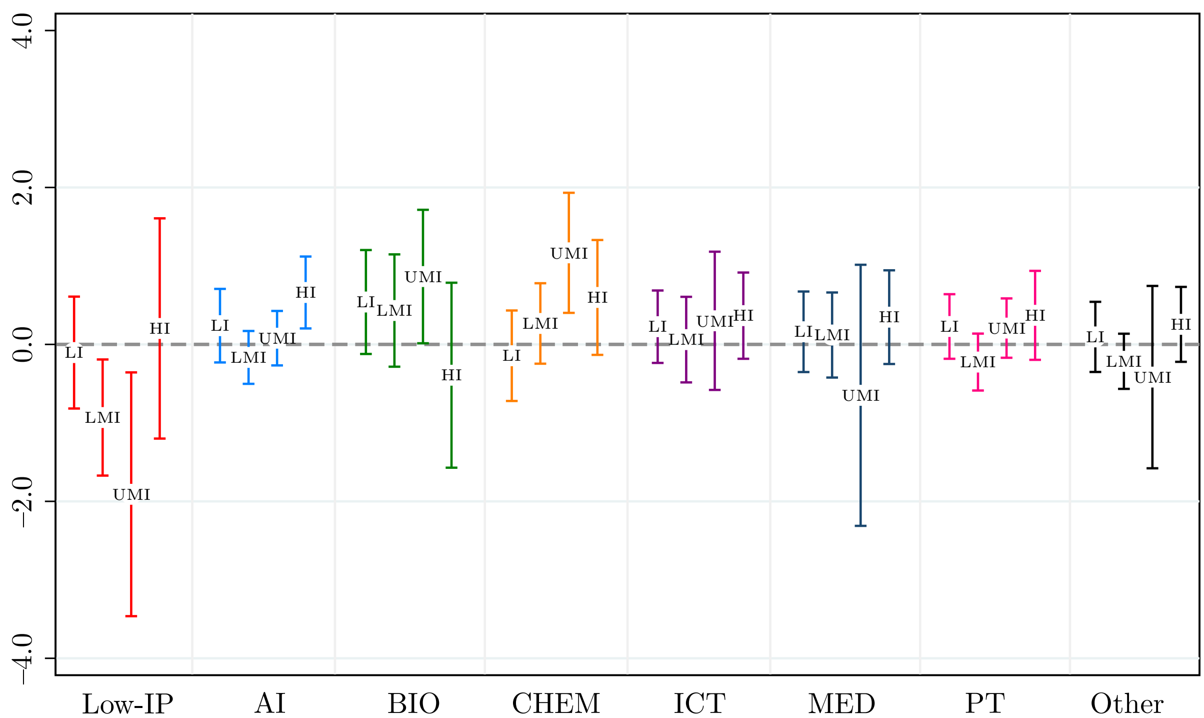
Notes: Dependent variable is log (exports), net of trade with the current or future IP-related PTA partner. Estimation method is OLS. Columns (1)–(8) are from a single regression corresponding to equation (4). Robust standard errors clustered by country are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Figure 3: Aggregate Exports of High-IP Clusters

3a: IPA Exporter Effects



3b: TRIPS Exporter Effects



Notes: Each figure depicts the point estimates and associated 95% confidence intervals corresponding to the estimates in Table 5.

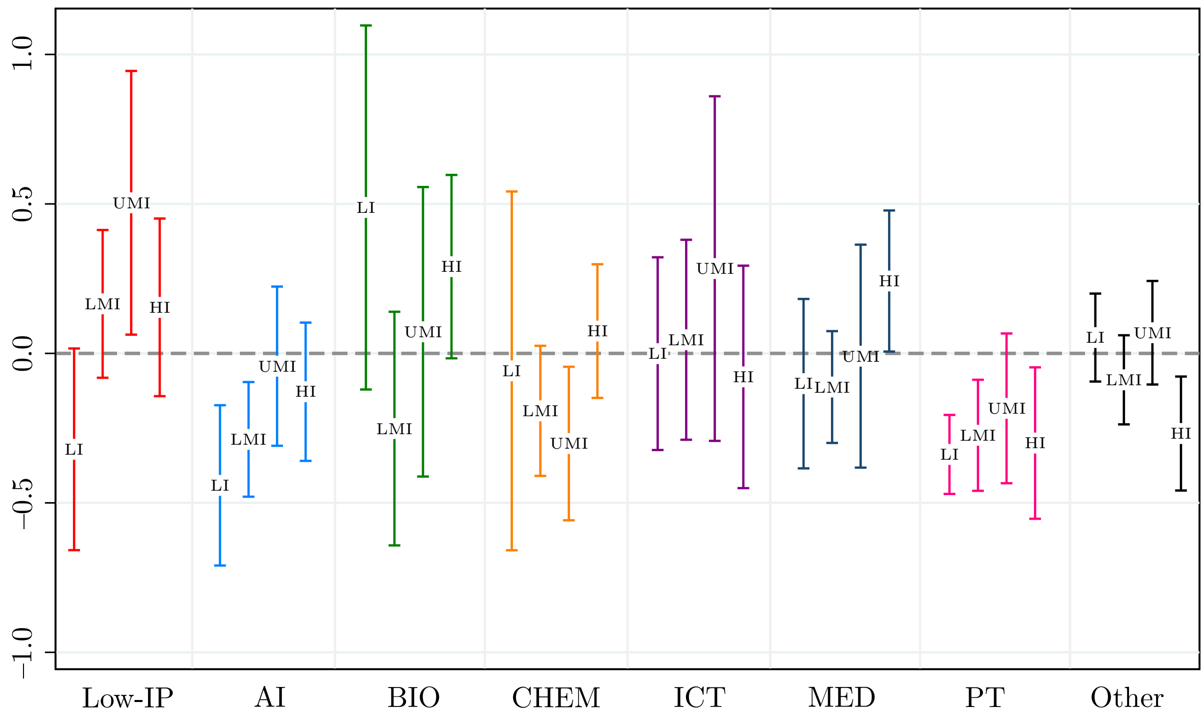
Table 6: Aggregate Imports of High-IP Clusters

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
log(GDP)	0.487***							
	(0.042)							
Sector × log(GDP)		0.195***	0.127***	0.226***	0.132***	0.120***	0.151***	0.047***
		(0.020)	(0.030)	(0.020)	(0.022)	(0.020)	(0.019)	(0.016)
Sector × LI × IPA	–0.321*	–0.441***	0.488	–0.058	–0.001	–0.101	–0.338***	0.053
	(0.171)	(0.136)	(0.309)	(0.304)	(0.163)	(0.144)	(0.067)	(0.075)
Sector × LMI × IPA	0.166	–0.288***	–0.251	–0.192*	0.046	–0.113	–0.274***	–0.088
	(0.125)	(0.097)	(0.198)	(0.110)	(0.170)	(0.095)	(0.094)	(0.076)
Sector × UMI × IPA	0.504**	–0.043	0.072	–0.302**	0.284	–0.009	–0.184	0.069
	(0.224)	(0.135)	(0.245)	(0.130)	(0.292)	(0.189)	(0.127)	(0.088)
Sector × HI × IPA	0.154	–0.128	0.290*	0.075	–0.079	0.242**	–0.300**	–0.268***
	(0.151)	(0.117)	(0.155)	(0.113)	(0.189)	(0.120)	(0.128)	(0.097)
Sector × LI × TRIPS	0.095	0.044	–0.182	0.165*	0.065	–0.152	0.091	0.072
	(0.115)	(0.129)	(0.144)	(0.099)	(0.120)	(0.135)	(0.103)	(0.081)
Sector × LMI × TRIPS	0.036	–0.220**	–0.154	0.147	0.155	–0.219**	–0.280***	–0.054
	(0.098)	(0.100)	(0.147)	(0.093)	(0.113)	(0.087)	(0.091)	(0.062)
Sector × UMI × TRIPS	–0.008	0.057	0.033	0.075	0.435***	0.071	–0.291***	–0.023
	(0.101)	(0.142)	(0.157)	(0.173)	(0.158)	(0.132)	(0.103)	(0.134)
Sector × HI × TRIPS	–0.167	0.291**	–0.225	0.033	0.144	0.161	0.024	0.035
	(0.171)	(0.144)	(0.197)	(0.193)	(0.189)	(0.138)	(0.148)	(0.119)
Observations								28,528
Country trends								Y
Group-sector-year FEs								Y

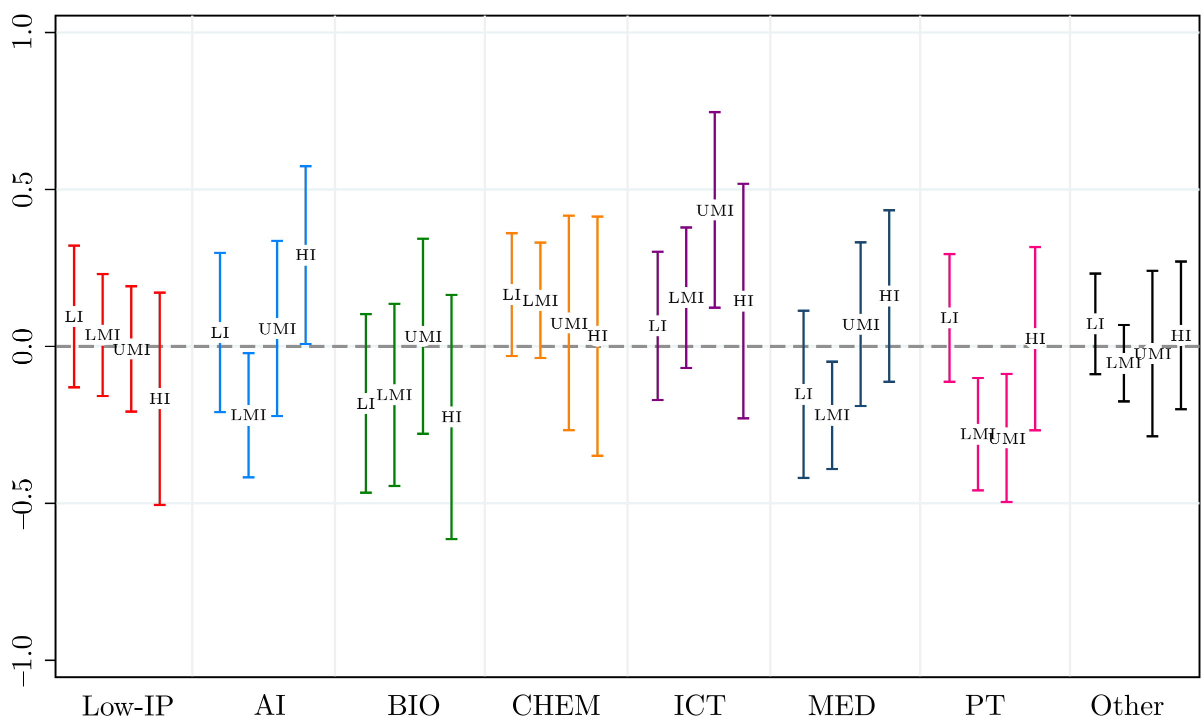
Notes: Dependent variable is log (imports), net of trade with the current or future IP-related PTA partner. Estimation method is OLS. Columns (1)–(8) are from a single regression corresponding to equation (4). Robust standard errors clustered by country are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Figure 4: Aggregate Imports of High-IP Clusters

4a: IPA Importer Effects



4b: TRIPS Importer Effects



Notes: Each figure depicts the point estimates and associated 95% confidence intervals corresponding to the estimates in Table 6.

$$
\begin{aligned}
TR_{ijst} = \exp\Big\{&\alpha_1 \log(GDP_{it}) + \alpha_2\, High\text{-}IP_s \times \log(GDP_{it}) \\
&+ \alpha_3 \log(GDP_{jt}) + \alpha_4\, High\text{-}IP_s \times \log(GDP_{jt}) \\
&+ \sum_g \beta_{1g}\, Group_{ig} \times Sector_s \times IPA_{it} + \sum_g \beta_{2g}\, Group_{jg} \times Sector_s \times IPA_{jt} \\
&+ \sum_g \gamma_{1g}\, Group_{ig} \times Sector_s \times TRIPS_{it} + \sum_g \gamma_{2g}\, Group_{jg} \times Sector_s \times TRIPS_{jt} \\
&+ \lambda_{(i)gst} + \lambda_{(j)gst} + \lambda_i\, t + \lambda_j\, t + \lambda_{ij}\Big\} + \nu_{ijst}.
\end{aligned} \tag{5}
$$

Finally, we estimate equation (5) using our extensive bilateral trade data set, with distinct importer and exporter effects of IPA and TRIPS as in equation (3). Again, here the dependent variable becomes TR_{ijst}—exports from country i to country j or imports into j from i—and we add log(GDP) of the trading partner and the additional Sector × log(GDP) interactions and country-pair fixed effects for exporters and importers, and we again perform the estimation with a PPML approach. Table 7 contains the results of this gravity specification, with the first page showing the coefficients on exports and the second page showing the coefficients on imports, again in a single regression.[20] We find first that low-IP exports are discouraged in the three top income groups by joining an IP-related PTA, consistent with prior results. However, there are significantly positive impacts on exports of LMI, UMI, and HI countries within several high-IP industries, including AI, BIO, CHEM, MED, and OTHER IP-intensive goods. This result is remarkable for it indicates that regressions of a country's total sectoral trade on membership disguise the robust and significant impacts on bilateral trade in detailed IP-intensive sectors. Again, these effects refer to trade with third nations outside any IP-related IPAs. In brief, the implementation of trade agreements with chapters mandating elevated protection standards seems substantially to expand exports of such goods across income groups and sectors. These effects hold also for TRIPS among LMI and HMI countries: other things equal, TRIPS implementation significantly raises exports of high-technology goods for emerging economies. These findings, with coefficients illustrated in Figures 5a and 5b, are new to the literature.

Turning to imports, there are some cases in which trade in these IP-sensitive sectors is increased and some in which it is diminished by IPA membership. Perhaps most notably we find that imports expand in BIO and MED in several cases, again pointing to the specific effects of these standards. TRIPS effects are less systematic and generally insignificant. All of these coefficients are illustrated in Figures 6a and 6b.

It is also of interest to investigate the economic significance of these estimated impacts. In Table 8 we present the implied changes in aggregate exports and imports in low-IP goods and three high-IP sectors, evaluated for the average country within each sector and income group. Keep in mind that these computations refer to trade impacts of the average IPA member with trade partners other than the major demandeur (the US, EU, or EFTA) and do not account for trade effects with that country or region. The figures in bold correspond to significant coefficients from corresponding earlier regressions. As may be seen there are substantial increases in exports to third countries of BIO and MED products from IPA membership, while low-IP exports fall in comparison with such trade in the control group of countries. Table 9 repeats this analysis using detailed bilateral trade flows. The latter table finds significant impacts nearly across the board in AI, BIO, and MED, with both TRIPS and IPA membership contributing to increases in exports. These are large effects in economic terms, albeit in relation to small average trade flows, particularly with regard to BIO products. IPA membership also significantly expands imports of BIO and MED products in lower-income and high-income economies when evaluated at this granular level.

Table 7: Bilateral Exports and Imports of High-IP Clusters

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Exporter effects								
log(GDP)	0.124***							
	(0.036)							
Sector × log(GDP)		0.610***	0.362***	0.405***	0.282***	0.623***	0.532***	0.383***
		(0.043)	(0.065)	(0.039)	(0.039)	(0.055)	(0.038)	(0.032)
Sector × LI × IPA	–0.079	0.092	0.272	–0.113	–0.791	1.260**	–0.655**	0.274
	(0.111)	(0.334)	(0.532)	(0.383)	(0.546)	(0.602)	(0.279)	(0.264)
Sector × LMI × IPA	–0.246**	0.939***	2.007***	0.338*	–0.121	0.995***	1.045***	0.482***
	(0.099)	(0.215)	(0.211)	(0.186)	(0.221)	(0.224)	(0.150)	(0.108)
Sector × UMI × IPA	–0.716***	1.534***	1.952***	0.325*	0.271	1.844***	0.624***	0.485***
	(0.146)	(0.230)	(0.254)	(0.186)	(0.279)	(0.288)	(0.193)	(0.110)
Sector × HI × IPA	–0.212**	0.461***	1.131***	0.523***	–0.453***	0.313***	0.586***	0.181**
	(0.099)	(0.099)	(0.158)	(0.086)	(0.098)	(0.116)	(0.113)	(0.072)
Sector × LI × TRIPS	–0.319***	0.380**	–0.469*	–0.216	1.698***	–0.493**	0.146	0.223*
	(0.078)	(0.167)	(0.283)	(0.183)	(0.160)	(0.207)	(0.157)	(0.120)
Sector × LMI × TRIPS	–0.559***	0.985***	1.227***	0.875***	2.812***	2.137***	1.207***	1.066***
	(0.083)	(0.289)	(0.254)	(0.223)	(0.180)	(0.253)	(0.201)	(0.147)
Sector × UMI × TRIPS	–0.489***	1.273***	1.451***	1.341***	1.624***	1.310***	1.732***	0.773***
	(0.077)	(0.252)	(0.229)	(0.173)	(0.198)	(0.224)	(0.173)	(0.145)
Sector × HI × TRIPS	0.432***	0.166	0.360*	0.149	–0.065	0.566***	0.376***	0.219***
	(0.102)	(0.134)	(0.191)	(0.108)	(0.116)	(0.197)	(0.113)	(0.071)
				⋮				

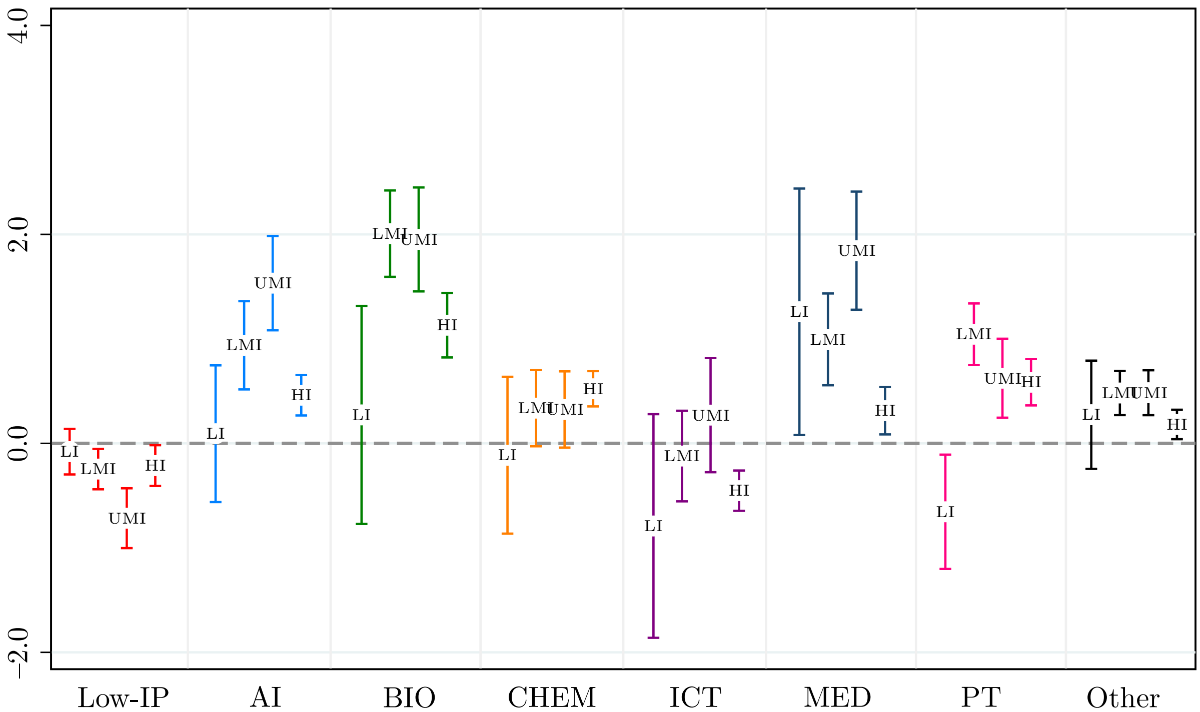
Table 7 (continued)

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Importer effects								
log(GDP)	0.527***							
	(0.032)							
Sector × log(GDP)		0.142***	0.146***	0.070**	–0.046	0.159***	0.079**	0.032
		(0.033)	(0.045)	(0.028)	(0.053)	(0.038)	(0.033)	(0.030)
Sector × LI × IPA	–0.139	0.065	2.893***	0.585**	–0.858***	1.147***	0.213	0.652***
	(0.168)	(0.218)	(0.365)	(0.250)	(0.248)	(0.273)	(0.190)	(0.136)
Sector × LMI × IPA	–0.004	–0.018	0.388*	–0.123	0.022	0.511***	–0.132	0.017
	(0.068)	(0.175)	(0.211)	(0.127)	(0.162)	(0.150)	(0.105)	(0.080)
Sector × UMI × IPA	–0.082	0.080	0.225	–0.358***	0.629***	0.037	0.082	0.086
	(0.102)	(0.110)	(0.218)	(0.137)	(0.174)	(0.149)	(0.113)	(0.076)
Sector × HI × IPA	0.027	0.102	0.498***	0.358***	–0.155	0.211*	0.069	–0.063
	(0.079)	(0.104)	(0.166)	(0.116)	(0.127)	(0.115)	(0.121)	(0.063)
Sector × LI × TRIPS	0.207*	0.078	–1.414***	0.213*	1.376***	–0.501***	0.144	0.094
	(0.106)	(0.137)	(0.271)	(0.129)	(0.175)	(0.160)	(0.147)	(0.089)
Sector × LMI × TRIPS	0.141**	–0.064	–0.331**	0.309***	0.455***	–0.478***	–0.290***	–0.157***
	(0.058)	(0.120)	(0.161)	(0.070)	(0.131)	(0.108)	(0.081)	(0.050)
Sector × UMI × TRIPS	–0.171**	0.251***	–0.019	0.312***	0.526***	–0.018	0.025	–0.018
	(0.078)	(0.078)	(0.156)	(0.088)	(0.125)	(0.122)	(0.058)	(0.046)
Sector × HI × TRIPS	0.052	–0.022	0.150	–0.197**	0.162	0.428***	–0.259**	–0.023
	(0.095)	(0.114)	(0.145)	(0.099)	(0.141)	(0.107)	(0.113)	(0.066)
Observations								4,220,144
Country trends								Y
Group-sector-year FEs								Y
Pair FEs								Y

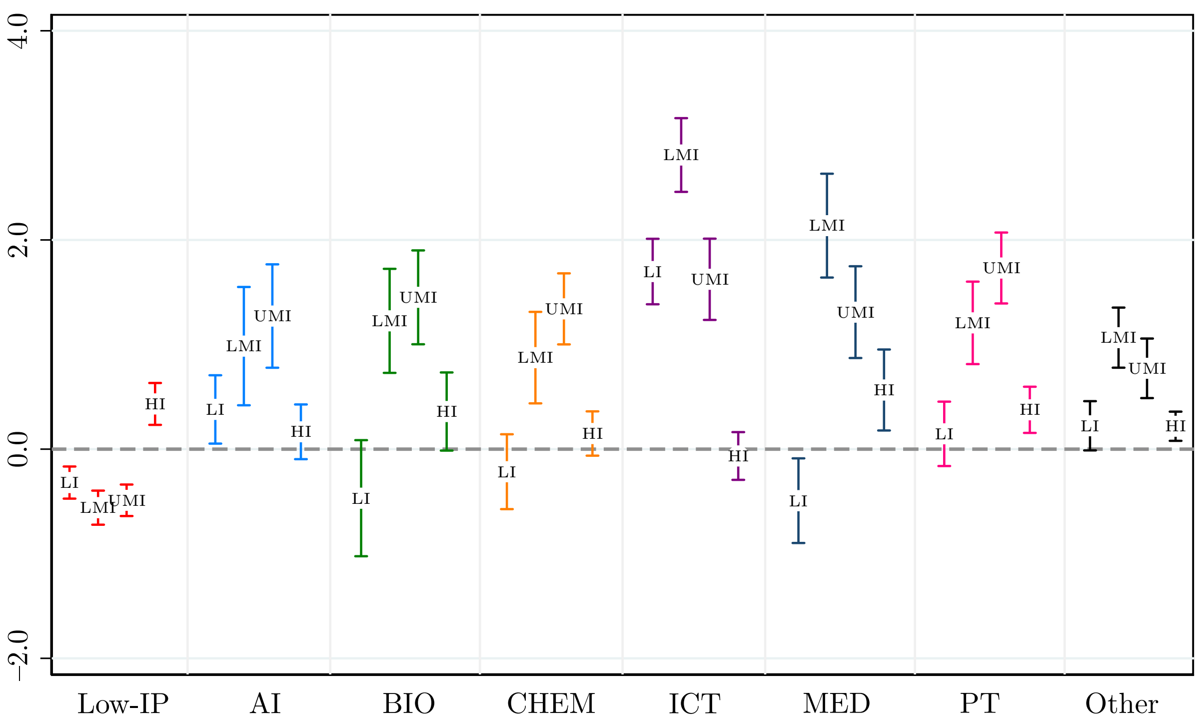
Notes: Dependent variable is TR_{ijst}, omitting observations of trade between current and future IP-related PTA partners. Estimation method is PPML. Columns (1)–(8) present coefficients from the same regression corresponding to equation (5). Robust standard errors clustered by bilateral pair are reported in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Figure 5: Bilateral Exports of High-IP Clusters

5a: IPA Exporter Effects



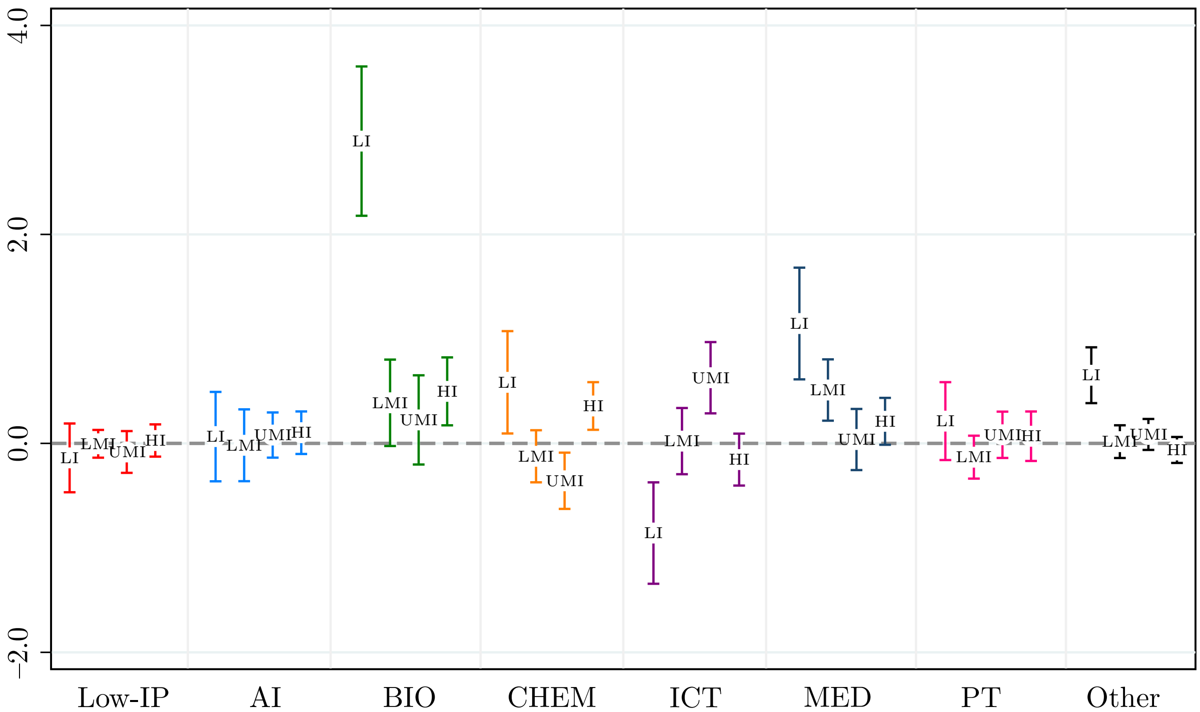
5b: TRIPS Exporter Effects



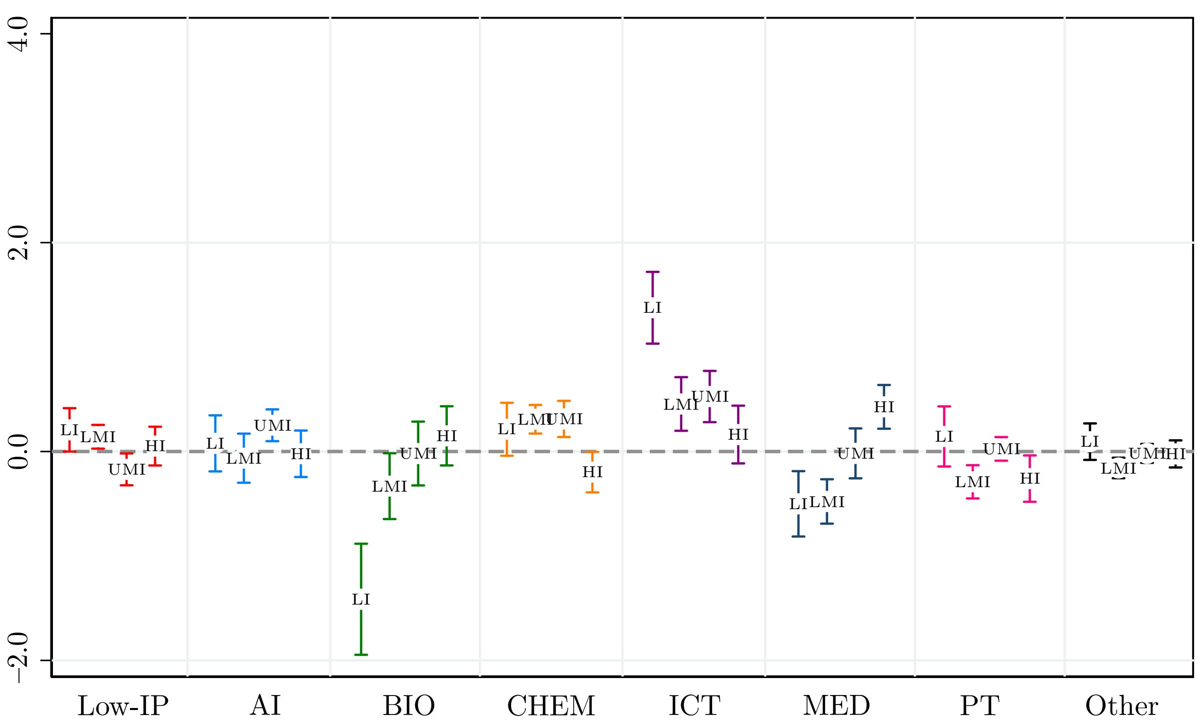
Notes: Each figure depicts the point estimates and associated 95% confidence intervals corresponding to the estimates in Table 7.

Figure 6: Bilateral Imports of High-IP Clusters

6a: IPA Importer Effects



6b: TRIPS Importer Effects



Notes: Each figure depicts the point estimates and associated 95% confidence intervals corresponding to the estimates in Table 7.

Table 8: Implied Economic Magnitudes of Aggregate Trade Effects (Million USD)

		(1) Low–IP	(2) AI	(3) BIO	(4) MED
Panel A: Exports					
IPA	LI	–2,419.62	**–58.84**	**266.45**	–2.28
		–27.89%	**–69.49%**	**164.85%**	–2.08%
	LMI	**–4,862.02**	15.82	**117.08**	**45.68**
		–39.53%	33.11%	**114.26%**	**65.37%**
	UMI	–7,810.02	**225.09**	189.64	78.70
		–34.56%	**93.29%**	56.67%	33.78%
	HI	**–18,517.89**	143.21	**15,793.37**	**1,076.10**
		–46.53%	8.00%	**255.02%**	**48.29%**
TRIPS	LI	–864.69	22.86	116.00	19.14
		–9.97%	27.00%	71.77%	17.47%
	LMI	**–5,189.31**	–7.31	55.37	8.91
		–42.19%	–15.30%	54.03%	12.75%
	UMI	**–11,687.05**	19.84	**460.10**	–111.24
		–51.71%	8.22%	**137.50%**	–47.74%
	HI	7,327.98	**1,679.39**	–2,008.37	924.39
		18.41%	**93.87%**	–32.43%	41.48%
Panel B: Imports					
IPA	LI	**–2,549.01**	**–54.01**	121.63	–13.77
		–36.75%	**–35.66%**	62.91%	–9.61%
	LMI	267.28	**–36.57**	–113.77	–18.38
		3.77%	**–25.02%**	–22.20%	–10.68%
	UMI	**4,640.53**	–14.20	61.94	–2.73
		44.20%	–4.21%	7.47%	–0.90%
	HI	**16,555.49**	–174.77	**1,742.68**	**539.43**
		29.56%	–12.01%	**33.64%**	**27.38%**
TRIPS	LI	473.29	6.81	–32.17	–20.21
		6.82%	4.50%	–16.64%	–14.10%
	LMI	**–776.64**	–28.86	–73.15	**–33.83**
		–10.95%	–19.75%	–14.27%	**–19.67%**
	UMI	–401.62	19.78	27.84	22.41
		–3.82%	5.87%	3.36%	7.36%
	HI	**–2,624.51**	491.32	–1,043.68	344.16
		–4.69%	33.78%	–20.15%	17.47%

Notes: The values in each cell give the implied economic effect of IPA or TRIPS accession on aggregate exports and imports (in million USD) evaluated at the average level of aggregate exports or imports by sector and income group. Bold entries indicate significance at at least the 10% level.

Table 9: Implied Economic Magnitudes of Bilateral Trade Effects (Thousand USD)

		(1) Low–IP	(2) AI	(3) BIO	(4) MED
Panel A: Exports					
IPA	LI	–4,766.25	36.36	227.50	**1,213.91**
		–12.28%	9.64%	31.26%	**252.54%**
	LMI	**–12,641.57**	**335.52**	**2,976.85**	**536.88**
		–23.28%	**155.74%**	**644.10%**	**170.47%**
	UMI	**–47,846.35**	**3,952.61**	**9,112.00**	**5,599.48**
		–52.67%	**363.67%**	**604.28%**	**532.18%**
	HI	**–35,262.13**	**4632.38**	**58,338.36**	**3,643.64**
		–19.91%	**58.57%**	**209.88%**	**36.75%**
TRIPS	LI	**–10,003.53**	**174.44**	–272.47	**–187.08**
		–25.77%	**46.23%**	–37.44%	**–38.92%**
	LMI	**–23,315.92**	**361.46**	**1,114.30**	**2,353.84**
		–42.94%	**167.78%**	**241.10%**	**747.40%**
	UMI	**–35,079.10**	**2,794.94**	**4,926.95**	**2,847.39**
		–38.61%	**257.16%**	**326.74%**	**270.62%**
	HI	**100,938.11**	1,428.28	**12,045.11**	**7,546.68**
		56.99%	18.06%	**43.33%**	**76.12%**
Panel B: Imports					
IPA	LI	**–7,109.28**	44.56	**14,848.21**	**1,272.50**
		–23.20%	6.72%	**1,704.74%**	**214.87%**
	LMI	–95.37	–11.72	**1,098.64**	**516.16**
		–0.30%	–1.78%	**47.40%**	**66.70%**
	UMI	–2,839.71	126.20	946.53	51.62
		–6.01%	8.33%	25.23%	3.77%
	HI	7,388.17	701.50	**15,083.63**	**2,079.25**
		2.94%	10.74%	**64.54%**	**23.49%**
TRIPS	LI	**7,923.49**	53.83	**–659.20**	**–233.37**
		25.86%	8.11%	**–75.68%**	**–39.41%**
	LMI	**5,004.89**	–40.74	**–653.10**	**–294.07**
		15.72%	–6.20%	**–28.18%**	**–38.00%**
	UMI	**–7,504.06**	**432.31**	–70.60	–24.43
		–15.89%	**28.53%**	–1.88%	–1.78%
	HI	17,667.89	–142.15	3,782.06	**4,728.17**
		7.04%	–2.18%	16.18%	**53.42%**

Notes: The values in each cell give the implied economic effect of IPA or TRIPS accession on bilateral exports and imports (in thousand USD) evaluated at the average level of bilateral exports or imports by sector and income group. Bold entries indicate significance at at least the 10% level.

5 Conclusion

IPRs provisions in preferential trade agreements have proliferated since their inception in the 1990s. The extent to which these provisions have influenced member countries' trade has gone largely unstudied and represents a potentially important area of inquiry. Focusing first on aggregate trade in high-IP sectors, our analysis suggest that controlling for TRIPS compliance, the additional effects of membership in an IP-related PTA generally seem to be limited. There are important variations across sectors, however. The most notable is that membership in IPAs does boost exports of biopharmaceutical goods and medical devices from high-income countries, suggesting that the emphasis of such agreements on special patent protection in medicines may be effective at encouraging trade. Moreover, exports of both biopharmaceuticals and information products seem to rise with membership in IPA among middle-income countries. Again, these are two areas that attract the most rigorous elements of protection in our treatment IPAs. In brief, IP-related PTAs are also "trade-related" in significant, if limited, ways. Moreover, these specific effects often dominate those coming simply from adherence to TRIPS, the multilateral framework for protecting intellectual property rights.

Moving to the analysis of detailed bilateral trade, with its far larger sample sizes, we find extensive evidence of significant impacts on trade flows of IPA membership. In these regressions both TRIPS and IPAs contribute to greater exports in biopharmaceutical products, medical devices, and analytical instruments. Again, these estimates capture impacts on trade with countries that are not members of the relevant preferential trade accords, suggesting that IP standards may encourage external trade. There is corresponding evidence of increased imports among lower-income and high-income economies in such sectors. In brief, the inclusion in trade agreements of prescriptive chapters establishing elevated standards for protection of intellectual property rights significantly expands trade in the sectors actually targeted by those rules. At the same time, it appears that trade in low-IP sectors is often diminished by this policy in comparison with trade in the control group of countries. In this regard, IPAs exert a form of conditional "comparative advantage" effect, shifting resources from low-IP goods to high-IP goods. This finding is new in the literature and raises the intriguing possibility that IPA membership can diminish trade in low-IP goods, even among lower-income economies.

The analysis here could be extended in potentially rewarding ways. Additional questions could be asked using the sectoral and bilateral trade data. For example, to what extent do the estimated effects represent increased trade of final goods versus intermediates as global supply chains respond to changes in relative institutional environments? The most important extension would be to investigate the channels through which IPRs chapters may affect measured trade. It is possible that IP-related PTAs have similar impacts on within-region FDI, which could supplement our findings. More fundamentally, it may be that IPRs provisions interact with investment rules, services liberalization, or other regulatory issues implicated by PTAs. Indeed, there may be complementary effects between tariff cuts and IPRs standards in driving high-technology trade. Ultimately, the new breed of regulation-intensive PTAs seems to be an important determinant of international policy environments, opening up useful areas for further research.

Notes

[1]The EU negotiates trade agreements as a single entity. While EFTA members (Iceland, Liechtenstein, Norway, and Switzerland) are empowered to strike bilateral deals, they share a coordinated trade policy that favors bargaining as a single bloc. Further, EFTA countries participate in the EU's single market.

[2]The decision by the Trump Administration to withdraw from the predecessor agreement, the Trans-Pacific Partnership, permitted the remaining members to moderate or suspend other TRIPS-Plus demands but IPRs protection remains a central principle of CPTPP.

[3]A recent paper by Campi and Duenas (2019) estimated a gravity model of bilateral trade and found evidence of a positive impact five years after signing such agreements. However, this effect seemed to hold for both high-intellectual property goods and low-intellectual property goods, raising some questions about the identification exercise.

[4]See Appendix Table A2 for the list of US-, EU-, and EFTA-negotiated IP-related agreements and their entry-into-force years.

[5]Our findings are robust to the alternative, in which a country's membership in active IP-related agreements between the EU and another party enters it into the treatment group, but not EU membership by itself.

[6]We combine the EU and EFTA agreements because there are fewer of them in the data than US-partnered PTAs. Note that Figure 2 incorporates only the IP-related PTAs that the EU and EFTA sign with other countries, not those among themselves, which is why there are slightly fewer agreements depicted than in Figure 1.

[7]For a full listing of the industrial classification and associated SITC Rev. 3 commodities codes, see Appendix Table A4. For details on the original US Patent and Trademark Office industrial classification, see U.S. Department of Commerce (2012), available at http://www.uspto.gov/.

[8]It is also worth noting that member and non-member countries within the UMI and LMI groups did not differ in their average levels of patent protection in 1995, as measured by the Ginarte-Park index, originally developed by Ginarte and Park (1997).

[9]This restriction implies that we do not include NAFTA, which was ratified prior to the TRIPS Agreement, in our regressions. However, we also estimate all regressions including NAFTA and find little difference in the results, which are available on request.

[10]This can be true for rich countries as well. For example, Australia's negotiators expressed reservations about elements of pharmaceuticals protection in their FTA with the United States (Maskus, 2012).

[11]A similar argument about developing countries taking on TRIPS obligations as an exogenous policy change within the broader market opportunities of the WTO is central to the identification in Delgado et al. (2013).

[12]Note that virtually all the IP-related PTAs in the sample are bilateral between the major partner and a single country. In just two agreements, CARIFORUM-EU and CAFTA, there are additional trading partners, all involving small trade flows, that we do not exclude from the estimation.

[13]For reasons discussed below, we transform equation (1) into an equivalent form that can recover all of these effects but which limits attention to the primary coefficients of interest. See equation (2).

[14]The beginning of this interval coincides with the ratification of the first IP-related PTAs, such as NAFTA, as well as the introduction of TRIPS and countries' subsequent compliance decisions. Furthermore, the interval extends sufficiently forward in time to incorporate even the most recent IP-related PTAs.

[15]For a full list of data descriptions and sources, see Appendix Table A1.

[16]See Appendix Table A3 for a full list of sample countries' income classifications.

[17]The λ_{gst} fixed effects control for the sector-specific, group-specific, and group-by-sector-specific effects that would otherwise need to be explicitly included in the specification.

[18]See Appendix 2 for a derivation of this equivalence.

[19]Note that the sectoral interactions with the log(GDP) term omit the interaction with the low-IP sector.

[20]In order to focus on trade with third countries we again exclude bilateral trade observations with the major IPA partner.

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Appendix 1

Table A1: Data Sources and Description

Variable	**Description**	**Data Source**
Trade flows	Trade flows in current USD by 6-digit HS code, 1995–2014	Gaulier and Zignago (2010)
GDP	GDP in current USD by country and year	World Bank (2016)
Income groups	Countries' income group classifications	World Bank (2016)
IPA	Entry-into-force years of preferential trade agreements	Dür et al. (2014)
TRIPS	Estimates of TRIPS compliance dates by country	Ginarte and Park (1997), Park (2008), and Hamdan-Livramento (2009)
Low-IP and high-IP industries	IP-intensive commodities by SITC Rev. 3 code	Delgado et al. (2013) based on U.S. Department of Commerce (2012)

Table A2: US, EU, and EFTA IP-related Preferential Trade Agreements and Entry-into-Force Years

Agreement	**Entry-into-force year**
Australia-US	2005
Bahrain-US	2006
Bulgaria-EFTA*	1993
CARIFORUM-EU	2008
Central American Free Trade Agreement	2006
Chile-US	2004
Colombia-EFTA	2011
Colombia-US	2012
EU-Macedonia	2001
EU-Turkey	1996
EFTA-Estonia	1996
EFTA-Latvia	2006
EFTA-Mexico	2001
EFTA-Slovenia	1995
European Free Trade Association	Varies by member
European Union	Varies by member
Jordan-US	2001
Morocco-US	2006
North American Free Trade Agreement*	1994
Oman-US	2009
Panama-US	2012
Peru-US	2009
Singapore-US	2004
South Korea-US	2012

Notes: * Indicates a pre-TRIPS IP-related PTA.

Table A3: Countries' Income Group Classifications

High income (HI, 38 countries)			
Andorra	Denmark	Italy	Singapore
Aruba	Finland	Japan	Spain
Australia	France	Kuwait	South Korea
Austria	French Polynesia	Macao	Sweden
Bahamas	Germany	Netherlands	Switzerland
Belgium	Greenland	New Caledonia	United Arab Emirates
Bermuda	Hong Kong	New Zealand	United Kingdom
Brunei	Iceland	Norway	United States
Canada	Ireland	Portugal	
Cyprus	Israel	Qatar	
Upper-middle income (UMI, 25 countries)			
Antigua and Barbuda	Czech Republic	Mauritius	St. Kitts and Nevis
Argentina	Gabon	Mexico	St. Lucia
Bahrain	Greece	Oman	Trinidad and Tobago
Barbados	Hungary	Saudi Arabia	Uruguay
Brazil	Libya	Seychelles	
Chile	Malaysia	Slovenia	
Croatia	Malta	South Africa	
Lower-middle income (LMI, 61 countries)			
Algeria	Fed. States of Micronesia	Marshall Islands	Solomon Islands
Belarus	Fiji	Moldova	St. Vincent and Grenadines
Belize	Grenada	Montenegro	Suriname
Bolivia	Guatemala	Morocco	Syria
Bulgaria	Indonesia	Palestine	Thailand
Cabo Verde	Iran	Panama	Tonga
Colombia	Iraq	Papua New Guinea	Tunisia
Costa Rica	Jamaica	Paraguay	Turkey
Cuba	Jordan	Peru	Turkmenistan
Djibouti	Kazakhstan	Philippines	Ukraine
Dominica	Kiribati	Poland	Uzbekistan
Dominican Republic	Latvia	Romania	Vanuatu
Ecuador	Lebanon	Russia	Venezuela
Egypt	Lithuania	Samoa	
El Salvador	Macedonia	Serbia	
Estonia	Maldives	Slovakia	
Low income (LI, 63 countries)			
Afghanistan	Comoros	Kenya	São Tomé and Príncipe
Albania	Congo	Kyrgyzstan	Senegal
Angola	Côte d'Ivoire	Laos	Sierra Leone
Armenia	Dem. Rep. of the Congo	Liberia	Somalia
Azerbaijan	Equitorial Guinea	Madagascar	Sri Lanka
Bangladesh	Eritrea	Malawi	Sudan
Benin	Ethiopia	Mali	Tajikistan
Bhutan	Gambia	Mauritania	Tanzania
Bosnia and Herzogovina	Georgia	Mongolia	Timor-Leste
Burkina Faso	Ghana	Mozambique	Togo
Burundi	Guinea	Nepal	Uganda
Cambodia	Guinea-Bissau	Nicaragua	Vietnam
Cameroon	Guyana	Niger	Yemen
Central African Republic	Haiti	Nigeria	Zambia
Chad	Honduras	Pakistan	Zimbabwe
China	India	Rwanda	

Notes: Groups reflect the country development level classification from the World Bank (2016) as given for the year 1995.

Table A4: Sectoral Definitions and Associated SITC Rev. 3 Codes and Descriptions

High-IP industries by mode of IPR-intensiveness	
Patent-intensive	
Crude fertilizers: 277, 278	Metalworking machinery: 73
Organic and inorganic chemicals: 51, 52	General machinery: 74139, 7421–3, 7427, 743–9
Dyeing materials: 53	Office machines: 75
Medicinal and pharmaceutical products: 54	Telecommunications: 76
Essential oils and perfume materials: 55	Electrical machinery: 77
Chemical materials and products: 59	Professional apparatus: 87
Rubber manufactures: 6214, 625, 6291–2	Photographic apparatus: 881–2, 884, 8853–4
Power-generating machinery: 71	Miscellaneous manufacturing: 8931, 893332, 8939, 8941–3, 8947, 8952, 89591, 897–9, 8991–6
Industrial machinery: 721–3, 7243, 7248, 725–8	
Trademark-intensive	
Dairy products and beverages: 022–4, 111, 1123	Manufactures of metal: 66494, 69561–2, 69564, 6966, 6973
Crude rubber: 231–2	
Pulp and waste paper: 251	Road vehicles: 784, 78531, 78536
Plastics: 57, 5813–7, 582–3	Furniture: 82
Paper and related articles: 64	Footwear: 85
Copyright-intensive	
Cinematographic film: 883	Printed matter & recorded media: 892, 8986–7
High-IP subsectors	
Analytical Instruments (AI)	Office machines: 7511–2, 7519, 75991–5
Laboratory instruments: 87325, 8742–3	Electrical and electronic components: 5985, 7722–3, 7731, 7763–8, 77882–4
Optical instruments: 8714, 8744	
Process instruments: 8745–6, 8749	***Medical Devices (MED)***
Biopharmaceuticals (BIO)	Diagnostic substances: 54192–3, 59867–9
Medicinal and pharmaceutical products: 5411–6, 54199, 542	Medical equipment and supplies: 59895, 6291, 774, 872, 8841
Chemicals (CHEM)	***Production Technology (PT)***
Chemically-based ingredients: 5513, 5922, 5972, 59899	Materials and tools: 2772, 2782, 69561–2, 69564
Dyeing and package chemicals: 531–2, 55421, 5977	Process and metalworking machinery: 711, 7248, 726, 7284–5, 73
Organic chemicals: 5124, 5137, 5139, 5145–6, 5148, 5156	General industrial machinery: 7413, 7417–9, 7427, 7431, 74359, 74361–2, 74367–9, 7438–9, 7441, 7444–7, 74481, 7449 7452–3, 74562–3, 74565–8, 74591, 74595–7, 746–7, 7482–3, 7486, 7492–9
Information and Communications Technology (ICT)	
Communications equipment: 7641, 76425, 7643, 76481, 7649, 77882–4	
Computers and peripherals: 752, 75997	
Low-IP sectors	
Animal and vegetable oils, fats, and waxes: 41–3	Manufactures of leather, cork and wood, minerals, or metal: 61, 63, 6511–4, 652, 654–9, 661–2, 6633, 6639 6641–5, 6648–9, 67, 6821–6, 68271, 683, 6841, 68421–6, 685–9, 6911–2, 69243–4, 6932–5, 694, 6975, 699
Food and live animals: 01, 03, 041–5, 05, 061, 071–2, 074–5, 08	
Inedible crude materials (except fuels): 21, 22, 244, 261–5, 289–9, 273, 28, 292–7, 29292–3, 29297–9	
Lubricants, mineral fuels, and related materials: 32–4	Miscellaneous: Prefabricated buildings (811–2), travel goods (83), and apparel and accessories (84)

Notes: From Delgado et al. (2013), based on U.S. Department of Commerce (2012).

Appendix 2

Equivalence of equations (1) and (2) (suppressing GDP and TRIPS terms for simplicity)

Treatment-control approach with heterogeneous treatment effects:

$$\begin{aligned}\log(TR_{ist}) = {} & \beta_1\, IPA_{it} + \sum_{g\neq LI} \beta_{2g}\, Group_{ig} \times IPA_{it} + \sum_{s\neq Low\text{-}IP} \beta_{3s}\, Sector_s \times IPA_{it} \\ & + \sum_{g\neq LI}\sum_{s\neq Low\text{-}IP} \beta_{4gs}\, Group_{ig} \times Sector_s \times IPA_{it} \\ & + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.\end{aligned} \tag{6}$$

$s = \{Low\text{-}IP, High\text{-}IP\}$, $g = \{LI, LMI, UMI, HI\}$

$Group_{ig}$ is an indicator for country i belonging to income group g, and $Sector_s$ is an indicator for a particular observation being for trade in sector s. The IPA_{it} terms give the DID treatment effects (implicitly assuming that treatment effects are "0/1" effects and are invariant to the year in which treatment is received, or time elapsed since treatment took place) and are interpreted as follows:

β_1	Effect of IPA membership on the Low-IP trade of LI countries.
β_{2g}	The difference in the effect of IPA membership on the Low-IP trade of LMI, HMI, or HI countries. For example $(\beta_1 + \beta_{2,LMI})$ is the total effect of IPA membership on the Low-IP trade of LMI countries.
β_{3s}	The difference in the effect of IPA membership on High-IP versus Low-IP trade for LI countries. For example $(\beta_1 + \beta_{3,High\text{-}IP})$ is the effect of IPA on the High-IP trade of LI countries.
β_{4gs}	The difference in the effect of IPA membership on the High-IP trade of LMI, HMI, and HI countries relative to their Low-IP trade and relative to LI countries. For example $(\beta_1 + \beta_{2,LMI} + \beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP})$ is the effect of IPA on the High-IP trade of LMI countries.

Note that the λ_{gst} terms (being a generalization of a λ_{gs}, or Sector × Group, fixed effect) control for the main effects of Group and Sector, as well as the effects of the double interactions of Group × Sector.

The above expression is equivalent to

$$
\begin{aligned}
\log\left(TR_{ist}\right) = & \sum_{g} \tilde{\beta}_{2g}\, Group_{ig} \times IPA_{it} + \sum_{s \neq Low\text{-}IP} \beta_{3s}\, Sector_{s} \times IPA_{it} \\
& + \sum_{g \neq LI} \sum_{s \neq Low\text{-}IP} \beta_{4gs}\, Group_{ig} \times Sector_{s} \times IPA_{it} \\
& + \lambda_{gst} + \lambda_{i}\, t + \varepsilon_{ist},
\end{aligned}
$$

from suppressing the main effect of IPA_{it} and including the $Group_g \times IPA_{it}$ interaction for LI countries. Here the $\tilde{\beta}_{2g}$ terms are the direct effects of IPA_{it} on Low-IP trade, broken down by income group, equivalent to the $(\beta_1 + \beta_{2g})$ terms above for the non-LI countries. The effect of IPA on the High-IP trade of LI countries would be measured by $\left(\tilde{\beta}_{2,LI} + \beta_{3,High\text{-}IP}\right)$, while $\beta_{4g,High\text{-}IP}$ measures the difference in the effect of IPA on the High-IP trade of LMI, UMI, and HI countries relative to the High-IP trade of LI countries. For example, the total effect of IPA on the High-IP trade of LMI countries would be measured by $\left(\tilde{\beta}_{2,LMI} + \beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP}\right)$, which is analogous to the effect $(\beta_1 + \beta_{2,LMI} + \beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP})$ in the previous specification.

In a similar fashion, the double interaction of $Sector_s \times IPA_{it}$ – which captures the difference in the effect of IPA on LI countries' High-IP trade relative to their Low-IP trade – can be suppressed by combining it with the triple interaction term:

$$
\begin{aligned}
\log\left(TR_{ist}\right) = & \sum_{g} \tilde{\beta}_{2g}\, Group_{ig} \times IPA_{it} \\
& + \sum_{s \neq Low\, IP} \tilde{\beta}_{4gs}\, Group_{ig} \times Sector_{s} \times IPA_{it} \\
& + \lambda_{gst} + \lambda_{i}\, t + \varepsilon_{ist}.
\end{aligned}
$$

Here, as before, $\tilde{\beta}_{2g}$ is the effect of IPA on Low-IP trade of a country belonging to income group g, and $\left(\tilde{\beta}_{2g} + \tilde{\beta}_{4g,High\text{-}IP}\right)$ is the effect of IPA on the High-IP trade of countries by group. Thus for this specification, for example, the total effect of IPA on the High-IP trade of LMI countries would be measured by $\left(\tilde{\beta}_{2,LMI} + \tilde{\beta}_{4,LMI,High\text{-}IP}\right)$, which is equivalent to $\left(\tilde{\beta}_{2,LMI} + \beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP}\right)$ from the previous specification.

Finally, the double interaction terms for $Group_g \times IPA_{it}$ can themselves be converted to triple interaction terms by introducing Low-IP versus High-IP interactions, i.e., by suppressing the main effect of $Group_g \times IPA_{it}$ and introducing an interaction with *Low-IP*:

This is the "fully-interacted" model:

$$\log(TR_{ist}) = \sum_g \tilde{\beta}_{2g}\, Group_{ig} \times Low\text{-}IP_s \times IPA_{it} + \sum_g \tilde{\tilde{\beta}}_{4g}\, Group_{ig} \times High\text{-}IP_s \times IPA_{it} + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}. \tag{7}$$

The $\tilde{\tilde{\beta}}_{4g}$ terms are equal to the $\tilde{\beta}_{2g}+\tilde{\beta}_{4gs}$ terms measuring effects on High-IP trade by group from the previous specification. This equation can be generalized to the High-IP industrial breakdown with the following specification:

$$\log(TR_{ist}) = \sum_g \sum_s \tilde{\tilde{\beta}}_{4gs}\, Group_{ig} \times Sector_s \times IPA_{it} + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}$$

for $s = \{Low\, IP, AI, BIO, \ldots\}$

Demonstrating the numerical equivalence (within rounding error) of each specification (omitting the reporting of the GDP and TRIPS terms for simplicity)

Difference-in-differences with heterogeneous treatment effects:

$$\begin{aligned}\log\left(TR_{ist}\right) = {} & \beta_1\, IPA_{it} + \sum_{g\neq LI} \beta_{2g}\, Group_{ig} \times IPA_{it} + \sum_{s\neq Low\text{-}IP} \beta_{3s}\, Sector_s \times IPA_{it} \\ & + \sum_{g\neq LI} \sum_{s\neq Low\text{-}IP} \beta_{4gs}\, Group_{ig} \times Sector_s \times IPA_{it} \\ & + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.\end{aligned} \tag{1}$$

Coefficient	Estimate	Effect	Implied Total Effect
β_1	–0.337	LI, Low-IP	$\beta_1 = -0.337$
$\beta_{2,LMI}$	–0.170	LMI, Low-IP	$\beta_1 + \beta_{2,LMI} = -0.337 - 0.170 = -0.507$
$\beta_{2,UMI}$	–0.090	UMI, Low-IP	$\beta_1 + \beta_{2,UMI} = -0.337 - 0.090 = -0.427$
$\beta_{2,HI}$	–0.221	HI, Low-IP	$\beta_1 + \beta_{2,HI} = -0.337 - 0.221 = -0.558$
$\beta_{3,High\text{-}IP}$	0.396	LI, High-IP	$\beta_1 + \beta_{3,High\text{-}IP}$ $= -0.337 + 0.396 = 0.059$
$\beta_{4,LMI,High\text{-}IP}$	0.672	LMI, High-IP	$\beta_1 + \beta_{2,LMI} + \beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP}$ $= -0.337 - 0.170 + 0.396 + 0.672 = 0.561$
$\beta_{4,UMI,High\text{-}IP}$	0.908	UMI, High-IP	$\beta_1 + \beta_{2,UMI} + \beta_{3,High\text{-}IP} + \beta_{4,UMI,High\text{-}IP}$ $= -0.337 - 0.090 + 0.396 + 0.908 = 0.877$
$\beta_{4,HI,High\text{-}IP}$	0.992	HI, High-IP	$\beta_1 + \beta_{2,HI} + \beta_{3,High\text{-}IP} + \beta_{4,HI,High\text{-}IP}$ $= -0.337 - 0.221 + 0.396 + 0.992 = 0.830$

Subsuming the main effect of IPA by including all groups in the $\boldsymbol{Group_g \times IPA_{it}}$ interaction:

$$\begin{aligned}\log\left(TR_{ist}\right) = & \sum_{g} \tilde{\beta}_{2g}\, Group_{ig} \times IPA_{it} + \sum_{s \neq Low\text{-}IP} \beta_{3s}\, Sector_s \times IPA_{it} \\ & + \sum_{g \neq LI} \sum_{s \neq Low\text{-}IP} \beta_{4gs}\, Group_{ig} \times Sector_s \times IPA_{it} \\ & + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist},\end{aligned}$$

Coefficient	**Estimate**	**Equivalent to**
$\tilde{\beta}_{2,LI}$	–0.337	$\beta_1 = -0.337$
$\tilde{\beta}_{2,LMI}$	–0.506	$\beta_1 + \beta_{2,LMI} = -0.337 - 0.170$
$\tilde{\beta}_{2,UMI}$	–0.426	$\beta_1 + \beta_{2,UMI} = -0.337 - 0.090$
$\tilde{\beta}_{2,HI}$	–0.558	$\beta_1 + \beta_{2,HI} = -0.337 - 0.221$
$\beta_{3,High\text{-}IP}$	0.396	
$\beta_{4,LMI,High\text{-}IP}$	0.672	
$\beta_{4,UMI,High\text{-}IP}$	0.908	
$\beta_{4,HI,High\text{-}IP}$	0.992	

Subsuming the double interaction of $\boldsymbol{Sector_s \times IPA_{it}}$ by including all groups in the $\boldsymbol{Group_g \times Sector_s \times IPA_{it}}$ interaction:

$$\begin{aligned}\log\left(TR_{ist}\right) = & \sum_{g} \tilde{\beta}_{2g}\, Group_{ig} \times IPA_{it} \\ & + \sum_{s \neq Low\, IP} \tilde{\beta}_{4gs}\, Group_{ig} \times Sector_s \times IPA_{it} \\ & + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}.\end{aligned}$$

Coefficient	**Estimate**	**Equivalent to**
$\tilde{\beta}_{2,LI}$	–0.337	
$\tilde{\beta}_{2,LMI}$	–0.506	
$\tilde{\beta}_{2,UMI}$	–0.426	
$\tilde{\beta}_{2,HI}$	–0.558	
$\tilde{\beta}_{4,LI,High\text{-}IP}$	0.396	$\beta_{3,High\text{-}IP} = 0.396$
$\tilde{\beta}_{4,LMI,High\text{-}IP}$	1.068	$\beta_{3,High\text{-}IP} + \beta_{4,LMI,High\text{-}IP} = 0.396 + 0.672$
$\tilde{\beta}_{4,UMI,High\text{-}IP}$	1.304	$\beta_{3,High\text{-}IP} + \beta_{4,UMI,High\text{-}IP} = 0.396 + 0.908$
$\tilde{\beta}_{4,HI,High\text{-}IP}$	1.388	$\beta_{3,High\text{-}IP} + \beta_{4,HI,High\text{-}IP} = 0.396 + 0.992$

Subsuming the double interaction of $Group_g \times IPA_{it}$ by including all sectors in the $Group_g \times Sector_s \times IPA_{it}$ interaction:

$$\log(TR_{ist}) = \sum_g \tilde{\beta}_{2g}\, Group_{ig} \times Low\text{-}IP_s \times IPA_{it} + \sum_g \tilde{\tilde{\beta}}_{4g}\, Group_{ig} \times High\text{-}IP_s \times IPA_{it} + \lambda_{gst} + \lambda_i\, t + \varepsilon_{ist}. \quad (2)$$

Coefficient	**Estimate**	**Equivalent to**
$\tilde{\beta}_{2,LI,Low\text{-}IP}$	–0.337	
$\tilde{\beta}_{2,LMI,Low\text{-}IP}$	–0.506	
$\tilde{\beta}_{2,UMI,Low\text{-}IP}$	–0.426	
$\tilde{\beta}_{2,HI,Low\text{-}IP}$	–0.558	
$\tilde{\tilde{\beta}}_{4,LI,High\text{-}IP}$	0.060	$\tilde{\beta}_{2,LI} + \tilde{\beta}_{4,LI,High\text{-}IP} = -0.337 + 0.396$
$\tilde{\tilde{\beta}}_{4,LMI,High\text{-}IP}$	0.562	$\tilde{\beta}_{2,LMI} + \tilde{\beta}_{4,LMI,High\text{-}IP} = -0.506 + 1.068$
$\tilde{\tilde{\beta}}_{4,UMI,High\text{-}IP}$	0.878	$\tilde{\beta}_{2,UMI} + \tilde{\beta}_{4,UMI,High\text{-}IP} = -0.426 + 1.304$
$\tilde{\tilde{\beta}}_{4,HI,High\text{-}IP}$	0.830	$\tilde{\beta}_{2,HI} + \tilde{\beta}_{4,HI,High\text{-}IP} = -0.558 + 1.388$