Essays in International Trade, Intellectual Property Rights, and Technology Transfer

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Essays on International Trade, Intellectual Property Rights, and Technology Transfer

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Abstract

In the first study, I investigate how preferential trade agreements (PTAs) with complex chapters covering IPRs affect the composition of members' aggregate trade flows, focusing on high-technology sectors. Despite the proliferation of PTAs with strong IPRs standards, their effect on such trade has not been studied systematically. The identification framework defines treatment PTAs as those in which one partner is the United States or either the European Union or European Free Trade Association—economies that include the most substantive IPRs provisions in the PTAs that they negotiate. The results are broken down by income groups and trade in specific IP-sensitive sectors. I find that the addition of IPRs chapters with elevated regulatory standards into PTAs has relatively limited total effects on trade, but strongly encourages trade in biopharmaceutical goods. There are additional important but heterogeneous cross-border impacts, suggesting that "behind the border" regulations within PTAs do influence trade.

In the second study, I extend the analysis of the first to assess the existence of IPR policy spillover effects on PTA members' trade with partners outside of the PTA. Using a panel of bilateral trade data in a gravity framework, I analyze PTA members' bilateral trade along both the intensive and extensive margins. Countries that enter into IPR-related PTAs with the United States or Europe exhibit a significant restructuring of their patterns of trade relative to otherwise similar countries that do not, in both exports and imports and along both margins.

The third study unpacks the issues surrounding joint ventures and technology transfer in China. I first explore the selection of Chinese partners that form joint ventures. Second, I find evidence for technology transfer to Chinese joint venture partner firms. Third, I investigate whether joint ventures generate externalities to other Chinese firms, finding that such externalities are positive and large, perhaps twice the size of wholly-owned FDI spillovers. Furthermore, the positive external effect is largest if the foreign firm is from the United States, and this effect is virtually absent in broad sectors that include economic activities for which China's FDI policy has prohibited joint ventures.

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Chapter 1

Introduction

International trade is increasingly trade in embodied knowledge. High-technology, research-intensive goods (advanced electronics, pharmaceuticals, medical and surgical devices, etc.) embody substantial R&D, knowledge assets, and other investments. The extent to which the owners of intellectual property (IP) can realize the benefits from ownership of their knowledge assets, then, plays a significant role in the decisions that IP owners make with regard to any number of economic outcomes—for instance, which markets to serve, how to serve these markets, and where to locate production and research activities. At this basic level, international policies that shape domestic intellectual property rights (IPRs) regimes will be a determinant of the patterns of trade, though the effect of the former on the latter is not accompanied by any unambiguous predictions.

Flows of foreign direct investment (FDI) are likewise beholden to similar considerations. Multinational enterprises (MNEs) must choose which markets to serve, weighing the respective costs and benefits that arise from exporting versus local production versus licensing. IPRs are, of course, an integral component of this consideration, as the ability of foreign investors to protect their proprietary knowledge assets plays a first-order role in such decisions.

And beyond the arena of IPRs, foreign investors must consider other regulatory issues that arise from entering destination markets—for instance, restrictions on the scope or types of FDI that can be conducted—which will in turn affect the patterns of global investment. As one of the principal arguments for developing countries to encourage FDI is based on the knowledge externalities and technology transfer that they engender, it is important to quantify the efficacy of different investment policy regimes in giving rise to such benefits.

A full appraisal of the effects of globalization requires thoughtful consideration of the impacts of trade and investment policy. And in designing efficient regulatory regimes, policymakers should have a nuanced understanding of the interplay between policy and variables such as trade, investment, and technology transfer, and in this dissertation, I investigate the way in which several important policy environments shape such outcomes.

The studies in Chapters 2 and 3 consider the role of IPR provisions in trade agreements in influencing trade patterns. IPRs chapters in recent trade agreements have effected a substantial upgrading of the IPRs regimes of the countries that adhere to them. Specifically, I consider those trade agreements negotiated by the United States, the European Union, or the European Free Trade Association, which tend to possess the strongest IPRs chapters.

In considering the effects of membership in such trade agreements—and the accompanying adoption of the rigorous IPR standards that they entail—on member countries' trade, these studies produce several key findings. First, accession to an IPR-related PTA expands the aggregate exports of trade agreement members in knowledge-intensive sectors, which tend to rely most heavily on effective enforcement of IPRs. Sectoral composition is a crucial component of this result, as the results are most pronounced in biopharmaceutical trade. Second, in considering the average bilateral trade of trade agreement members I find that membership is associated with measurable impacts on several trade outcomes. On the intensive margin of trade, the value of exports and imports in particular knowledge intensive sectors expands. I also consider the extensive margin, finding that an increase in the number of unique traded product varieties arises from membership in IP-related PTAs. These results are sensitive to the development levels of trading partners.

In Chapter 4, I consider the role of China's policy of requiring international joint ventures (IJVs) in facilitating technology transfer to Chinese firms. IJVs (business partnerships between firms headquartered in different countries to form a new commercial entity) represent a major vehicle for FDI, particularly in China. China's objective in maintaining requirements for IJVs in particular industries is to encourage technology transfer from advanced economies, but the extent to which this policy has been effective is little-understood.

This study can be summarized by several main results. First, in exploring the selection of domestic partners to form IJVs, I find that foreign investors pick Chinese partners that are on average more productive, larger, more innovative, export-oriented, and government-connected. Such well-established partners help promote the success of the IJV. Second, I consider what I denote "intergenerational effects," finding that not only do the IJVs themselves benefit from technology transfer (as measured by several firm performance measures), but the domestic Chinese partners—the “parents” of the joint venture—do as well. Lastly, I investigate the existence of knowledge externalities arising from IJVs, finding that other Chinese firms in industries with a higher presence of IJVs benefit from the dissemination of foreign know-how.

Chapter 2

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

The international framework for protecting 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

[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 Adminstration 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.

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 I undertake in this study. Specifically, I 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 trade, controlling for compliance with TRIPS standards.

As discussed in Section 2.3 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, 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 IPR-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 IPR-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 I hope to begin filling with this study.[3] Specifically, I 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. I 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), I 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, this study 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.

Traditional studies of PTAs consider reductions in trade barriers between members as the primary policy impact of 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

[3] A recent working paper by Campi and Dueñas (2017) 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.

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 study I study the effects of membership in IPR-related PTAs, negotiated with strong demandeur countries, on trade in goods that intensively use intellectual property, accounting for levels of per-capita income. I estimate impacts on member nations' aggregate trade in IP-intensive sectors, using a difference-in-differences approach comparing treatment agreements with a control group. I then consider bilateral trade flows in these sectors in a gravity context. I adopt successively more rigorous specifications to deal with endogenous selection into such agreements. In general, I 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.

The remainder of the chapter is organized as follows. Section 2.1 provides historical background on the development of PTAs with strong intellectual-property chapters, which I call IPR-related PTAs, and gives an overview of their scope and coverage. It also briefly revisits the ambiguous theory surrounding IPRs. Section 2.2 describes the empirical framework and Sections 2.4 and 2.5 provide estimates of the effects of IPR-related PTAs on aggregate and bilateral imports and exports at the sectoral level. Section 2.6 discusses some implications of the results and presents concluding remarks.

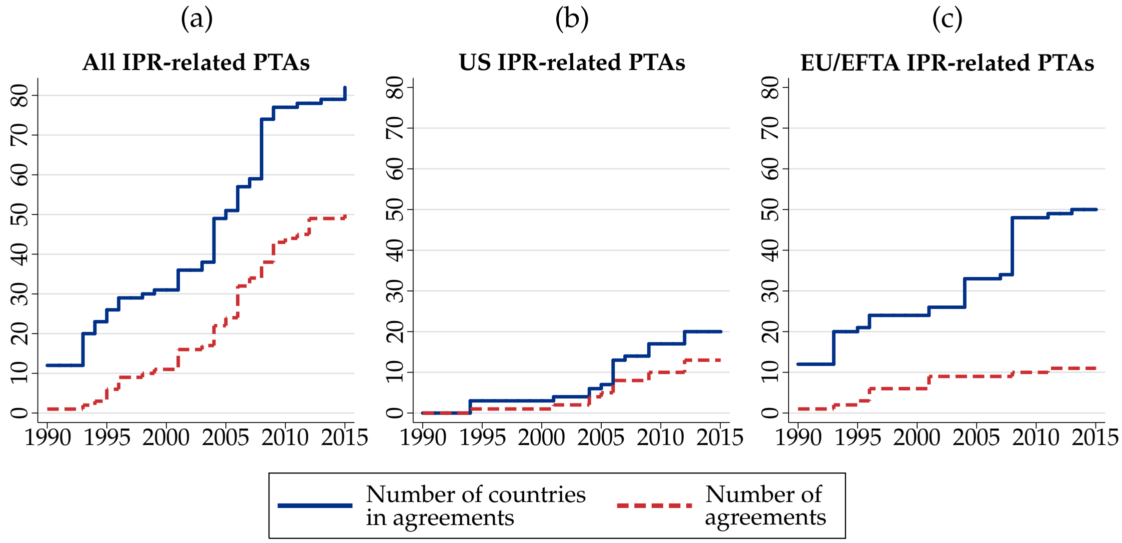
2.1 Background

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 I nt 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 2.1a illustrates the persistent growth after 1993 in the number

Figure 2.1: Number of IPR-related PTAs and Number of Countries With Membership in One or More IPR-related PTAs, 1990 to 2015



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

of PTAs that are "IPR-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 2.1b and 2.1c, in contrast, show the growth in IPR-related PTAs involving the US, the EU, or EFTA. There were 24 such agreements by 2015 (listed in Table 2.1), involving 70 countries. Owing to the high degree of standards harmonization in IPRs, I classify the EU itself as an IPR-related trade agreement in the sample.[4] As noted, these PTAs involve more extensive expectations about standards and enforcement. Thus, I focus the 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,

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

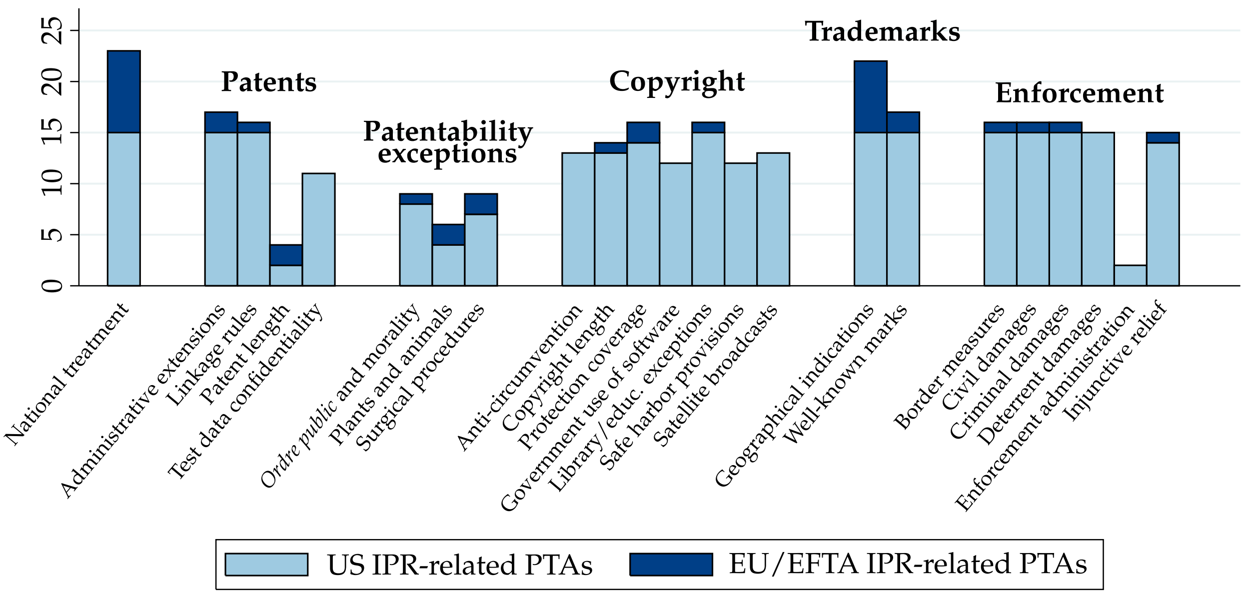
Table 2.1: US, EU, and EFTA IPR-related Preferential Trade Agreements

Agreement Name	Entry-into-force Year
US agreements	
North American Free Trade Agreement (NAFTA)	1994
Jordan-USA	2001
Chile-USA	2004
Singapore-USA	2004
Australia-USA	2005
Bahrain-USA	2006
Central American Free Trade Agreement (CAFTA)	2006[1]
Morocco-USA	2006
Oman-USA	2009
Peru-USA	2009
Colombia-USA	2012
Panama-USA	2012
South Korea-USA	2012
EU/EFTA agreements	
European Free Trade Association (EFTA)	Varies by member[2]
European Union	Varies by member
Bulgaria-EFTA	1993
Slovenia-EFTA	1995
Estonia-EFTA	1996
Turkey-EU	1996
Macedonia-EU	2001
Mexico-EFTA	2001
Latvia-EFTA	2006
CARIFORUM-EU	2008
Colombia-EFTA	2011

[1] For most countries in CAFTA, the entry-into-force year was 2006. The entry-into-force years for the Dominican Republic and Costa Rica were 2007 and 2009, respectively.
[2] EFTA's membership has been fluid, with several countries entering and leaving the agreement over time (e.g. Sweden or the United Kingdom). Since the sample that will be used in the empirical analysis begins in 1995, and EFTA's four current members (Iceland, Liechtenstein, Norway, and Switzerland) joined in 1995, EFTA's membership remains fixed for the period of the analysis.

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 I exploit in the econometric analysis. The point here is that different countries likely negotiate agreements to emphasize

Figure 2.2: Number of IPR-related Trade Agreements by Presence of Specific Provisions



Source: Author's construction.

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 2.2 sheds light on specific provisions found in IPR-related trade agreements reached by these entities, cumulated across them.[5] 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 IPR-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

[5] I combine the EU and EFTA agreements because there are far fewer of them in the data than US-partnered PTAs.

US-involved PTAs allow parties to exempt from patentability plants and animals, surgical or therapeutic procedures, or inventions that disrupt *ordre public*. The EU 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 IPR-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.

2.2 Hypotheses

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, 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. (2017) 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 cutoffs 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, IPR-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 I test statistically and for which I find specific and robust evidence.

2.3 Empirical Framework

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, the objective in the empirical analysis is to uncover what effects membership in IPR-related trade agreements has had on countries' aggregate imports and exports.

Regarding aggregate trade, I adopt a treatment-control econometric framework, where I 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 IPR-related PTA at any point during the sample, and control countries are all others. I take the 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.[6] Finally, because the effects of changes in IPRs regimes might vary by countries' comparative development levels, I later allow for any effect of membership in IPR-related trade agreements to vary by discrete income groups.

As detailed in Section 2.2, IPR-related PTAs cover multiple aspects of IPRs and vary in their specific regulatory provisions. Therefore, to add depth to the empirical analysis I later break down the sectoral classification. Specifically, I classify goods according to specific high-IP industry clusters as noted below. In all cases I 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.

Table 2.2 presents the characteristics of treatment ("member") vs. control ("non-member") countries. 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 aggregate values of high-IP and low-IP exports and imports. 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 IPR-related PTAs simply because

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

Table 2.2: Sample Summary Statistics for Year 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 current 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. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

they had initially high or low levels of trade in products that are sensitive to intellectual property protection.[7]

With this background, identification relies on three types of variation. First, during the sample some countries entered into IPR-related trade agreements, as I define them below, while others did not (note that countries rarely exit PTAs once they have joined). I 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 I distinguish between sectors

[7] 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.

in terms of their apparent relative usage of intellectual property, comparing high-IP industries with the low-IP reference group, with increasingly more specific definitions of IP-using industries as I 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 I refer to the primary regressions as "aggregate trade" the analysis is done with particular sectoral breakdowns. I use the term aggregate because I do not focus in those cases on bilateral trade impacts between country pairs. The third important element for identification is to control for TRIPS adherence. As noted above, most countries in the sample became compliant with TRIPS at some point in the period, which may have happened before or after their joining an IPR-related PTA. In order clearly to isolate the PTA effect, therefore, the preferred specification defines treatment countries as those which joined an IPR-related PTA only after they complied with TRIPS.

An obvious challenge to this identification strategy arises if the causality between trade and IPRs works in two directions. On the one hand, IPR-related PTAs might increase members' trade over and above TRIPS, the basic effect I 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 IPR-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 IPR-related PTAs in the 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.[8] Put differently, for such countries IPRs are second-order negotiating concessions that they would not ordinarily select as a matter of endogenous policy.[9] While this factor does not ensure that the IPRs effect I 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 I estimate specifications in which I 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. I 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.

2.4 Trade in High-IP Goods

Equation (2.1) describes the baseline regression approach, which is estimated separately for imports and exports:

$$\begin{aligned} \log(T_{ist}) = {} & \beta_1 \log(GDP_{it}) + \beta_2\, High\text{-}IP_s \times \log(GDP_{it}) \\ & + \beta_3\, IPA_{it} + \sum_g \beta_{4g}\, Group_i \times IPA_{it} + \sum_g \beta_{5g}\, Group_i \times High\text{-}IP_s \times IPA_{it} \\ & + \beta_6\, TRIPS_{it} + \sum_g \beta_{7g}\, Group_i \times TRIPS_{it} + \sum_g \beta_{8g}\, Group_i \times High\text{-}IP_s \times TRIPS_{it} \\ & + \alpha_{gst} + \alpha_i t + \varepsilon_{ist} \end{aligned} \quad (2.1)$$

The dependent variable, $\log(T_{ist})$, 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 IPR-related FTAs that has occurred in recent decades as well as contem-

[8] 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).

[9] 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).

poraneous changes in IPR policy at the international level, the sample period covers the years 1995 to 2014.[10] Because of the positive relationship between economic size and trade volume, I include $\log(GDP_{it})$, country i's GDP in year t. I also allow for the trade elasticity with respect to size to vary across sectors via the inclusion of $High\text{-}IP_s \times \log(GDP_{it})$. I obtain the data on countries' yearly trade flows and national income levels from, respectively, CEPII's BACI dataset from Gaulier and Zignago (2010) and World Bank (2016).[11]

The key variable is designed to incorporate cross-country differences in accession to IPR-related trade agreements. For this purpose, I introduce the variable IPA_{it} (for IPR-related agreement), which takes a value of 0 for the years in which country i is not party to an IPR-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. Note that β_3 is a coefficient of particular interest, in that it captures the difference in low-IP trade for IPR-related PTA members compared to those not party to such an agreement.

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, I also explore the role of differences in income in determining the trade of member countries by interacting group-level indicator variables for specific income groups with IPA and also with the high-IP indicator. I consider whether the effects of membership in IPR-related PTAs, as well as TRIPS compliance, are heterogeneous across income levels in addition to the sectoral dependence on IPRs. To define income groups I take the World Bank's classification of economies as low-income (LI), lower-middle-income (LMI), upper-middle-income (UMI), and high-income (HI).[12] I 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

[10] The beginning of this interval coincides with the ratification of the first IPR-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 IPR-related PTAs.

[11] For a full list of data descriptions and sources, see Appendix Table A.1.

[12] See Appendix Table A.2 for a full list of sample countries' income classifications.

with income group, permitting heterogeneous coefficients across development levels. Thus, note that β_{4g} represents the direct effect of the IPA variable for income group g and β_{5g} captures the high-IP interaction effect with the policy treatment IPA. Coefficients β_{7g} and β_{8g} represent the corresponding effects of TRIPS compliance. The regressions carefully define the timing of the treatment group. Specifically, I use countries that enter such an agreement only after they come into compliance with TRIPS.[13]

Recalling that the central question is whether IPR-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, I 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. Thus, I model these countries as not having adhered to TRIPS for the duration of the sample. These TRIPS-related controls and interactions allow us to separate the variation in aggregate trade attributable to IPR-related PTAs from that attributable to TRIPS compliance.

Finally, I control for unobservable factors that may affect aggregate trade volumes and may be correlated with the IPA policy variable. First, I 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 α_{gst}. Note that the definition of sector or commodity type s will vary with the particular specification, as discussed below. I also incorporate country time trends $\alpha_i t$, which control for unobservable national factors affecting trade over time. This case with the

[13] I also run a full set of regressions permitting all IPA interactions where I distinguish between agreements in force before ("pre") and after ("post") TRIPS, which yield consistent results and are available on request.

post-TRIPS treatment definition, is credibly the most rigorous specification and I will rely on it in the regressions I describe next.

While the regression results from this specification are recoverable, it is tedious to present all of them. Because the primary interest is in the total effects of the policy variables on Group × Sector trade, I find 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 (including the low-IP control group) in the triple interactions. This approach yields coefficients that indicate the total impact of a policy on the group and sector. Thus, the specification I estimate is:

$$\begin{aligned}\log(T_{ist}) = {} & \beta_1 \log(GDP_{it}) + \sum_s \beta_{2s}\, High\text{-}IP_s \times \log(GDP_{it}) \\ & + \sum_g \sum_s \beta_{gs}\, Group_i \times High\text{-}IP_s \times IPA_{it} \\ & + \sum_g \sum_s \beta_{gs}\, Group_i \times High\text{-}IP_s \times TRIPS_{it} \\ & + \alpha_{gst} + \alpha_i t + \varepsilon_{ist}\end{aligned} \tag{2.2}$$

I report the regression results for equation (2.2) in Table 2.3. In all regressions I report robust standard errors, which are clustered by country. The first column in each table presents the baseline regressions, including all countries in the sample. Succeeding columns eliminate trade with partner countries. In column 2 exports or imports of each treated country with all of its IPA partners (current or future) excluded. In column 3 trade flows with the current or future major demandeur trade partner (the US, EU, or EFTA) are excluded.[14] 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 the indicator for high-IP goods, suggesting that both trade flows are more elastic with respect to total demand than are low-IP sectors. I find in Table 2.3 that exports of low-IP goods are significantly reduced among LI and LMI countries that are in a treatment IPR-related PTA. This finding holds also for HI countries. Thus, these agreements seem to repress exports in goods that are less reliant on IP protection compared to other sectors. In contrast, there

[14] In this case EU partner countries are defined as those members existing in the contemporaneous year.

Table 2.3: Aggregate Trade in High-IP vs. Low-IP Sectors

	Exports		Imports	
	(1)	(2)	(3)	(4)
	Total	Total net of partner trade	Total	Total net of partner trade
log(GDP)	0.753***	0.722***	0.545***	0.526***
	(0.102)	(0.106)	(0.045)	(0.043)
High-IP × log(GDP)	0.140**	0.129**	0.084***	0.080***
	(0.061)	(0.064)	(0.015)	(0.017)
Low-IP × LI × IPA	–0.322	–0.327	–0.444**	–0.458**
	(0.291)	(0.246)	(0.172)	(0.184)
Low-IP × LMI × IPA	–0.549***	–0.503***	–0.083	0.037
	(0.170)	(0.174)	(0.091)	(0.109)
Low-IP × UMI × IPA	–0.621**	–0.424	0.165	0.366**
	(0.312)	(0.322)	(0.139)	(0.175)
Low-IP × HI × IPA	–0.528	–0.626*	0.175**	0.259***
	(0.335)	(0.346)	(0.088)	(0.099)
High-IP × LI × IPA	–0.072	0.049	–0.212**	–0.104
	(0.573)	(0.552)	(0.105)	(0.107)
High-IP × LMI × IPA	0.355*	0.559***	–0.136*	–0.228**
	(0.199)	(0.202)	(0.071)	(0.088)
High-IP × UMI × IPA	0.618**	0.875***	–0.000	0.021
	(0.278)	(0.329)	(0.095)	(0.160)
High-IP × HI × IPA	0.793***	0.897***	0.111	–0.039
	(0.299)	(0.308)	(0.101)	(0.127)
Low-IP × LI × TRIPS	–0.105	–0.136	0.066	0.075
	(0.207)	(0.211)	(0.089)	(0.088)
Low-IP × LMI × TRIPS	–0.548**	–0.594***	–0.116	0.004
	(0.216)	(0.218)	(0.072)	(0.079)
Low-IP × UMI × TRIPS	–0.728***	–0.725***	–0.039	0.001
	(0.255)	(0.271)	(0.080)	(0.082)
Low-IP × HI × TRIPS	0.169	0.149	–0.048	–0.079
	(0.480)	(0.484)	(0.154)	(0.158)
High-IP × LI × TRIPS	0.030	0.053	0.007	0.019
	(0.235)	(0.235)	(0.080)	(0.080)
High-IP × LMI × TRIPS	0.225	0.268	–0.058	–0.082
	(0.213)	(0.216)	(0.057)	(0.061)
High-IP × UMI × TRIPS	0.641**	0.776***	0.137	0.059
	(0.254)	(0.268)	(0.089)	(0.116)
High-IP × HI × TRIPS	0.094	0.092	0.118	0.086
	(0.419)	(0.421)	(0.122)	(0.125)
Observations	7,132	7,132	7,132	7,132
Number of countries	187	187	187	187
R^2	0.926	0.912	0.978	0.971
Country trends	✓	✓	✓	✓
Group-sector-year FE	✓	✓	✓	✓

Notes: Estimation method is OLS. Dependent variable is log (exports) in columns (1) and (2) and log (imports) in columns (3) and (4). Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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.

I find in Table 2.3 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 IPR-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 when trade with the major partner is excluded in the final column. This result, that imports of high-IP goods from third countries are diminished in developing countries, stands in contrast with prior literature, which largely conidered only such imports from OECD economies in total, as opposed to those associated with PTAs, without controlling appropriate for exclusion effects. Thus, the initial evidence suggests that, controlling for TRIPS, IPR-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 IPR-related PTAs.

2.5 Trade in High-IP Industry Clusters

The analysis in the previous section demonstrates how the effects of IPR-related PTAs membership vary by income groups, focusing on aggregate 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, $Sector_s$ denotes IPRs-intensive industry clusters as defined in Delgado et al. (2013), based on Porter (2003) and US Department of Commerce (2012). The 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). Analogous to equation (2.2), equation (2.3) describes the relationship between aggregate sectoral imports or exports and the income group- and sector-specific effects for both IPA and $TRIPS$:

$$\begin{aligned}\log(T_{ist}) = {} & \beta_1 \log\left(GDP_{it}\right) + \sum_s \beta_{2s}\, Sector_s \times \log\left(GDP_{it}\right) \\ & + \sum_g \sum_s \beta_{gs}\, Group_i \times Sector_s \times IPA_{it} \\ & + \sum_g \sum_s \beta_{gs}\, Group_i \times Sector_s \times TRIPS_{it} \\ & + \alpha_{gst} + \alpha_i t + \varepsilon_{ist}\end{aligned} \tag{2.3}$$

The regression results for equation (2.3) are in Table 2.4 for the aggregate export regressions. 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, I find that IPA membership reduces exports of low-IP goods (the control group) 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

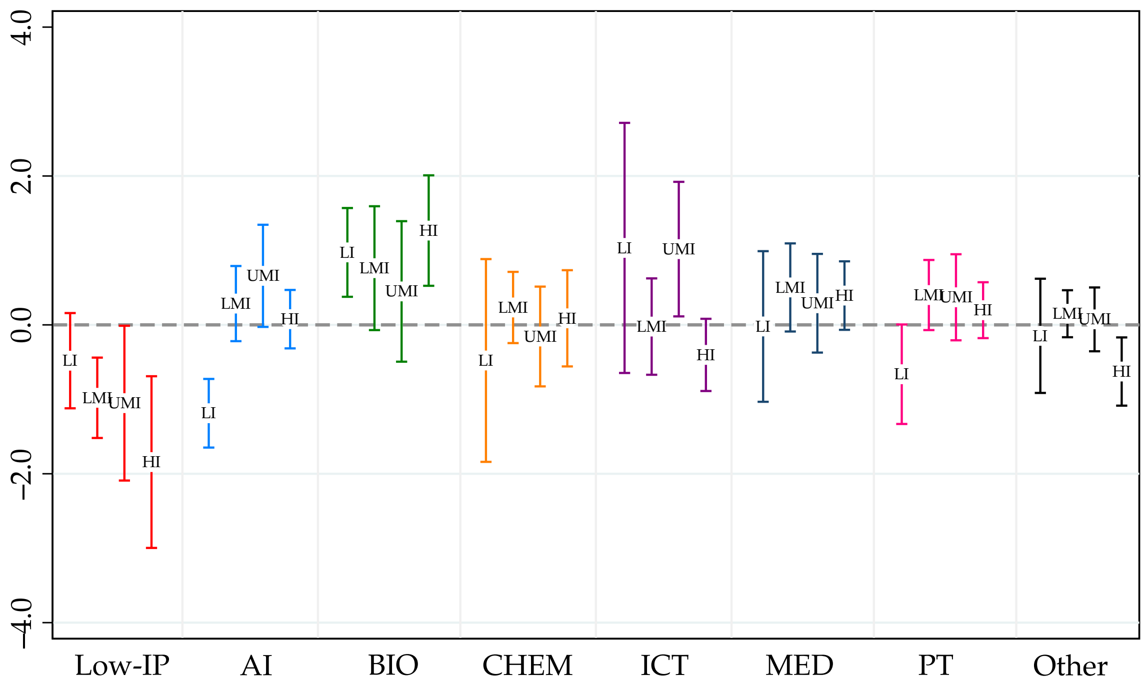
Table 2.4: Aggregate Exports in High-IP Clusters

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT
log(GDP)	0.446***						
	(0.097)						
Sector × log(GDP)		0.112*	0.185***	0.234***	0.139	0.186**	0.176***
		(0.065)	(0.066)	(0.075)	(0.085)	(0.072)	(0.059)
Sector × LI × IPA	–0.344	–1.368***	0.488	–0.351	1.605	–0.370	–1.060***
	(0.432)	(0.291)	(0.350)	(0.390)	(1.250)	(0.739)	(0.335)
Sector × LMI × IPA	–0.919***	0.094	0.502	0.090	–0.075	0.425	0.192
	(0.263)	(0.245)	(0.422)	(0.246)	(0.342)	(0.260)	(0.230)
Sector × UMI × IPA	–1.207**	0.440	0.357	–0.566*	0.760*	0.169	0.103
	(0.486)	(0.383)	(0.481)	(0.323)	(0.422)	(0.349)	(0.291)
Sector × HI × IPA	–1.713***	0.184	1.285***	0.269	–0.174	0.550**	0.144
	(0.654)	(0.222)	(0.441)	(0.393)	(0.307)	(0.257)	(0.220)
Sector × LI × TRIPS	–0.079	0.248	0.543*	0.032	0.287	0.190	0.229
	(0.361)	(0.239)	(0.319)	(0.297)	(0.248)	(0.261)	(0.211)
Sector × LMI × TRIPS	–0.906**	–0.159	0.257	0.211	0.176	0.156	–0.251
	(0.368)	(0.180)	(0.363)	(0.254)	(0.275)	(0.257)	(0.170)
Sector × UMI × TRIPS	–1.938**	–0.001	0.566	1.000**	0.153	–0.764	0.056
	(0.836)	(0.208)	(0.367)	(0.393)	(0.365)	(0.750)	(0.197)
Sector × HI × TRIPS	0.386	0.613***	–0.368	0.712*	0.354	0.288	0.362
	(0.725)	(0.198)	(0.629)	(0.403)	(0.290)	(0.296)	(0.298)
Observations							24,423
Number of Countries							187
R^2							0.912
Country trends							✓
Group-sector-year FEs							✓

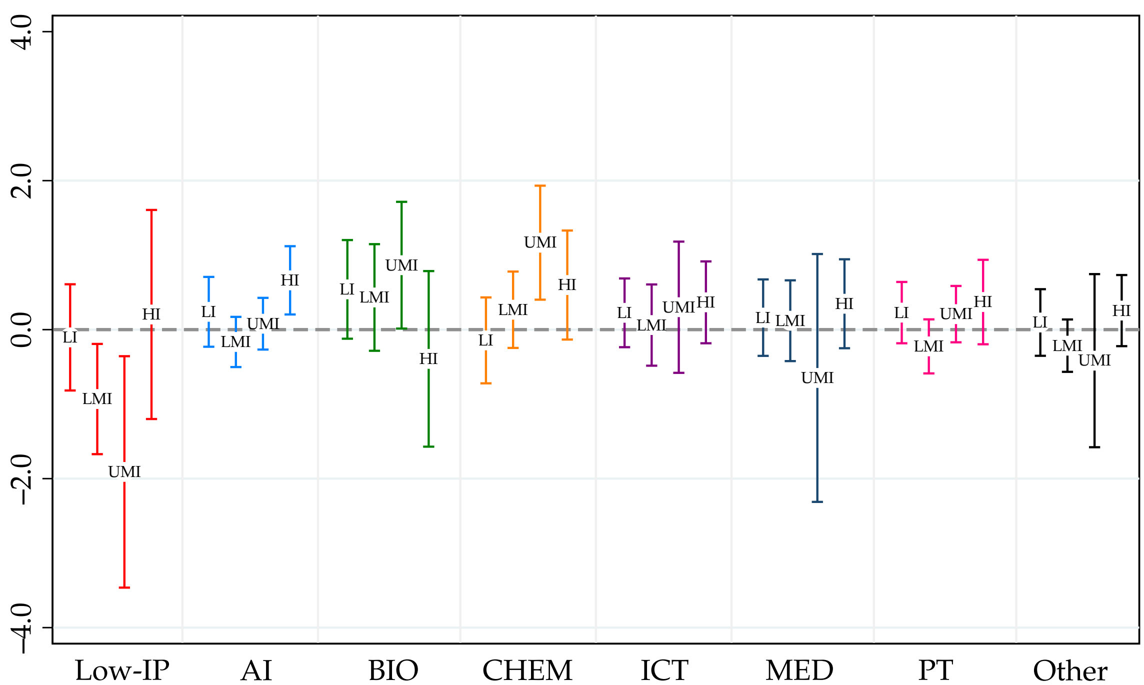
Notes: Columns (1)–(7) are from a single regression corresponding to equation (2.3). Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 2.3: Total Effects of IPA and TRIPS by Sector and Income Group: Aggregate Exports

2.3a: IPA Exporter Effects



2.3b: TRIPS Exporter Effects



Notes: For each subsector, the label in the center of the confidence band indicates the location of the point estimate of the coefficient on IPA or $TRIPS$ for countries in the indicated income group. The confidence bands correspond to the 95% confidence intervals on the estimates of each coefficient.

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 2.3a and 2.3b, which show 95% confidence intervals around coefficient estimates. The picture overall is one in which trade is little affected by membership in IPR-related PTAs and TRIPS but there are export-enhancing effects in specific sectors and country groups.

The aggregate imports results are in Table 2.5. With this breakdown, aggregate imports in LI and LMI countries are diminished significantly by IPA membership in AI, MED, and PT. In contrast, BIO imports are significantly raised among high-income economies, meaning that trade in both directions rises among such countries in pharmaceuticals within such agreements. Again, I 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 2.4a and 2.4b.

2.6 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. The analysis turns up a largely negative outcome: controlling for TRIPS compliance, the additional effects of membership in an IPR-related PTA generally seem to be insignificant using detailed trade data. That must be the primary conclusion of this analysis at this point. 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 the treatment IPAs. In brief, IPR-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.

The analysis here could be extended in several potentially rewarding ways. Additional ques-

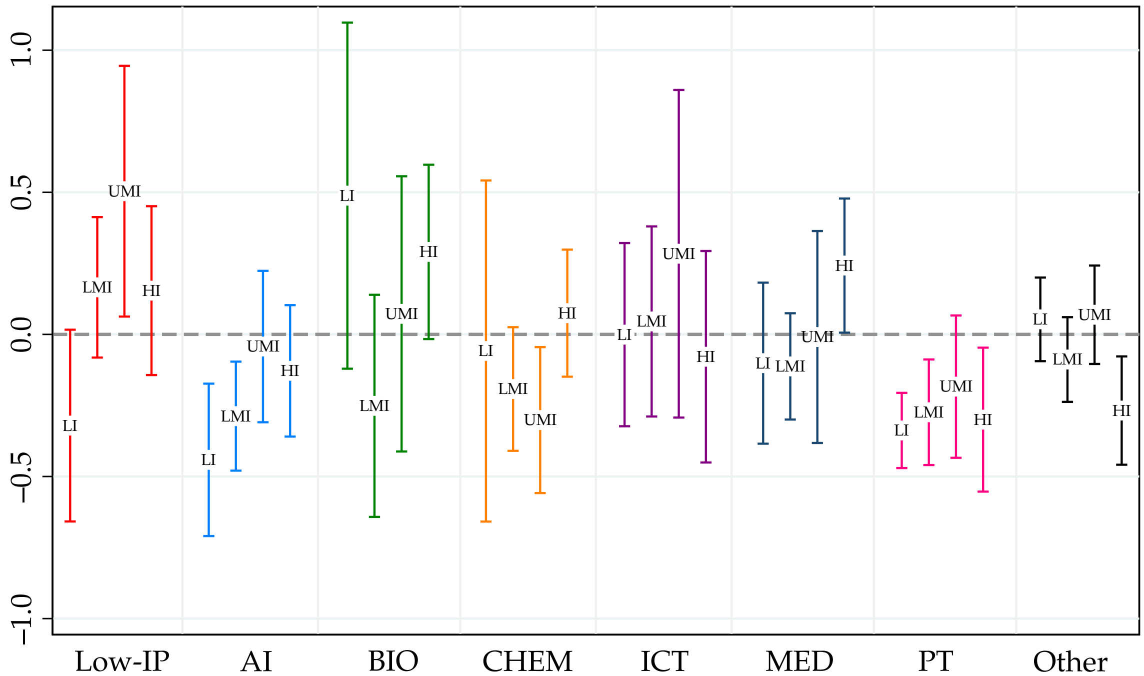
Table 2.5: Aggregate Imports in High-IP Clusters

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT
log(GDP)	0.491***						
	(0.043)						
Sector × log(GDP)		0.196***	0.113***	0.241***	0.128***	0.119***	0.154***
		(0.018)	(0.029)	(0.021)	(0.020)	(0.019)	(0.018)
Sector × LI × IPA	–0.428***	–0.489***	0.208	–0.237	–0.178	–0.165	–0.497***
	(0.163)	(0.109)	(0.291)	(0.260)	(0.148)	(0.136)	(0.094)
Sector × LMI × IPA	–0.107	–0.218***	0.039	–0.184**	–0.094	–0.140*	–0.256***
	(0.089)	(0.077)	(0.141)	(0.077)	(0.125)	(0.081)	(0.082)
Sector × UMI × IPA	0.211	–0.057	0.153	–0.186*	0.121	–0.041	–0.165
	(0.143)	(0.131)	(0.212)	(0.102)	(0.211)	(0.148)	(0.113)
Sector × HI × IPA	0.009	–0.139	0.503***	0.158*	–0.194	0.136	–0.166
	(0.125)	(0.092)	(0.154)	(0.095)	(0.175)	(0.099)	(0.130)
Sector × LI × TRIPS	0.066	0.036	–0.184	0.117	0.050	–0.148	0.067
	(0.118)	(0.129)	(0.138)	(0.098)	(0.117)	(0.135)	(0.105)
Sector × LMI × TRIPS	–0.174**	–0.223**	–0.123	0.085	0.074	–0.252***	–0.267***
	(0.086)	(0.095)	(0.137)	(0.091)	(0.112)	(0.084)	(0.090)
Sector × UMI × TRIPS	–0.115	–0.027	0.122	0.128	0.253*	–0.088	–0.151**
	(0.087)	(0.126)	(0.141)	(0.135)	(0.147)	(0.102)	(0.069)
Sector × HI × TRIPS	–0.166	0.282**	–0.217	0.047	0.139	0.143	0.042
	(0.171)	(0.141)	(0.198)	(0.182)	(0.188)	(0.138)	(0.156)
Observations							24,962
Number of Countries							187
R^2							0.971
Country trends							✓
Group-sector-year FEs							✓

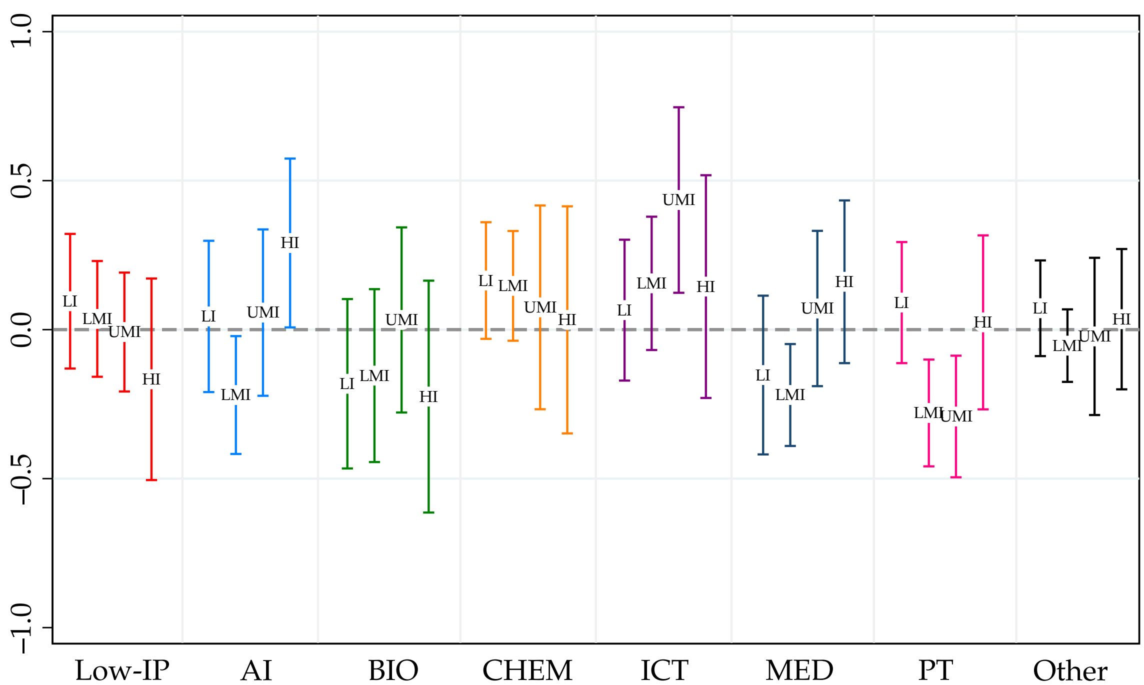
Notes: Columns (1)–(7) are from a single regression corresponding to equation (2.3). Robust standard errors clustered by country are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 2.4: Total Effects of IPA and TRIPS by Sector and Income Group: Aggregate Imports

2.4A: IPA Importer Effects



2.4B: TRIPS Importer Effects



Notes: For each subsector, the label in the center of the confidence band indicates the location of the point estimate of the coefficient on *IPA* or *TRIPS* for countries in the indicated income group. The confidence bands correspond to the 95% confidence intervals on the estimates of each coefficient.

tions 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? It would also be useful to study the effects on bilateral trade, both within and outside the treatment PTAs, to see if IPRs provisions exert a separate effect on trade creation or trade diversion. The most important extension would be to investigate the channels through which IPRs chapters may affect measured trade. It is possible that IPR-related PTAs have similar impacts on within-region FDI, which could supplement the findings here. 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.

Chapter 3

Preferential Trade Agreements, Intellectual Property Rights, and Third-Country Trade: Assessing the Impacts of the New Multilateralism

The rise in globalization in recent decades has tied national economies closer together, both through increased interdependence from trade and investment relationships, as well as countries' commitments to international agreements (such as preferential trade agreements (PTAs) and bilateral investment treaties) and multilateral institutions (such as the WTO). As the degree of international integration has risen, the scope of PTAs has expanded beyond their traditional purviews of market access concessions and trade liberalization. Increasingly, trade agreement negotiations venture into policy areas that, at first pass, might seem beyond the scope of the typical issues of tariff reductions and the lowering of non-tariff barriers to trade.

This shift in focus has been towards the inclusion of policy provisions relating to other aspects of economic integration, such as trade in services, foreign investment rules, safety and sanitary standards, government procurement policies, and labor and environmental regulations, among others. One such policy area that these so-called "deep" agreements increasingly encompass is that of IPRs, an aspect of PTAs that shapes the way in which PTA members formulate their domestic IPR regimes. And while as recently as the early 1990s, PTAs were generally devoid of substantive language on IPRs, the PTAs negotiated in recent years—particularly those agreements with at least one advanced economy as a member—generally contain extensive chapters on IPRs de rigueur.

Since IPRs are the legal framework by which knowledge-creators are able to reap the rewards from their ideas and innovations, their effects are at essence an issue relating to the broader impacts of behind-the-border domestic regulatory regimes. However, the fact that new products, processes, creative works, and other knowledge assets cross borders at an ever-increasing rate implies that IPRs are as much an international issue as they are a domestic one. As they relate to international trade, IPRs fall under the broad umbrella of institutional quality acting as a source of comparative advantage (though I will later posit several mechanisms relating IPRs to trade). The literature in this area (e.g. work by Antràs 2005, Levchenko 2007, and Nunn 2007) describes countries' institutional quality, or the effectiveness of their regulatory regimes, as playing a role analogous to Heckscher-Ohlin-style endowments. Institutions determine the patterns of comparative advantage in the sense that the economic activities that are particularly intensive in their reliance on the existence of efficacious regulatory regimes—for example, the enforceability and specificity of contracts, well-defined property rights, or protections for investors—will be the activities in which countries possessing well-developed regulatory regimes will specialize.[1]

IPRs are integral to this notion, in that the extent to which the creators and owners of knowledge assets in sectors that most rely on IPRs (generally, R&D-intensive industries such as pharmaceuticals, chemicals, electronics, and other advanced manufactures, or creative works such as music recordings, movies, printed media, or software) are able to realize the returns to their IP will determine to a significant degree the extent to which countries specialize in these particular economic activities. Certainly this could go both ways, as countries might maintain rigorous IPR regimes in the interest of protecting already-robust IP-intensive export industries, or encourage inward technology transfer from abroad, but the relationship between IPRs and trade remains apparent.

In this study, I ask whether when a country enters into an IPR-related PTA, specifically, one with the US, the EU, or the European Free Trade Association (EFTA),[2] does the resulting upgrading of the country's IPR regime materially impact its trade with *other, non-PTA member third countries*? I will describe this as the "third-country effect" of IPRs-upgrading within PTAs, as the strengthening of domestic IPRs regimes has the potential to generate spillovers on member countries' interactions with trade partners outside of the PTA. I focus on the PTAs negotiated by the US, the EU, and EFTA because the PTAs enacted by these countries tend to be more substantive in their treatment of IPRs relative to the agreements signed by other advanced economies. The difference is particularly stark in these agreements' emphasis on so-called "TRIPS-Plus" provisions.

[1]See Nunn and Trefler (2014) for an overview of the literature on the intersection of institutions and comparative advantage.

[2]Though the EU and the European Free Trade Association are distinct entities, because of the degree of economic interdependence, cultural and economic similarities, and the similarity in the IPR language of the PTAs they negotiate with other countries, I describe their PTAs as "European" agreements.

Appealing again to the notion of comparative advantage being shaped in part by IPRs, I will explore empirically whether countries party to IPR-related PTAs trade relatively more (or less) in commodities that are most (or least) intensive in their reliance on various aspects of IPRs by investigating the exports and imports of these countries along both the intensive and extensive margins of trade. That this study investigates the third-country effects of IPR chapters within PTAs means that it will be exploring a novel channel through which PTAs impart their impacts, and shedding light on the effects of an increasingly important facet of globalization.

Setting aside the issue of IPRs, the literature on the effects of the formation of PTAs is broad and well-established. As framed in the early treatment by Viner (1950), PTAs engender competing effects. New trade might be created that did not exist prior to the PTA when trade liberalization makes importing from a fellow PTA member cheaper than sourcing particular commodities domestically (*trade creation*). On the other hand, a country's existing trade with non-PTA members might be reallocated to a PTA member country when intra-PTA tariffs fall and extra-PTA most-favored nation (MFN) tariffs remain the same (*trade diversion*).

However, given that IPR provisions apply equally to fellow PTA members and non-members alike, the third-country trade effects considered here are distinct from the traditional trade-creating or trade-diverting effects of PTAs. The strengthening of domestic IPR regimes because of provisions in IPR-related trade agreements will thus have ramifications for trade that are distinct from those that manifesting from the generic narrative that arises from market accession concessions in PTAs.

Focusing on the third-country effects of IPRs provisions in PTAs further allows us to sidestep the selection bias that might arise with respect to the types of countries that enter into PTAs with the US, Europe, or other advanced economies (Baier and Bergstrand, 2009). The principal concern might be that countries enter into PTA negotiations with advanced economies, fully anticipating the IPR policy provisions they will be required to adopt, because they already undertake a comparatively high (or low) level of trade in IPR-intensive commodities. In other words, the direction of causality might not be one in which IPR regimes influence the patterns of trade, but rather one in which domestic IPR regimes—particularly, as shaped by IPR-related PTA membership—are themselves determined by existing trade patterns. The potential for such a mechanism to distort any estimates of IPR effects is low when examining third-country trade, however. It is difficult to imagine that a country enters into a trade agreement with the goal of affecting its trade with partners outside of the PTA. The IPR provisions required in PTAs thus offer a credibly exogenous policy change for the countries that accede to them.

The empirical findings can be summarized as follows. First, using a bilateral gravity framework, I consider the effects of accession to an IPR-related PTA with either the US or Europe on the value of agreement members' trade with third countries. I find that membership in such agreements—and the resultant upgrading of members' IPRs regimes—leads to significant impacts on members' bilateral trade with countries outside of the PTA (an effect on the intensive margin of trade). Exports in IPR-intensive industries (industries that are relatively more reliant on the protections afforded by IPRs) from PTA member countries at middle and high levels of development tend to increase significantly, while these same exports for countries at lower levels of development are largely unaffected. Conversely, IPR-related PTA accession is associated with a reduction in the value of non-IPR-intensive exports of middle- and high-income countries. Both results are consistent with changes in the broader pattern of comparative advantage stemming from improvements in institutional quality as determined by IPR regimes.

Second, using a more disaggregated sectoral breakdown which considers trade in IPR-intensive subsectors such as pharmaceuticals, chemicals, and information and computer technology (among others), I find that these effects vary substantially across industries. The value of the exports of developed countries in many of these IPR-intensive subsectors, and the imports of these commodities by less-developed countries, is larger than that of otherwise similar countries that are not party to IPR-related PTAs.

Third, I also examine the extensive margin of trade (as defined by the number of product varieties exported to or imported from a trading partner), which reveals that these effects are realized in most cases through an expansion in the number of varieties that PTA member countries export and import. Finally, the third-country effects are delineated according to the level of development of PTA members' trading partners, an exercise that sheds light on the distributive effects on trade of IPR chapters in PTAs. I find that the effects on third-country exports are largely concentrated in PTA members' trade with middle- and high-income countries, while any effects on imports generally arise in trade with low- and middle-income partners. This final analysis shows that a complete picture of the effects of IPR provisions in PTAs on trade is only apparent when considering the relative development levels of trading partners.

The remainder of the paper is organized as follows. Section 3.1 outlines the policy background at the intersection of PTAs and IPRs, emphasizing the recent history of the PTAs negotiated by the US or Europe, whose trade agreements generally contain the most rigorous provisions on IPRs. This section further gives a brief overview of the existing research linking IPRs and trade, and uses this motivates the third-country effect induced by IPRs-upgrading by detailing several channels through which stronger IPRs could affect trade. Section 3.2 describes the data and presents the empirical analysis of the third-country trade effects of IPR-related PTAs, considering the effects of accession to such agreements along lines of countries' development levels and the sectoral composition of bilateral trade. Section 3.7 considers the implications of the empirical results and provides a concluding discussion.

3.1 IPRs, Trade, and the Third-Country Mechanism

The number of trade agreements in force has risen unabated over the last several decades. Correspondingly, the number of countries party to such agreements has risen, with nearly all of the world's countries party to at least one (and often many more than one) PTA. This, coupled with near-universal accession of countries to the GATT/WTO (with its founding principles of MFN, national treatment, and the abolition of distortionary trade policies) has effected a dramatic reduction in the average levels of the traditional barriers to trade (tariffs and other non-tariff instruments such as quotas).

As average tariff rates have fallen, the scope of trade agreements has increasingly turned towards other arenas relevant to international integration—items such as investment rules, trade in services, health and safety standards, environmental and labor regulations, and intellectual property rights, among others. The proliferation of these "deep" agreements, so-called because of their inclusion of substantive provisions on non-trade policy areas, has had far-reaching implications for the way in which domestic regulatory regimes are formulated, as economies increasingly engage in policy-setting in such multilateral venues (Limão, 2016).

Why should IPRs be a part of PTA negotiations? Several explanations can be advanced for their inclusion, but a complete understanding requires a brief survey of recent developments in the global system of IPRs. Prior to the 1990s, national IPRs regimes varied considerably. Countries were free to enact their own policies towards IPRs, and aside from voluntary commitments to various international conventions, no uniform international system existed to harmonize policies across borders. The 1995 WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) upended this status quo, however, in its implementation of a consistent, minimum level of protection and coverage of IPRs for countries acceding to the agreement.

TRIPS was the culmination of contentious negotiations at the WTO's Uruguay Round. As producers of a large share of the world's intellectual property, the interests of the US and Europe favored consistent and rigorous protection of IPRs across borders, while the concerns of negotiators from developing countries were that stronger IPRs would stifle access to new product varieties (particularly pharmaceuticals) and necessitate costly implementation efforts. The middle ground afforded by TRIPS offered developing countries considerable leeway in their timelines with which to comply with TRIPS (with least-developed countries effectively freed from hard deadlines on compliance).

Further, developing countries were granted allowances with regard to how they were allowed to interpret and implement key provisions. Certain provisions on patent granting processes in pharmaceuticals and chemicals that were negotiating objectives of the US and Europe, such as linkage rules deterring generic competition and test data confidentiality, were left out. From the point of view of the US and Europe, then, TRIPS was (and remains) an imperfect mechanism in ensuring that IPR regimes are consistent and sufficiently comprehensive, and the difficulty of obtaining further IPRs concessions from other WTO members highlights the shortcomings of a global approach.

PTAs, then, offer an alternative venue in which the US and Europe are able to obtain IPR policy concessions from foreign governments in smaller settings. The prospect of bilateral trade concessions could sway foreign negotiators to agree to adopt rigorous IPR standards they would not agree to in a larger multilateral setting where economic interests evince less overlap (Maskus, 1997). One commonality underlying the recent PTAs negotiated by the US and Europe, as put by Horn et al. (2010), is that "an issue of particular interest with regard to [EU] and US PTAs is the extent to which they can be seen as a means of transferring the regulatory regimes of the [EU] and the US to other countries."

The origins of this "transferring of regulatory regimes" via PTAs can be dated to the mid-1990s, specifically to the implementation of the landmark North American Free Trade Agreement (NAFTA). NAFTA (at the behest of US negotiators) was the first agreement of its kind to devote substantive coverage to IPRs, with Mexico (and to a lesser extent, Canada) required to adopt specific standards and policies in IPRs. This included more specific rules on the allowable applications of copyrights than those offered by TRIPS, more rigorous prohibitions on compulsory licensing, stronger protections for pharmaceuticals, semiconductors, and trade secrets, and stricter enforcement requirements than TRIPS. Further, NAFTA required a swifter implementation schedule for members than did TRIPS.

In the two decades following NAFTA, the US enacted a number of bilateral and multilateral PTAs, with in-depth chapters on IPRs a mainstay of the agreements. And, while the language in these IPRs chapters has evolved, largely due to an increased emphasis on provisions relating to pharmaceuticals and chemicals (as well as a growing focus on the protection of IPRs for digital assets such as software), they exhibit noticeable consistency in their emphases and specific policy prescriptions, with a general focus on patent obligations, the treatment of copyrights, and requirements for effective enforcement. From Biadgleng and Maur (2011), these "TRIPS-Plus" (so-called for their requirements on IPR regimes that go beyond those of TRIPS) provisions required by the US include:

- **Patents**: the granting of patent term extensions resulting from delays in the patent application process and exclusivity on test data for pharmaceuticals and chemicals;

- **Copyrights**: the adoption of copyright terms 20 years longer than those required by TRIPS, accession to the World Intellectual Property Organization (WIPO) treaties on copyrights and performances/recordings, and adoption of rules on the anti-circumvention of digital rights management safeguards;

- **Enforcement**: no exceptions for implementation of IPR rules based on the partner's development level, the extension of border measures for counterfeit and infringing goods to include goods in transit to other destinations, and a broader definition of infringing activities subject to criminal measures.

The combination of sector-specific provisions, and more general enforcement and coverage measures, suggests that the countries that enter into a PTA with the US must adopt substantial changes to their domestic IPR regimes.

What can be said of the IPR provisions required by European PTAs? The large number of European products possessing specific geographical origins (typically, agricultural and food products where the location of production—e.g. Champagne, Gouda, or Cognac—is associated with the features of the product) means that European negotiators have adopted a focus on more rigorous treatment of geographical indications in their PTAs. Such provisions mandate the recognition of particular indications and the phasing out of products that make improper use of a geographically-based appellation.

With respect to other areas of IPRs, early European agreements were characterized by generalities or non-binding language, but more recent agreements are more specific in what they require. Like their US counterparts, European PTAs have recently emphasized the inclusion of TRIPS-Plus provisions. To illustrate, the 2008 CARIFORUM-EU agreement requires signatories to adopt language on patentability and minimum standards of enforcement and acceptable practices in their IPR regimes. Members must also accede to numerous treaties on multiple areas of IPRs, such as the World Intellectual Property Organization Copyright Treaty, the Rome Convention on performances, recordings, and broadcasts, the Patent Cooperation Treaty, and the Hague Agreement on industrial designs, among others. This approach of having partners accede to such treaties has marked many of the agreements that Europe has negotiated, but the general trend in European agreements has been towards more comprehensive standards in the same vein as the agreements negotiated by the US (Shabalala and Bernasconi, 2007).

Three Channels Linking IPRs and Trade

Clearly, IPRs have become an area of importance in the trade deals negotiated by advanced economies, particularly those of the US and Europe. A question that follows is, why should IPRs be relevant in international trade? This question has been explored in the theoretical and empirical literatures for some time, but at the broadest level, the link between the two can be characterized by the three channels that I will highlight below. These channels are, first, institutional quality as a source of comparative advantage, second, what the literature has dubbed market-power versus market-expansion effects, and third, the location and investment mode decisions of MNEs. The interplay of each of these make the system of IPRs a fundamental determinant of the direction and magnitude of trade.

First, IPRs are part of the broad interaction between institutional quality and trade, which casts the effectiveness of countries' institutions—contract enforcement and specificity (Antràs 2005; Levchenko 2007; Nunn 2007), the rule of law and efficacy of the legal system (Ma et al. 2010; Yu et al. 2015) the smoothness of credit markets (Rajan and Zingales 1998; Beck 2002), etc.—as a determinant of comparative advantage. Effective institutions facilitate the economic activities that require complicated legal relationships and well-defined property rights, incentivize innovation by ensuring that its returns can be effectively realized, and generally promote economic exchange. On the other hand, substandard institutional quality (e.g., the insecurity of property rights, capricious government rules and regulations, or pervasive corruption) acts as an impediment to trade (Anderson and Marcouiller 2002; de Groot et al. 2004).

In the sense that they determine the rewards to innovation and establish clear ownership of knowledge assets, IPRs are a fundamental determinant of a country's institutional quality. And, related to this notion, IPRs help determine the extent of inward technology transfer (Yang and Maskus, 2009), which could further effect changes in the structure of a country's comparative advantage and the composition of its trade. In the classical sense of comparative advantage, countries with robust IPR regimes should be expected to specialize relatively more in those commodities that intensively rely on their protections, and thus export relatively more in industries that are intensive in their reliance on IPRs, and export less in IPRs-unintensive industries (and vice versa for imports).

The second channel is not entirely distinct from the first. To illustrate, consider the role that patents—temporary legal monopolies on a specific process or product—play in allowing innovators to realize profits from their inventions (analogous logic can be extended for the issues underlying copyrights, trademarks, geographical indications, and other rights). When an inventor of a new product obtains a patent, they are effectively granted the right to act as a monopolist in their particular variety for the duration of the patent, assuming the patent is actively enforced by the granting authority. This creates rewards for innovators that might not otherwise exist, which could take the form of larger profit streams or reductions in the costs of efforts to deter imitation.

Thus, on one hand, the prospect granted by IPRs of being able to behave more monopolistically engender a *market power effect*, where patent-holders are able to constrain the supply of their product to a particular market and inflate prices. On the other hand, the bolstered incentives for innovators afforded by effective patent rights lead to extensive margin effects, expanding the dynamic flow of new product varieties and improving the incentives to export to markets where the costs of deterring imitation might otherwise make the market unprofitable—the *market expansion effect*.

At the international level, innovators' ability to realize these profits will determine their optimal decision with regard to several outcomes. This could include the optimal level of R&D and innovation to undertake (and where to undertake it), where to locate production, which markets to sell their products to, and importantly, how much of their product to sell to particular markets. The overall direction of these countervailing effects is theoretically ambiguous and depends on which effect dominates. Their interaction, however will to some extent determine the value of a destination market's imports of IPR-intensive commodities.

Finally, another key aspect of the mechanisms linking IPRs and trade relates to the foreign investment decisions of MNEs, as exporting versus foreign direct investment offer alternative means by which to serve destination markets. IPRs serve a fundamental role in determining which markets MNEs choose to serve, and how to serve them. These decisions are determined in part by the likelihood that imitation or appropriation of a multinational's proprietary knowledge assets or production processes will take place. Strong IPRs and their effective enforcement signal to owners of IP that these sorts of actions are less likely to occur (see, e.g., Markusen 2001 or Javorcik 2004).

With an increase in the rigor of a country's IPRs, multinationals might be more inclined to serve a market through local production or licensing versus exports, which would reduce the destination market's imports of IPR-intensive commodities. FDI might also increase competitive pressures on local firms operating in these particular industries, who might as a result export less to other markets. At the same time, it could also be the case that MNEs establish production in a target market and then export from there to nearby markets—e.g. a foreign firm constructing a new plant in Chile to sell to the Argentinean and Peruvian markets. The effect on exports is thus ambiguous. While this analysis focuses on the relationship between IPRs and trade, FDI remains a crucial component of the nexus between the two, and even though the estimation approach will be unable to delineate the specific mechanisms underlying the results, the FDI versus exporting decisions of MNEs are inherently interlinked.

The exact effects of stronger IPRs on trade are thus ambiguous, but the mechanisms outlined above offer some guidance on what impacts are to be expected. Overall, positive export effects might be anticipated in IPR-intensive sectors depending on the direction and relative size of the MNEs channel, while impacts on imports are theoretically ambiguous. Industries that are relatively less reliant on IPRs, however, are expected to be minimally impacted, with the only clear prediction arising from the comparative advantage channel. These effects could be manifested along the intensive margin, the extensive margin, or both. The sector-specificity of many of the agreements' provisions also suggests that any empirical impacts are likely to vary across industries.

Further, the three channels outlined above are not the only potential explanations for the relationship between the IPR provisions of PTAs and members' trade. More broadly, when countries enter into PTAs, they effectively signal their adherence to a policy orientation that is unlikely to change abruptly (owing to the cost of breaching international commitments), which enhances the attractiveness of the country's markets for trade and investment (Fernández and Portes, 1998). This is in contrast to unilateral domestic policy decisions, which Büthe and Milner (2008) note can easily be changed at the expense of foreign economic agents. The predictability and consistency of trade policy has been shown to be an important determinant of trade patterns (Handley 2014;

Handley and Limão 2015), and the "lock-in" effects of a consistent policy orientation with regard to IPRs should translate to trade in industries where such rights are front and center.

IPRs and Trade: Empirical Evidence

The ambiguous predictions from the theory on the role of IPRs in determining the patterns of trade suggest that the real-world relationship can be uncovered only through empirical investigation. The earliest work in this direction, that of Ferrantino (1993), considered the role of countries' accession to international treaties on IPRs (such as the Paris Convention for the Protection of Intellectual Property) in influencing the exports and overseas affiliate sales of US multinationals. Ferrantino failed to find significant links between destination market IPRs and US multinationals' exports to their affiliates or foreign affiliates' sales. In contrast, the findings of Maskus and Penubarti (1995) established the empirical existence of a link between trade and the extent of countries' patent protection. Increases in the level of patent protection were correlated with higher levels of manufacturing imports by developing countries, and when imports were further disaggregated by industry, this effect turned out to be exclusive to trade in the least patent-sensitive industries, rather than industries most reliant on patents.

Following Maskus and Penubarti (1995), several other noteworthy studies have approached the issue of IPRs and trade. Smith (2001) further explored the relationship between foreign patent rights and trade, examining the behavior of US multinationals with regard to their decisions vis-à-vis exporting versus selling through an affiliate versus licensing. Exports tended to be positively associated with stronger foreign patent rights, likewise affiliate sales and licensing, particularly in destination markets with strong imitative capacities, where stronger IPRs did more to mitigate the risk of imitation.

Extending this notion, Co (2004) found that foreign patent rights were unimportant on their own. Rather, it is the interaction of foreign patent rights and destination markets' imitative abilities that mediates the link between IPRs and trade. In her gravity model of US exports to 71 countries from 1970 to 1992, Co found that for countries of average imitative abilities, US exports of R&D-intensive commodities were expected to increase by 9% for every unit increase in the country-level patent rights index of Ginarte and Park (1997). Co rationalized this finding using the logic that the foreign markets that offered the greatest threat of imitative competition for US multinationals are the markets where strong foreign patent rights would be most strongly related to trade flows. Conversely, US exports of non-R&D-intensive goods were anticipated to fall by 8–11% for a unit increase in this index, potentially reflecting the underlying changes in comparative advantage as engendered by domestic IPRs regimes.

Particular focus has been paid to the effects of TRIPS on trade and investment flows. Ivus (2010) examined whether developing countries' accession to TRIPS, and resulting upgrading of their IPRs regimes, led to increased imports of IP-intensive commodities from developed economies. The study accounted for the potential endogeneity of countries' IPR regimes with the composition of trade by using colonial origin as an instrument for IPR strength, as countries with British or French colonial backgrounds generally inherited the comparatively advanced legal frameworks of their metropoles. Her findings suggested a substantial increase in developing countries' imports—an estimated $35 billion in value—resulting from TRIPS implementation. This expansion was found to have resulted from an increase in quantities, rather than prices, evidence in favor of a significant market-expansion effect.

Of particular relevance to this research is the work of Delgado et al. (2013), who investigated the effect of TRIPS on countries' aggregate trade (both in terms of exports and imports) in IPR-intensive commodities. Delgado et al. (2013) exploited the effective exogeneity of TRIPS accession (based on the fact that TRIPS is a mandatory component of WTO membership for most countries), and further, considered whether the effects of IPRs-upgrading might vary across levels of development. They specifically considered whether developing countries were impacted differently by TRIPS than were advanced economies, based on the idea that advanced economies already possessed well-developed IPRs regimes by the time they began to implement TRIPS. In essence, their results showed that TRIPS compliance exerted a significant impact on the trade of knowledge-intensive goods relative to a control group of non-knowledge-intensive goods. Further, they found evidence of an increase in the imports of knowledge-intensive goods of developing countries from high-income countries.

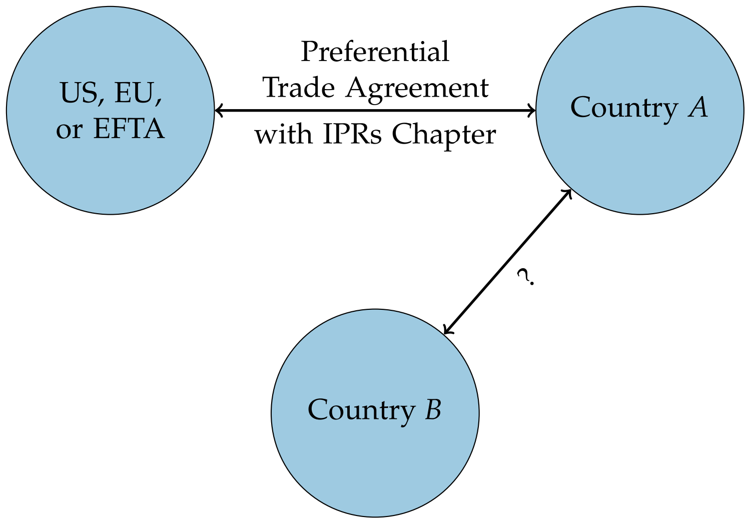
What these past works did not consider, however, was whether a contemporaneous policy change was systematically implemented alongside TRIPS. Namely, little previous research has investigated the effects of the IPR-related PTAs considered here, with notable exceptions of Maskus and Ridley (2016) and Campi and Dueñas (2017), which found muted effects. Since the empirical analysis in this study will consider the implementation of policies that generally coincided with countries' implementation of the TRIPS agreement—and which might evince similar effects on trade—it will be essential to disentangle the effects of TRIPS from the effects of IPR-related PTA accession.

Given that IPRs determine the structure of costs and benefits in a wide array of economic activities, a holistic view of the issue in an international setting would consider each of the potential outcomes of changes in domestic IPR regimes in conjunction. Investment flows, innovation, production, and trade decisions are made jointly. I will focus on trade for the reason that the policy objectives of PTAs pertain first and foremost to trade. Investment, innovation, and other activities are certainly influenced by the structure of PTAs, but it is reasonable to imagine that the first order effects of trade agreements are on trade. It is also the case that trade is one of the most prominent channels of globalization, and evaluating how regulatory regimes shape global trade flows is of crucial importance in producing an accurate assessment of the effects of policy.

The Third-country Mechanism

The survey of the literature should make it apparent that IPRs and trade are interrelated—and despite the agnostic predictions from theory, the empirical literature seems to have coalesced around the notion that stronger IPR regimes are generally correlated with expanded trade in R&D- or IPR-intensive products, with effects breaking down along lines of countries' levels of development as well as their imitative abilities. In light of the preceding discussion, what can be hypothesized about the effects of IPR-related PTAs? These multilateral agreements, particularly those negotiated by the United States and Europe, effect substantive changes in the IPR regimes of member countries. Given the multiple ways in which IPRs and the composition of countries trade are interlinked, the effects of such policy-upgrading should spill over into members' commerce with countries outside of the agreements. This is what I will denote as the third-country effect of

Figure 3.1: IPR-Related PTA Accession and Third-Country Bilateral Trade



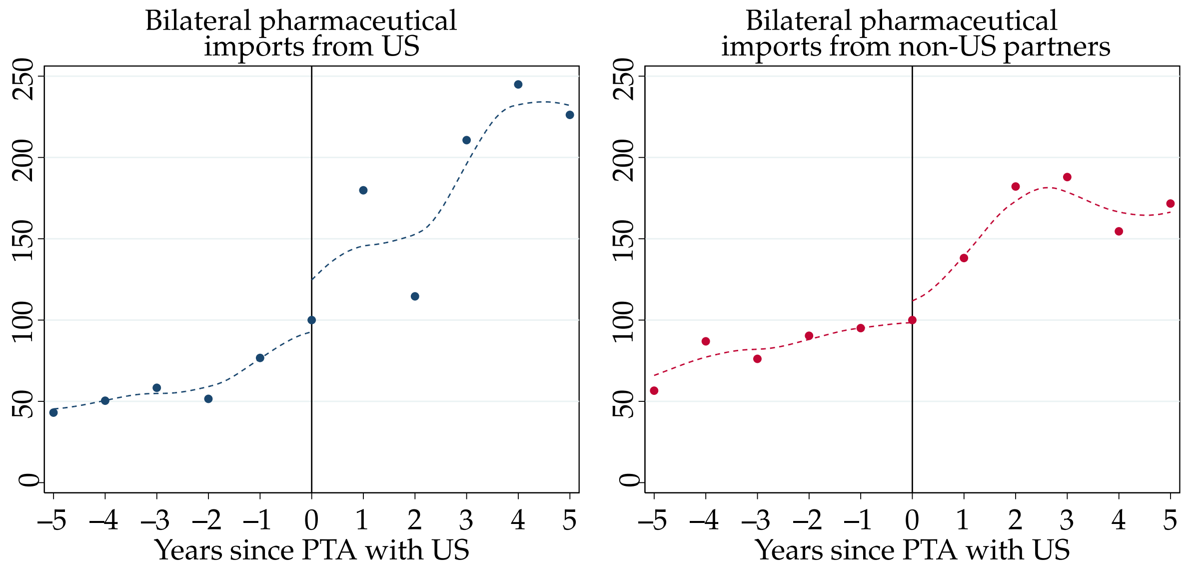
IPRs on PTA members' trade.[3]

Figure 3.1 illustrates this hypothesized effect. When some Country *A* enters into a PTA with the US or Europe, trade between member countries is likely to increase—this is the standard Vinerian notion of trade creation resulting from PTAs. These effects could conceivably vary across sectors depending on the scope of the trade liberalization and tariff cuts and reductions in non-tariff barriers are allocated. The third-country effect, however, suggests that Country *A*'s trade with Country *B* (where *B* could denote any trade partner outside of the PTA) is impacted—when Chile, for instance, signed its IPR-related PTA with the US, is its trade with Argentina also impacted as a result of the policy change, particularly in IPR-intensive industries? If the structure of IPRs regimes indeed influence the patterns of trade—for any of the reasons outlined above—the systematic upgrading of IPRs regimes because of the provisions in PTAs should engender an effect on trade with non-PTA member countries.

This third-country mechanism will be central to the empirical identification strategy. In thinking about threats to being able to credibly identify the effects of IPRs provisions in PTAs, it may be that countries endogenously select into IPR-related PTAs with the US or Europe (or other ad-

[3]PTA membership might expand FDI flows from third countries into PTA member countries, but for a different reason than the one this study considers with respect to IPRs and trade. PTAs expand the size of the effective market that foreign investors face, which may bolster the incentives for horizontal FDI (see, e.g., Dee and Gali 2003 or Levy Yeyati et al. 2003).

Figure 3.2: Bilateral Pharmaceutical Imports of Low-Income US IPR-related PTA Members



Notes: Each point represents the average value of PTA members' bilateral imports (averaged across all non-US partners in the second panel) in the indicated number of years before or after the formation of each country's PTA with the US., with a local polynomial smoother fitted over the first and second halves of the 10-year interval. The value of trade flows with each partner type (US versus average non-US) is normalized such that the value of bilateral trade in the year that the PTA with the US entered into force is equal to 100.

vanced partners) because they already undertake a high (or low) level of IPRs-intensive trade. In other words, selection into the policy "treatment" might be nonrandom with respect to the outcome of interest. On the other hand, it is more difficult to imagine that Country A enters into an IPR-related PTA with the objective of affecting its IPRs-intensive trade with Country B. If that were the case, Country A could unilaterally improve its IPRs standards without the effort of negotiating and enacting a PTA—a country with such a goal could accede to international treaties on IPRs, adopt TRIPS-Plus standards, or bolster enforcement efforts of its own volition. The policy treatment of IPR-related PTA accession is thus credibly exogenous to members' trade with non-PTA members. This third-country mechanism in the context of PTAs with IPRs chapters is a novel contribution to the existing literature.

Figure 3.2 presents a specific case where the existence of a third-country effect is evident in the data by portraying the average bilateral trade in biopharmaceuticals of low-income US IPR-related PTA partners in an event-study framework. Here, the year 0 is the year in which each country entered into an IPR-related PTA with the US, with the value of imports in each panel normalized to equal 100 in this year. The first panel depicts imports from the US, an increase that is expected to be one of the first-order effects of PTA accession, IPRs-related or otherwise. On average, low-income partners' imports of biopharmaceuticals from the US increases in the wake of the formation of the PTA—a reduction in barriers to trade leads to more trade, and the trend in the growth of trade is elevated after the agreements are enacted.

The second panel, however, presents a more surprising finding. This series depicts average bilateral trade with all non-US partners (or, in the case of multilateral PTAs such as NAFTA or CAFTA, all non-PTA-partner trade). Strikingly, average imports from countries besides the US increase substantially after the enactment of the PTA, with imports departing dramatically from their pre-PTA trend. This phenomenon is at odds with a notion of trade diversion, and goes against the idea that the effects of the PTA are confined principally to trade between PTA members. And, unless the represented PTA member countries systematically cut their MFN tariff rates, entered into other trade agreements, or enacted other trade- or IPR-related policies at the same time they entered into a PTA with the US, then on its face, this is strong evidence for the existence of the third-country mechanism.[4] Whether this effect is evident in other sectors and at other levels of development, and after controlling for other determinants of trade, will be the focus of the next section.

3.2 Empirical Framework

In this section, I employ a panel of sector-level bilateral trade data for 187 countries (and thus $187 \times 186 = 34{,}872$ potential country-pair linkages), with coverage over the years 1995 to 2014 (a period over which numerous US and European IPR-related preferential trade agreements were negotiated and entered into force), to examine the role that IPR-related PTAs play in determining the composition and magnitude of members' third-country trade flows.

I construct the sample—unidirectional trade flows between bilateral country pairs in a given

[4] To echo the argument from earlier, it could be that PTA formation tends to coincide with countries coming into compliance with TRIPS, and that TRIPS was the driver of this change in IPR-intensive commodity trade. Thus, I control for the timing of TRIPS compliance in the econometric framework, both by directly controlling for TRIPS compliance and through the definition of the IPR-related PTA treatment.

year and sector—in the following way. For bilateral linkages between countries that will enter into an IPR-related PTA (as defined above) at any point in the sample, or have entered into an IPR-related PTA, I omit these linkages' observations from the analysis. In the context of the relation depicted in Figure 3.1, I discard all observations on trade between each Country A and the US, the EU, or EFTA (depending on which set of partners Country A forms a PTA with), both before and after the formation of the PTA—this includes trade in both directions. This means that identification of the third-country effect is based on observations of bilateral trade between Country A and extra-PTA countries such as Country B.[5]

Observations on all other linkages are preserved, which includes trade flows for bilateral pairs in which neither country is an IPR-related PTA member, as well as trade between third countries and the US, the EU, or EFTA. This approach exploits variation in countries' accession to IPR-related PTAs with the US or Europe, and considers whether the policy effects vary across industrial sectors or along lines of national development levels, exploiting the third-country mechanism to isolate the impact of PTAs' IPR provision on extra-PTA trade. In estimating the effect of the policy of interest on bilateral trade, the gravity framework is a natural approach, and I tailor the methodology to address the pitfalls with the gravity approach outlined in, for instance, Anderson and van Wincoop (2003), Baier and Bergstrand (2007), and Head and Mayer (2014).

The policy treatment of IPR-related PTA accession is defined by the indicator variables IPA_{it} and IPA_{jt}. For a particular observation, these variables respectively denote exporter i's or importer j's membership in year t in an IPR-related PTA with the US or Europe that entered into force after the country's compliance with TRIPS.[6] The variables switch from zero to one in the year

[5] I further conduct a version of the main analysis in which, in addition to omitting trade between current and future IP-related PTA members, I omit all observations of trade between countries that are both party to (or will both be party to at some point in the sample) an IPR-related PTA with either the US or Europe. For example, in this alternative version, trade between Chile and Peru is omitted because both countries enter into a PTA with the US (observations for which one country joins a PTA with the US and the other with Europe are still included). This approach accounts for any higher order effects on trade that might arise when two countries both have an IPR-related PTA with a large common trading partner. The results for this approach (shown in Appendix Table A.4) are qualitatively similar to the results in the main analysis.

[6] I define the timing of the policy relative to TRIPS implementation in such a way to disentangle the effects of TRIPS compliance from the provisions of the PTA, and because pre-TRIPS agreements generally possess weaker language on IPRs than their post-TRIPS counterparts. Even though NAFTA contains IPR standards that are stronger than those of TRIPS, this policy definition precludes NAFTA's consideration as a pre-TRIPS IPR-related PTA (though I find that the results are not sensitive to this particular treatment of the NAFTA countries). If the analysis instead considers any IPR-related PTA negotiated with the US or Europe, either pre- and post-TRIPS, the results are qualitatively similar.

that a particular country enters into such an agreement, and remain equal to one as long as the country remains party to the agreement.[7] For example, since Chile's PTA with the US entered into force in 2004, then for all observations for the year 2004 and later in which Chile is an exporter, IPA_{it} is equal to one, and for all observations in which Chile is an importer, IPA_{jt} is equal to one. To emphasize the interpretation of the IPA variables, it is important to note once more that they correspond to third-country effects, which give the impact of i's (j's) membership in an IPR-related PTA on i's (j's) trade with some extra-PTA member j (i)—hence the variable's definition being specific to a single country in a bilateral linkage.[8]

There are several factors (both observable and unobservable) that might confound the estimates, and I take steps to mitigate their influence. Given the time frame over which the IPR-related PTAs in the sample were implemented, the concern could be raised that a contemporaneous policy change was effected for nearly all of the countries in the sample in the form of the TRIPS agreement. After its enactment as a result of the Uruguay Round of WTO negotiations, WTO member countries gradually undertook the process of implementing and complying with its provisions, and if IPRs indeed influence trade flows, and if TRIPS implementation is correlated in some way with IPR-related PTA accession (e.g., because member countries systemically undertake an assortment of efforts to upgrade their IPRs), then neglecting to control for the impact of TRIPS would bias the estimate of the effect of IPR-related PTA membership.[9] I thus control for countries' compliance with the TRIPS agreement as of year t with the indicator variables $TRIPS_{it}$ and $TRIPS_{jt}$, defined analogously to the IPA variables, estimating compliance dates based on the methodology used in Park (2008), Hamdan-Livramento (2009), and Delgado et al. (2013).

[7]Since no countries exited any of the IPR-related PTAs during the sample, the variable effectively switches on once and stays that way for the remainder of the sample. A handful of countries (Chile, Colombia, Mexico, and Peru) have entered into agreements with both the US and Europe. Treatment status for these countries is defined in the same way as countries party to only one IPR-related PTA. The policy variable switches from zero to one and stays equal to one, even after a second IPR-related PTA is entered into.

[8]A separate exercise would be to consider trade between countries belonging to the same IPR-related PTA (i.e., to introduce a variable IPA_{ijt}), but such an exercise would identify a different effect. It would also be difficult in such an exercise to disentangle the generic effects of PTAs from the IPR effects. See Campi and Dueñas (2017) for work in this direction.

[9]While developed countries were able to comply with TRIPS quickly (with most advanced economies in compliance by 1995), countries identifying as developing were given more leeway in their timelines for compliance. In general—but with several notable exceptions—developing economies were given until 2001 to be in compliance with the IPRs standards required by TRIPS. Even so, for many economies nominally in compliance with the agreement, adherence to its provisions is often imperfect. Least-developed countries were exempted from any compliance deadline, and even today many of these countries are not in compliance with TRIPS.

Data

The data on bilateral trade flows is based on the BACI dataset from *Centre d'Études Prospectives et d'Informations Internationales* (CEPII, see Gaulier and Zignago 2010), which contains the value of bilateral trade flows at the 6-digit level by Harmonized System (HS) classification for every potential country pair from 1995 onward. I initially assign each HS commodity code as belonging to either an IPR-intensive ("high-IP") or IP-unintensive ("low-IP") Standard International Trade Classification (SITC) Revision 3 code, based on the categorization by Delgado et al. (2013) of SITC industries based on the extent to which they depend on IPRs. Since the original trade data is classified by HS commodities and the industry categorization of Delgado et al. (2013) is based on SITC, each 6-digit HS commodity is assigned to an SITC code based on the HS-SITC correspondence prepared by the Eurostat RAMON database (Eurostat, 2017).

High-IP industries are industries that are generally most reliant on different forms of IPRs (patents, copyrights, trademarks, and others) to safeguard their knowledge assets—industries including, for example, chemicals and pharmaceuticals (patent-intensive), beverages and automobiles (trademark-intensive), or printed matter and recorded media (copyright-intensive). Low-IP industries are ones that rely relatively less on such rights. These include, for instance, industries such as food and live animals, manufactures of leather or wood, or inedible crude materials. To have a clearly defined treatment and control set of industries, those industries that are classified as being neither high-IP nor low-IP are not assigned to either category, and are not included in the estimation.[10]

I further subdivide the high-IP industries into several IPR-intensive subsectors to measure the effects of IPR-related PTA accession at a more refined industrial level. Industries are assigned to the IPR-intensive subsectors defined by Delgado et al. (2013) based on a classification of IPR-intensive US industries by the US Department of Commerce (2012). These subsectors include analytical instruments (AI), biopharmaceuticals (BIO), chemicals (CHEM), information and communications technology (ICT), medical devices (MED), and production technology (PT), and other

[10] See the Appendix for a description of the data sources and data construction process. Appendix Table A.1 lists the sources for each variable used in the analysis. Table A.2 lists the countries used in the empirical analysis as well as their respective income group classifications. For a full list of high-IP industries broken down by mode of IPR-intensiveness, as well as the low-IP industry definitions, and associated SITC codes, see Appendix Table A.3.

high-IP goods belonging to none of the above categories (Other). Based on results from the existing literature, along with the numerous sector-specific emphases embedded in IPR-related PTAs, noticeable differences might materialize in the extent to which trade in different sectors is affected by IPRs-upgrading.

Finally, since much of the existing literature focuses on the differential effects of IPRs on economies at different stages of development, I assign countries to one of four different income groupings based on per capita incomes, taken from the World Bank's classification (World Bank, 2016). Countries are classified as being low income (denoted LI), lower-middle income (LMI), upper-middle income (UMI), or high income (HI). To account for the potentially endogenous relationship between the value of trade and per-capita incomes, I fix countries' income classification at their levels at the beginning of the sample (1995).

3.3 Trade in High-IP Goods

There are several issues with typical formulations of gravity that I address in the empirical approach. First, the omission of zeroes in bilateral trade flows has been highlighted as a potential source of bias in OLS estimates of the gravity equation, given that the natural logarithm of zero is undefined. Several approaches have been suggested to address this while preserving the log-linearity of the estimation, such as adding one to each observation and estimating a tobit regression to account for the leftward censoring of the data, or the introduction of a correction term for selection bias following Heckman (1979).[11] Alternatively, some researchers have proposed estimating the underlying structural gravity model via a non-linear least squares approach, though the assumptions necessary to ensure the consistency of such estimates can be unrealistic.

A second issue, as detailed in Santos Silva and Tenreyro (2006), is that the log-linearization of the underlying structural gravity relationship introduces heteroskedasticity which can potentially bias the estimates of gravity coefficients, including those on policy variables such as trade agreement membership. The estimator described by Santos Silva and Tenreyro (2006) addresses both

[11] Implementing the Heckman selection correction in a gravity framework can be problematic, since in the first stage of estimating selection into a zero versus non-zero trade linkage, the inclusion of at least one instrumental variable is required such that the variable (i) predicts whether a trade flow is zero or not, and (ii) is uncorrelated with trade flows. Variables that satisfy such an exclusion restriction are generally difficult to find; see Burger et al. (2009).

of the above issues, wherein the underlying gravity relationship is not log-linearized for estimation via OLS, but rather, estimated with trade flows in their original levels via a Poisson Pseudo-Maximum Likelihood (PPML) estimator, an approach first outlined in Gourieroux et al. (1984).[12] PPML estimates of the gravity equation have been shown to produce consistent estimates of gravity coefficients and are robust to various forms of heteroskedasticity, with the estimates generated using PPML often deviating considerably from those produced with a more traditional log-linear gravity approach.[13]

In the baseline specification, I consider the relationship between the value of bilateral trade in high-IP versus low-IP industries and IPR policies. To motivate the estimation approach, consider the following formulation of the gravity equation as depicted in equation (3.1), which describes unidirectional bilateral trade flows as a function of economy sizes, the IPA and $TRIPS$ policy variables, and other terms:

$$\begin{aligned} T_{ijst} = \exp\Big\{ & \beta_1 \log\left(GDP_{it}\right) + \beta_2\, High\text{-}IP_s \times \log\left(GDP_{it}\right) \\ & + \beta_3 \log\left(GDP_{jt}\right) + \beta_4\, High\text{-}IP_s \times \log\left(GDP_{jt}\right) \\ & + \beta_5\, Low\text{-}IP_s \times IPA_{it} + \beta_6\, High\text{-}IP_s \times IPA_{it} \\ & + \beta_7\, Low\text{-}IP_s \times TRIPS_{it} + \beta_8\, High\text{-}IP_s \times TRIPS_{it} \\ & + \beta_9\, Low\text{-}IP_s \times IPA_{jt} + \beta_{10}\, High\text{-}IP_s \times IPA_{jt} \\ & + \beta_{11}\, Low\text{-}IP_s \times TRIPS_{it} + \beta_{12}\, High\text{-}IP_s \times TRIPS_{jt} \\ & + \alpha_i\, t + \alpha_j\, t + \alpha_{g_i st} + \alpha_{g_j st} + \alpha_{ij} \Big\} + \nu_{ijst}. \end{aligned} \tag{3.1}$$

The dependent variable is the unidirectional value of bilateral exports from exporter i to importer j in sector s in year t, which is denoted by T_{ijst}. To be clear, since the approach estimates

[12] Alternatively, some researchers (for instance, Head et al. 2009 and van Oort et al. 2010) have recently adopted a negative binomial pseudo maximum likelihood (NBPML) approach to estimate the gravity relationship. The NBPML approach is based on less restrictive assumptions on the relation between the conditional mean and conditional variance of the dependent variable, and also addresses "excess zeros" in the trade data—the scenario under which the number of observed zeros exceeds the number of zeros predicted by the Poisson model (Burger et al., 2009). As noted by Bosquet and Boulhol (2010), however, the NBPML is inappropriate in a gravity context, since when the dependent variable is continuous (as is the case with the value of trade flows), the parameter estimates depend artificially on the scale of the dependent variable. In other words, the arbitrary scaling of trade flows in, for instance, thousands of dollars versus millions of dollars would yield entirely different estimates depending on the scale.

[13] On the differences in results between the two approaches, see Egger and Tarlea (2015), or Larch et al. (2017).

a third-country trade effect, the dependent variable here is unidirectional bilateral trade between countries that are not, and will not be, partners with the US or Europe in an IPR-related PTA. For instance, recalling again the example of Chile, the observations on Chilean bilateral trade exclude *all* of Chile's trade with the US, including trade in years before the signing of the agreement.[14]

In the baseline, s indexes IPR-intensive (high-IP) versus non-IPR-intensive (low-IP) sectors. $High\text{-}IP_s$ and $Low\text{-}IP_s$ are indicator variables that respectively denote which sector s a particular observation represents. Given the gravity approach, I control for the size of each economy in a bilateral linkage by including both importer and exporter GDPs. I further allow for scale effects to vary across traded sectors through the sector-GDP interaction terms. The sector-specific income elasticities of trade, then, are given by β_1 for low-IP exports, $\beta_1 + \beta_2$ for high-IP exports, β_3 for low-IP imports, and $\beta_3 + \beta_4$ for high-IP imports.

The terms on the third line of equation (3.1) measure the impact of IPR-related PTA accession on the exports of country i in low-IP (β_5) and high-IP (β_6) industries.[15] Analogously for TRIPS, the fourth line of equation (3.1) depicts the effects on exporters of TRIPS compliance on both their low-IP (β_7) and high-IP (β_8) exports. The expressions on the fifth and sixth lines mirror the exporter terms, showing the respective effects on the importer j in a particular bilateral linkage of IPR-related PTA accession or TRIPS compliance.

I design the econometric specification in such a way that it controls for a wide range of unobserved factors. First, importer- and exporter-specific linear time trends ($\alpha_i\, t$ and $\alpha_j\, t$) are included, which capture disparities in trade flow dynamics across countries. It could be that countries that join IPR-related PTAs are countries whose openness to trade grows over the duration of the sample for reasons unrelated to IPR-related PTA accession. By controlling for these trends I account

[14] I also perform the estimation using two other alternative samples. In one version, no restriction is applied to the data (and thus *all* bilateral trade flow observations are used). In the other, rather than discarding all trade with current and future IPR-related PTA partners, I omit all bilateral trade with the US/EU/EFTA, even for countries that never enter into an IPR-related PTA with these countries. Results that estimate equation (3.2) using these alternative samples are presented in the Appendix.

[15] Note that this specification yields equivalent results to one with a main effect common across all industries and an industry specific interaction, but with a slightly different interpretation. For example, if instead of $\beta_5\, Low\text{-}IP_s \times IPA_{it} + \beta_6\, High\text{-}IP_s \times IPA_{it}$, the relevant terms were instead $\beta_5\, IPA_{it} + \beta_6\, High\text{-}IP_s \times IPA_{it}$. In this alternative case, β_5 would be the total effect of IPR-related PTA accession on low-IP exports (the main effect), and $\beta_5 + \beta_6$ would be the total effect of IPR-related PTA accession on high-IP exports (the main effect plus the interaction effect). In the more detailed specifications, such an assortment of main effects and interactions would make interpretation extremely cumbersome. Hence, I adopt this specification which yields the total sector-income group-specific effect with a single term.

for differences in the dynamics of trade flows that might otherwise be attributed to the policy of interest.

I further include importer and exporter income group-sector-year fixed effects ($\alpha_{g_i st}$ and $\alpha_{g_j st}$, where g_i and g_j denote respectively the income group of the exporter and importer in a given bilateral pair), which encompass year-specific shocks that could vary across income groups and sectors. These factors could include, for instance, supply shocks that are common across sectors, income group-specific demand shocks, global macroeconomic fluctuations, or some combination of either.

It is generally the case that traditional gravity approaches control for determinants of bilateral trade costs such as geographical distance or whether a trading pair shares a common border, language, or colonial history. I sidestep the choice of variables to include in this direction with the inclusion of a country-pair fixed effect α_{ij}, which controls for all unobserved, time-invariant factors that affect bilateral trade flows.[16] Finally, ν_{ijst} is an error term.

What should the effects of the IPR policy variables above be based on the earlier discussion and results from the existing literature? When countries upgrade their IPR regimes, either via PTAs or TRIPS, insignificant or negative estimates on the low-IP export effects β_5 and β_7 and positive coefficients on the high-IP export effects β_6 and β_8 might materialize as stronger IPRs shift comparative advantage towards specialization in IPR-intensive industries and away from non-IPR-intensive industries.

Ultimately, the effects are likely to vary across levels of development. For many reasons (including imitative capacity or the quality of other institutions besides IPRs), the effects of stronger IPRs might be different for least-developed countries, versus countries in the middle of the income distribution, versus advanced industrial economies. Thus, while I introduce equation (3.1) (which implicitly assumes homogeneous policy impacts across countries at different levels of developments, an assumption generally rebutted in the literature) to motivate the empirical analysis, the estimates of this equation are not presented here. Instead, I expand on this basic specification

[16]Note that in addition to controlling for time-invariant bilateral variation, α_{ij} also encompasses the inclusion of country-level fixed effects α_i and α_j, as α_{ij} is perfectly collinear with a linear combination of α_i and α_j terms. Intuitively, controlling for the time-invariant features of each bilateral pair also controls for the time-invariant features of the countries themselves.

by allowing for the effects of IPR-related PTA and TRIPS accession to vary between low income, lower-middle income, upper-middle income, and high-income countries.[17]

Equation (3.2) is similar to equation (3.1), but now, the IPA and $TRIPS$ variables are interacted with the income group of the importer or exporter—thus, the policy effects originally captured by coefficients β_5 through β_{12} are now allowed to differ across income groups:

$$\begin{aligned} T_{ijst} = \exp\Big\{ & \beta_1 \log\left(GDP_{it}\right) + \beta_2\, High\text{-}IP_s \times \log\left(GDP_{it}\right) \\ & + \beta_3 \log\left(GDP_{jt}\right) + \beta_4\, High\text{-}IP_s \times \log\left(GDP_{jt}\right) \\ & + \sum_g \beta_{5g}\, Group_i^g \times Low\text{-}IP_s \times IPA_{it} + \sum_g \beta_{6g}\, Group_i^g \times High\text{-}IP_s \times IPA_{it} \\ & + \sum_g \beta_{7g}\, Group_i^g \times Low\text{-}IP_s \times TRIPS_{it} + \sum_g \beta_{8g}\, Group_i^g \times High\text{-}IP_s \times TRIPS_{it} \\ & + \sum_g \beta_{9g}\, Group_j^g \times Low\text{-}IP_s \times IPA_{jt} + \sum_g \beta_{10g}\, Group_j^g \times High\text{-}IP_s \times IPA_{jt} \\ & + \sum_g \beta_{11g}\, Group_j^g \times Low\text{-}IP_s \times TRIPS_{jt} + \sum_g \beta_{12g}\, Group_j^g \times High\text{-}IP_s \times TRIPS_{jt} \\ & + \alpha_i\, t + \alpha_j\, t + \alpha_{g_i st} + \alpha_{g_j st} + \alpha_{ij} \Big\} + \nu_{ijst}. \end{aligned} \tag{3.2}$$

$Group_i^g$ and $Group_j^g$ are indicator variables that denote whether exporter i or importer j belongs to income group $g \in \{\text{LI}, \text{LMI}, \text{UMI}, \text{HI}\}$. With three dozen coefficients of interest to interpret (2 sectors $\times$ 4 income groups $\times$ 2 policies for both importers and exporters), this is a complicated regression equation.[18]

Turning to estimation, the results from estimation of equation (3.2) are shown in Table 3.1.[19] Columns 1 and 2 respectively display the exporter and importer coefficients, both of which are generated by the same regression. Because of the inclusion of the bilateral pair fixed effect α_{ij},

[17] I further test whether the results are sensitive to the choice of income groupings, i.e., the 1995 World Bank classification. As alternatives, I employ (i) the World Bank classification for the year 2000, (ii) quartiles of GDP per capita levels in 1995 and 2000, and (iii) terciles of GDP per capita levels in 1995 and 2000. The findings are qualitatively unchanged with the use of these alternative definitions.

[18] To illustrate the correct interpretation, consider the impact of exporter i's accession to an IPR-related PTA on its high-IP exports. The exact effect depends on the income group of i, and is given by either β_{6LI}, β_{6LMI}, β_{6UMI}, and β_{6HI}. For instance, a low-income country in an IPR-related PTA will see an expected difference of β_{6LI} in its high-IP exports. Similar interpretations will apply to the other sector, group, and policy combinations.

[19] Only recently have algorithms been developed to efficiently estimate relationships with a large number of high-dimensional fixed effects such as ours. I implement the PPML estimation using a modification of the iterative Gauss-Seidel algorithm of Guimarães and Portugal (2010) based on the `reghdfe` module for Stata by Sergio Correia (2014).

observations on bilateral linkages where trade is always zero—e.g. Afghanistan is never recorded as exporting to Zimbabwe during any of the years in the sample—must be omitted, since this fixed effect perfectly predicts trade between such pairs. It is important to note that the estimates in both columns are from the same regression, with exporter and importer effects "unstacked" to facilitate their presentation.[20]

I first focus on the results for exporters in column 1. The income elasticities of exports are significantly positive, and broadly conform to previous estimates from the literature. The income elasticity with respect to high-IP exports ($0.129 + 0.373 = 0.512$) is larger than for low-IP exports (0.129), suggesting that larger economies tend to specialize more in IPR-intensive industries. With regard to the *IPA* policy variable interactions, I find statistically significant effects that conform to what should arise from the strengthening of IPR regimes. The low-IP exports of low-income countries to third countries do not seem to be impacted. Countries at middle and high levels of development (LMI, UMI, and HI), however, see their exports of low-IP goods decline, with respective coefficients for LMI and UMI countries of –0.265, –0.748, and –0.222, each of which is significant at the 95% level. These estimates correspond to average reductions in low-IP bilateral trade with third countries of –23.3% ($= \left(e^{-0.265} - 1\right) \times 100\%$), –52.7% ($= \left(e^{-0.748} - 1\right) \times 100\%$), and –19.9% ($= \left(e^{-0.222} - 1\right) \times 100\%$) for PTA members in these respective income groups.[21]

That low-IP exports to third-countries decline for certain types of PTA members accords with ex ante intuition on the structure of comparative advantage as it relates to IPRs. What, then, can be said about high-IP exports, which might be expected to increase when PTA members implement stronger IPRs? As with their low-IP exports, the exports of low-income countries in high-IP industries do not seem to be impacted in a statistically significant way. However, the decline in low-IP exports for members three highest income groups is accompanied by a profound increase in high-IP exports. These estimates imply increases in high-IP exports of 47.4% for LMI countries, 60.2%

[20] A version of equation (3.2) is also estimated without controls for TRIPS compliance, the results for which are presented in the Appendix. Estimates on the *IPA* interactions are largely similar, but dramatic differences in certain coefficients suggests that omitting TRIPS compliance would bias the results.

[21] This percentage change expression of the coefficients results from the exponential relationship between T_{ijst} and the binary policy variables. For some $y = \exp\{\beta_1 x_1 + \beta_2 x_2\}$, where x_1 is an indicator variable, the percentage difference in the value of y when $x_1 = 1$ versus when $x_1 = 0$ is given by $\left(\frac{\exp\{\beta_1+\beta_2 x_2\}-\exp\{\beta_2 x_2\}}{\exp\{\beta_2 x_2\}}\right) \times 100\%$, which, after manipulation, simplifies to $\left(e^{\beta_1} - 1\right) \times 100\%$.

Table 3.1: Bilateral Trade in Low-IP and High-IP Sectors

	(1) Exports	(2) Imports
log(GDP)	0.129***	0.533***
	(0.036)	(0.032)
High-IP × log(GDP)	0.373***	0.023
	(0.033)	(0.034)
LI × Low-IP × IPA	−0.131	−0.264*
	(0.107)	(0.154)
LMI × Low-IP × IPA	−0.265***	−0.003
	(0.097)	(0.066)
UMI × Low-IP × IPA	−0.748***	−0.062
	(0.143)	(0.099)
HI × Low-IP × IPA	−0.222**	0.029
	(0.100)	(0.079)
LI × High-IP × IPA	−0.064	0.298**
	(0.215)	(0.134)
LMI × High-IP× IPA	0.388***	0.019
	(0.111)	(0.078)
UMI × High-IP × IPA	0.471***	0.258***
	(0.155)	(0.082)
HI × High-IP × IPA	0.173***	−0.031
	(0.067)	(0.068)
LI × Low-IP × TRIPS	−0.298***	0.230**
	(0.077)	(0.107)
LMI × Low-IP × TRIPS	−0.561***	0.146**
	(0.084)	(0.058)
UMI × Low-IP × TRIPS	−0.488***	−0.173**
	(0.077)	(0.078)
HI × Low-IP × TRIPS	0.451***	0.068
	(0.102)	(0.096)
LI × High-IP × TRIPS	0.595***	0.354***
	(0.115)	(0.097)
LMI × High-IP × TRIPS	1.428***	−0.079
	(0.154)	(0.049)
UMI × High-IP × TRIPS	1.130***	0.137**
	(0.163)	(0.055)
HI × High-IP × TRIPS	0.150**	0.012
	(0.074)	(0.059)
Observations		1,055,276
No. of country pairs		27,892
Country trends		✓
Group-sector-year FEs		✓
Pair FEs		✓

Notes: The dependent variable is bilateral trade flows excluding trade with future/current IPR-related PTA partners. Columns (1) and (2) present exporter and importer coefficients from the same regression. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

for UMI countries, and 18.9% for HI countries. While it is not possible from the reduced-form analysis to determine the precise origin of these effects, the relative magnitudes of the coefficients across income groups hint at a potential explanation beyond a basic restructuring of comparative advantage.

First, it could be the case that LI countries are unequipped to realize the impacts of IPRs-upgrading. Other impediments to trade, such as underdeveloped institutions in areas besides IPRs, impede these countries' ability to develop and maintain robust export sectors in IPR-intensive industries. Exports of LMI countries, however, are affected by IPRs-upgrading, but these countries seem to be able to only imperfectly benefit from their effects. As with LI countries, it might be that other institutional features of these countries inhibit the role of improved IPRs in influencing comparative advantage. The exports of UMI countries, on the other hand, are significantly impacted. The twin facts that the magnitude of increase in high-IP exports is larger than the reduction in low-IP exports ($60.2\% > |-52.7\%|$), and that these countries tend to have higher levels of exports in high-IP industries than low-IP industries, means that these countries see their overall trade with countries outside of their PTA increase.

Finally, HI PTA members also see their high-IP exports rise and their low-IP exports fall, but less so than LMI and UMI PTA members. The reasons for this could be twofold. HI countries tend to be large economies, and large changes in exports (in percentage terms) are comparatively more difficult to realize (for instance, it is likely easier to effect a 10% increase in $10 billion of exports than it is $1 trillion of exports). Further, these economies—countries such as Australia, South Korea, or Singapore—tend to already possess relatively advanced domestic IPR regimes, and for such countries, the impacts of the IPR provisions in PTAs are likely to be marginal. All-in-all, the effects on exports seem to be consistent with a pronounced effect on the structure of comparative advantage as determined by IPRs.

Turning now to the importer effect estimates of IPA (column 2 in Table 3.1), I estimate a significantly positive income elasticity on imports (with an estimate of 0.533), with no significant difference between the low-IP and high-IP income effects. Significant effects on imports of IPR-related PTA accession fail to arise to the same degree as with exports, with the exceptions of I akly negative effects on the low-IP imports of LI countries, and positive effects on the high-IP imports of LMI and HI countries.

This (lack of a) result suggests several interpretations. First, that any effects of IPR-related PTA accession are concentrated on the export side, and the countervailing effects described earlier make it difficult to observe systematic impacts on imports. Or, it could be that importer effects do exist, but are masked by the level of aggregation in this specification. In the next section, the high-IP sector is disaggregated into a more detailed sectoral breakdown, which will shed more light on the seemingly non-existent importer effects.

Though TRIPS is not the primary focus of the analysis, it is worthwhile to briefly describe what the estimates of the associated coefficients convey (in the empirical exercises to follow, discussion of the TRIPS estimates will be omitted for the sake of exposition). The export results in column 1 seem to mirror the estimates of the IPA export coefficients. Across all levels of income, TRIPS compliance corresponds to substantial decreases in low-IP exports (though only in a statistically significant way for LI, LMI, and UMI countries) and substantial increases in high-IP exports (for all income groups). This has an important implication for the results on IPR-related PTA membership effects. It is not TRIPS alone, nor IPR-related PTAs alone, that impact trade via IPRs-upgrading. The policies seem to operate in tandem, and IPR-related PTA accession offers a channel for IPRs upgrading with impacts that go beyond those of TRIPS.

3.4 Trade in High-IP Industry Clusters

The most important takeaway thus far is the finding of significant effects of IPR-related PTA accession on exports to extra-PTA third countries in low-IP and high-IP sectors consistent with an IPRs-induced restructuring of comparative advantage. This was coupled with scattered effects on imports, which, despite their ambiguity, were also consistent with the predictions from earlier. A natural question that follows, then, is how these effects break down along more disaggregated sectoral breakdowns.

Based on the discussion in Section 3.1, the specific provisions in each agreement suggest that the impacts will be manifested more strongly in particular sectors. For example, provisions such as test data confidentiality and prohibitions on generic competition will have the most visible impacts on trade in biopharmaceuticals and chemicals, while expanded protections for integrated circuit designs might imaginably be most applicable to trade in ICT-related commodities.

Further, beyond the sector-specificity of certain provisions, IPR-intensive sectors vary in just how intensively they rely on certain rights. Stronger patents, copyrights, and trademarks, or more effective enforcement of such rights, might affect certain industries more than others. Along these lines, I modify the specification from equation (3.2) to allow for a more refined breakdown of the high-IP sector. To do this, I divide the high-IP commodities into the seven IPR-intensive subsectors (in a categorization based on Delgado et al. 2013 and US Department of Commerce 2012) described earlier. Again, these subsectors include analytical instruments (AI), biopharmaceuticals (BIO), chemicals (CHEM), information and computer technology (ICT), medical devices (MED), production technology (PT), and a residual category of high-IP commodities that fall under none of these categories (Other).[22] The estimating equation that I now employ is otherwise the same as before, but I can now delineate the effects of IPR-related PTA accession in the following way:

$$
\begin{aligned}
T_{ijst} = \exp\Big\{ & \beta_1 \log\left(GDP_{it}\right) + \sum_s \beta_{2s}\, Sector_s \times \log\left(GDP_{it}\right) \\
& + \beta_3 \log\left(GDP_{jt}\right) + \sum_s \beta_{4s}\, Sector_s \times \log\left(GDP_{jt}\right) \\
& + \sum_g \beta_{5g}\, Group_i^g \times Low\text{-}IP_s \times IPA_{it} + \sum_g \sum_s \beta_{6gs}\, Group_i^g \times Sector_s \times IPA_{it} \\
& + \sum_g \beta_{7g}\, Group_i^g \times Low\text{-}IP_s \times TRIPS_{it} + \sum_g \sum_s \beta_{8gs}\, Group_i^g \times Sector_s \times TRIPS_{it} \\
& + \sum_g \beta_{9g}\, Group_j^g \times Low\text{-}IP_s \times IPA_{jt} + \sum_g \sum_s \beta_{10gs}\, Group_j^g \times Sector_s \times IPA_{jt} \\
& + \sum_g \beta_{11g}\, Group_j^g \times Low\text{-}IP_s \times TRIPS_{jt} + \sum_g \sum_s \beta_{12gs}\, Group_j^g \times Sector_s \times TRIPS_{jt} \\
& + \alpha_i\, t + \alpha_j\, t + \alpha_{g_i st} + \alpha_{g_j st} + \alpha_{ij} \Big\} + \nu_{ijst}.
\end{aligned} \tag{3.3}
$$

Here, s indexes the seven high-IP subsectors, with $s \in \{\text{AI}, \text{BIO}, \text{CHEM}, \text{ICT}, \text{MED}, \text{PT}, \text{Other}\}$. $Sector_s$ is an indicator variable for whether a specific observation belongs to a particular high-IP subsector. As before, each of the coefficients on the policy interactions reveal the total policy

[22] See the Appendix for a full list of the industries and associated SITC codes comprising each of these subsectors.

impact of either IPA or $TRIPS$, separately for exporters and importers, broken down along lines of countries' income levels and across the low-IP and high-IP subsectors. The triple interactions are admittedly even more cumbersome than the double interactions in the previous specification, but the interpretation will be nearly identical.[23]

Tables 3.2a and 3.2b show the results from estimating equation (3.3), omitting trade between current and future IPR-related PTA partners as before.[24] Note again that each of the columns in the table are from the same regression, with the columns depicting the coefficients for each sector-specific policy interaction, and that as before, both the exporter and importer effects are from the same regression (with the exporter effects given in Table 3.2a and the importer effects given in Table 3.2b). To facilitate interpretation of the numerous coefficients, I also graphically present the corresponding coefficient estimates—estimates of the effect on exporters or importers of IPR-related PTA accession, by sector and income group—with corresponding 95% confidence interval bands.

Turning to the results for the exporter effects, I estimate income elasticities of exports that are generally strongly and significantly positive, but which vary by sector. The elasticity with respect to low-IP exports is estimated to be only 0.124, but the elasticities for the high-IP subsectors range from 0.466 ($= 0.124 + 0.282$) for ICT to 0.747 ($= 0.124 + 0.623$) for MED.

The estimates for the exporter coefficients for IPA offer a more nuanced picture than the one found in the simple high-IP versus low-IP sectoral breakdown. As before, the low-IP exports of LMI, UMI, and HI countries in IPR-related PTAs are lower on average, but these export losses are offset by sizable export gains in most of the high-IP subsectors, a result that is again consistent with IPRs playing a role in determining comparative advantage. While the exports of every high-IP subsector (aside from ICT exports, estimates for which are either statistically insignificant, or in the case of HI countries, exhibit a significant decline) are estimated to expand, the most sizable gains are to be found in biopharmaceutical trade. Other positive export effects arise in analytical instruments, chemicals, medical devices, production technology (aside from LI exports, which are

[23] For instance, to obtain the effect of IPR-related PTA accession on the BIO imports of a lower-middle income country, the relevant coefficient would be the estimate of $\beta_{10LMI,BIO}$.

[24] Results from estimating equation (3.3) using all bilateral trade observations for this sectoral breakdown, including trade between current and future PTA partners, as well as results using a sample that omits all trade with the US, the EU, or EFTA countries as partners (regardless of PTA membership) are presented in the Appendix.

Table 3.2a: Bilateral Trade in Low-IP and High-IP Subsectors, Exports

	(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)
				⋮				

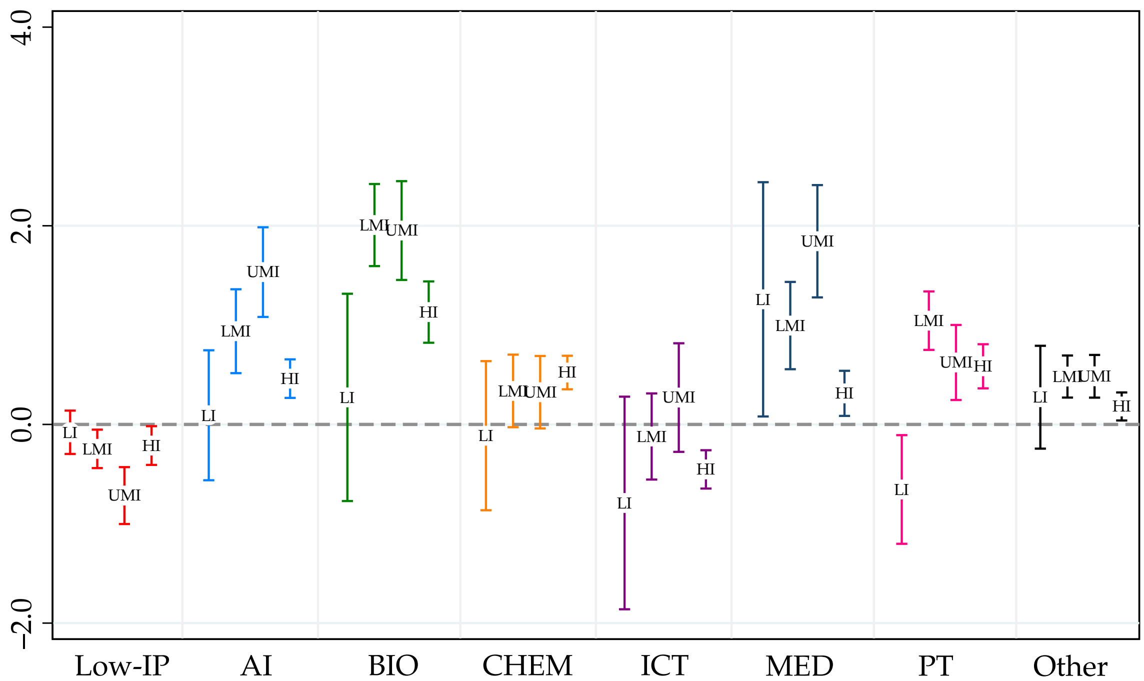
Table 3.2b: Bilateral Trade in Low-IP and High-IP Subsectors, Imports

	(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
No. of country pairs								27,886
Country trends								✓
Group-sector-year FEs								✓
Pair FEs								✓

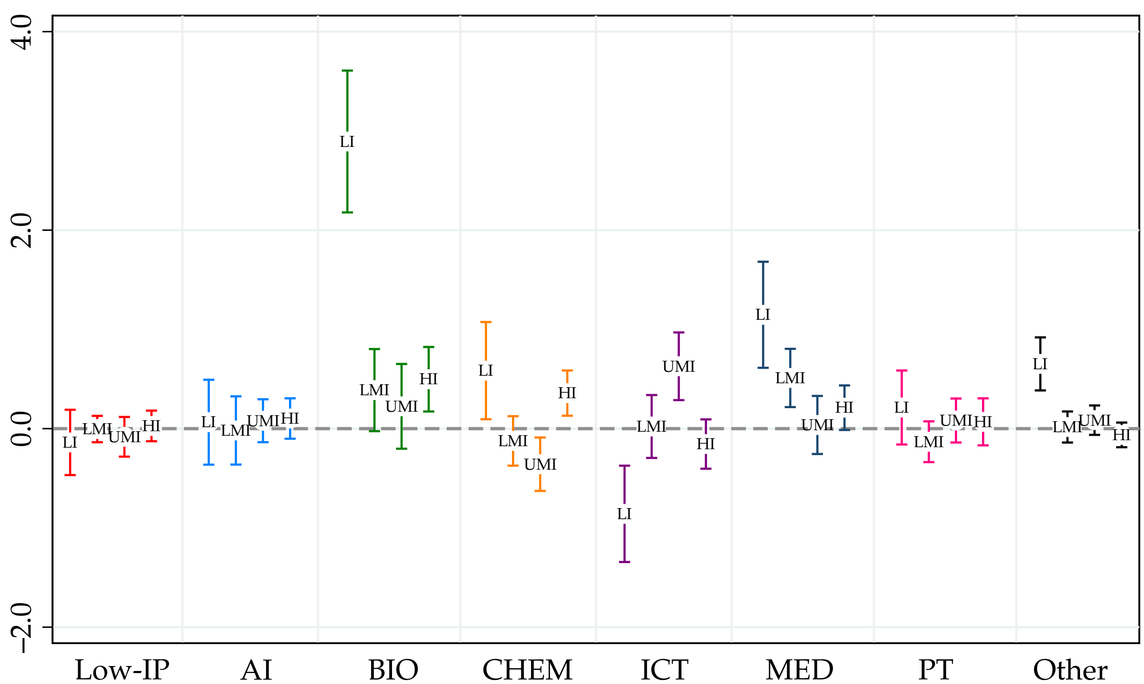
Notes: The dependent variable is unidirectional bilateral trade flows, excluding bilateral linkages with current and future IPR-related PTA partners. Each of the columns report coefficients from a single regression, delineated by sector. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Figure 3.3: Intensive Margin Effects of IPR-related PTA Accession, by Income Group and Sector

3.3a: Exporter Effects



3.3b: Importer Effects



Notes: For each subsector, the label in the center of the confidence band indicates the location of the point estimate of the coefficient on *IPA* for countries in the indicated income group. The confidence bands correspond to the 95% confidence intervals on the estimates of each coefficient.

surprisingly found to evince a negative effect), and other high-IP sectors, and the disparities in the estimates suggest that the impacts are highly sector-specific.

That the strongest results arise in biopharmaceutical trade should come as no surprise. The interests of pharmaceutical firms coincide strongly the implementation of a strong international system of IPRs, given the R&D- and patent-intensive nature of the industry. When a country has a system of IPRs that favors creators and owners of knowledge assets—and pharmaceuticals are undoubtedly a commodity that embodies significant R&D and proprietary knowledge—on average its pharmaceutical sector sees its exports expand considerably (with estimated average increases of 644.1% for LMI countries, 604.3% for UMI countries, and 209.9% for HI countries). The fact that the PTAs negotiated by the US and Europe emphasize this sector so strongly leads to effects that spill over beyond the membership of the PTAs in profound ways.

On the import side, significant results are again scattered across various income group-sector permutations, but certain results merit particular interest. The most striking result here is on the pharmaceutical imports of LI countries, which on average increase by a dramatic 1,704.7%. When viewed in conjunction with the results in the next section on the extensive margin of trade, this will be powerful evidence in favor of a strong market expansion effect dominating any market power effects in pharmaceuticals.

Beyond pharmaceutical trade, other notable effects come through on the import side. LI PTA members also witness their imports of chemicals, medical devices, and other high-IP commodities increase in the wake of the implementation of rigorous IPRs standards, while ICT imports are seen to decline. For LMI countries, medical device imports increase substantially, while for UMI countries chemicals imports decline and ICT imports increase, in contrast with the effect on the ICT imports of LI countries. Finally, HI countries undergo significant increases in their imports of pharmaceuticals and chemicals, which again accords with the logic on the effects of pharmaceutical- and chemical-sector specific provisions, as even advanced economies are required by their PTA obligations to implement strong protections for these sectors that were not in place before.

To recap, the systematic third-country results on exports and scattered results on imports are preserved when considering more disaggregated high-IP subsectors. The positive export effects on high-IP trade remain consistent with broad comparative advantage effects, but in examining specific sectors, it can be seen that some sectors' exports are affected more noticeably than others; most notably, in order of magnitude, pharmaceuticals, medical devices, analytical instruments, and production technology. And while many of the effects seem to be imparted through the export channel, there are considerable impacts to be seen in some industries. The most pronounced effect arise in the imports of LI PTA members of pharmaceuticals, but these countries also import more chemicals, medical devices, and other high-IP commodities. HI PTA members also import more in these industries, suggesting that consumers in economies at different levels of development receive expanded access to these commodities.

3.5 The Extensive Margin of IPR-intensive Trade

The effects that have been considered thus far have been intensive margin effects on the value of third-country bilateral trade flows. From the discussion in Section 3.1, it is conceivable that stronger IPRs reveal their effects both with respect to the value of trade as well as the extensive margin of trade, which I will take to be the number of varieties exported or imported within each of the specific low-IP and high-IP sectors.

Stronger IPRs in a PTA member country might facilitate domestic production of IPR-intensive goods that would not otherwise be produced and exported, and could potentially expand the extensive margin of exports. Similar logic could motivate an expansion in the number of imported varieties. Stronger IPRs in a destination market reduce the expected costs of entering that market that might arise from deterring imitation or ensuring that IPRs are effectively enforced. On the other hand, if stronger IPRs expand the set of varieties that are produced domestically, this could crowd out imports of these varieties, and thus the expected overall effect on the extensive margin of imports is not immediately evident. IPRs, then can thus be expected to influence the extensive margin of third-country trade in ways similar to the ones posited earlier, but for subtly different reasons.

Equation (3.4) presents the specification to be estimated, which is a slight modification of the one in equation (3.3):

$$
\begin{aligned}
X_{ijst} = \exp\Big\{ & \beta_1 \log\left(GDP_{it}\right) + \sum_s \beta_{2s}\, Sector_s \times \log\left(GDP_{it}\right) \\
& + \beta_3 \log\left(GDP_{jt}\right) + \sum_s \beta_{4s}\, Sector_s \times \log\left(GDP_{jt}\right) \\
& + \sum_g \beta_{5g}\, Group_i^g \times Low\text{-}IP_s \times IPA_{it} + \sum_g \sum_s \beta_{6gs}\, Group_i^g \times Sector_s \times IPA_{it} \\
& + \sum_g \beta_{7g}\, Group_i^g \times Low\text{-}IP_s \times TRIPS_{it} + \sum_g \sum_s \beta_{8gs}\, Group_i^g \times Sector_s \times TRIPS_{it} \\
& + \sum_g \beta_{9g}\, Group_j^g \times Low\text{-}IP_s \times IPA_{jt} + \sum_g \sum_s \beta_{10gs}\, Group_j^g \times Sector_s \times IPA_{jt} \\
& + \sum_g \beta_{11g}\, Group_j^g \times Low\text{-}IP_s \times TRIPS_{jt} + \sum_g \sum_s \beta_{12gs}\, Group_j^g \times Sector_s \times TRIPS_{jt} \\
& + \alpha_i\, t + \alpha_j\, t + \alpha_{g_i st} + \alpha_{g_j st} + \alpha_{ij} \Big\} + \nu_{ijst}.
\end{aligned}
\tag{3.4}
$$

Interpretation of the coefficients will be the same as equation (3.3), as will the construction of the dataset in its omission of trade between current and future IPR-related PTA partners. The only difference from the earlier equation is the dependent variable X_{ijst}, which is defined as the count of unique 6-digit HS commodities within a particular sector s that are exported from country i to country j in year t.[25]

This is an imperfect measure of the extensive margin (consider, for instance, the most disaggregated definition of the extensive margin of trade in specific chemicals or pharmaceuticals, where varieties can be delineated at the molecular level), yet it still captures the role of IPRs in influencing the binary decision of whether a particular variety is traded between two countries. On one hand, if the notion of IPRs acting as a determinant of comparative advantage is to be believed, then a country with stronger IPRs will export more varieties of IPR-intensive commodities to a larger number of markets than an otherwise similar country with weaker IPRs. Further, in making the decision on whether and how to serve a particular foreign market, owners of knowledge

[25]The low-IP and high-IP sectors and subsectors are comprised of SITC codes that encompass levels of aggregation ranging from 2-digit to 5-digit industries. Even at the most disaggregated 5-digit level of SITC classifications, the SITC industries can be disaggregated even further into corresponding 6-digit HS commodity codes. The number of 6-digit HS commodities within each sector based on the 2012 revision of the HS classification is: low-IP (2106), AI (41), BIO (69), CHEM (178), ICT (76), MED (40), PT (267), and other (1606).

assets and producers of IPR-intensive commodities must I igh the potential revenues to be gained in the new market against the costs of serving the market, both of which will be determined in part by the destination's IPR regime—by the enforcement efforts of the government, by the rules on coverage and duration of protection, and by the costs that might otherwise be incurred to deter imitation or appropriation.

Table 3.3a presents the results for the exporter coefficients and Table 3.3b the analogous results for the importer coefficients for the relation between IPR-related PTA accession and the extensive margin of bilateral trade with third countries. The results are also depicted graphically in Figure 3.4. On the export side, some of the results mirror the analysis of the intensive margin effects, while some results contrast noticeably. While the earlier results on the high-IP exports of LI countries were generally insignificant, the results here show a significant positive effect on the number of low-IP varieties exported to third countries, and significantly negative effects on the number of varieties within the analytical instruments, medical device, and production technology high-IP subsectors. For LMI partners, however, this effect is largely reversed. On average, the number of low-IP varieties exported declines, while the number of varieties exported in a number of high-IP subsectors expands considerably. And, for UMI and HI countries, the effects are more scattered, as in some subsectors the number of exported varieties expands, while in others it contracts.

How do these results on the extensive margin of exports fit with the narrative that arose from the results on the intensive margin? Immediately obvious is that, as before, the direction and significance of the effects depends on the development level of the PTA member and industrial composition. Again, there seem to be threshold effects that impede the least-developed PTA partners from realizing substantial effects on their exports. On the other hand, for LMI countries positive effects abound in nearly all of the high-IP subsector, with impacts ranging from a 12.2% increase in the number of exported varieties within chemicals, to a sizable 45.2% increase in the number for pharmaceuticals.

One explanation for these results is the notion that stronger IPRs alter the incentives to produce and export particular varieties that would otherwise not be traded by LMI countries. Stronger IPRs provide sufficient benefits for exporters to, in a Melitz (2003) sense, alter the extensive margins of exports. Why, then, are the export results less consistent for UMI and HI countries? Recall

Table 3.3a: The Extensive Margin of Trade in Low-IP and High-IP Subsectors, Exports

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Exporter effects								
log(GDP)	–0.092***							
	(0.010)							
Sector × log(GDP)		0.016***	0.030***	0.164***	–0.062***	0.037***	0.063***	0.048***
		(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.003)
Sector × LI × IPA	0.121***	–0.372***	0.118	0.297**	–0.091	–0.426***	–0.292***	0.026
	(0.047)	(0.069)	(0.097)	(0.141)	(0.059)	(0.103)	(0.071)	(0.058)
Sector × LMI × IPA	–0.138***	0.273***	0.373***	0.115***	0.158***	0.301***	0.218***	0.041
	(0.025)	(0.035)	(0.042)	(0.040)	(0.035)	(0.035)	(0.032)	(0.026)
Sector × UMI × IPA	–0.285***	0.136***	0.053	–0.198***	0.233***	–0.056	0.007	–0.045**
	(0.027)	(0.037)	(0.040)	(0.034)	(0.044)	(0.037)	(0.028)	(0.022)
Sector × HI × IPA	–0.049***	0.010	0.309***	0.266***	–0.173***	–0.017	0.089***	–0.036***
	(0.014)	(0.021)	(0.020)	(0.017)	(0.019)	(0.018)	(0.014)	(0.010)
Sector × LI × TRIPS	–0.232***	0.206***	0.138***	0.137***	0.146***	0.245***	0.168***	0.082***
	(0.015)	(0.033)	(0.030)	(0.031)	(0.027)	(0.026)	(0.031)	(0.015)
Sector × LMI × TRIPS	0.096***	–0.207***	0.150***	0.102***	0.179***	0.015	–0.114***	0.054***
	(0.017)	(0.031)	(0.041)	(0.038)	(0.028)	(0.028)	(0.022)	(0.015)
Sector × UMI × TRIPS	–0.060***	0.035	0.170***	–0.014	–0.100***	–0.083**	0.170***	–0.049**
	(0.023)	(0.043)	(0.048)	(0.031)	(0.038)	(0.038)	(0.031)	(0.020)
Sector × HI × TRIPS	0.124***	0.306***	0.377***	–0.061**	0.153***	0.360***	0.274***	0.120***
	(0.018)	(0.023)	(0.030)	(0.027)	(0.025)	(0.028)	(0.019)	(0.014)

⋮

Table 3.3b: The Extensive Margin of Trade in Low-IP and High-IP Subsectors, Imports

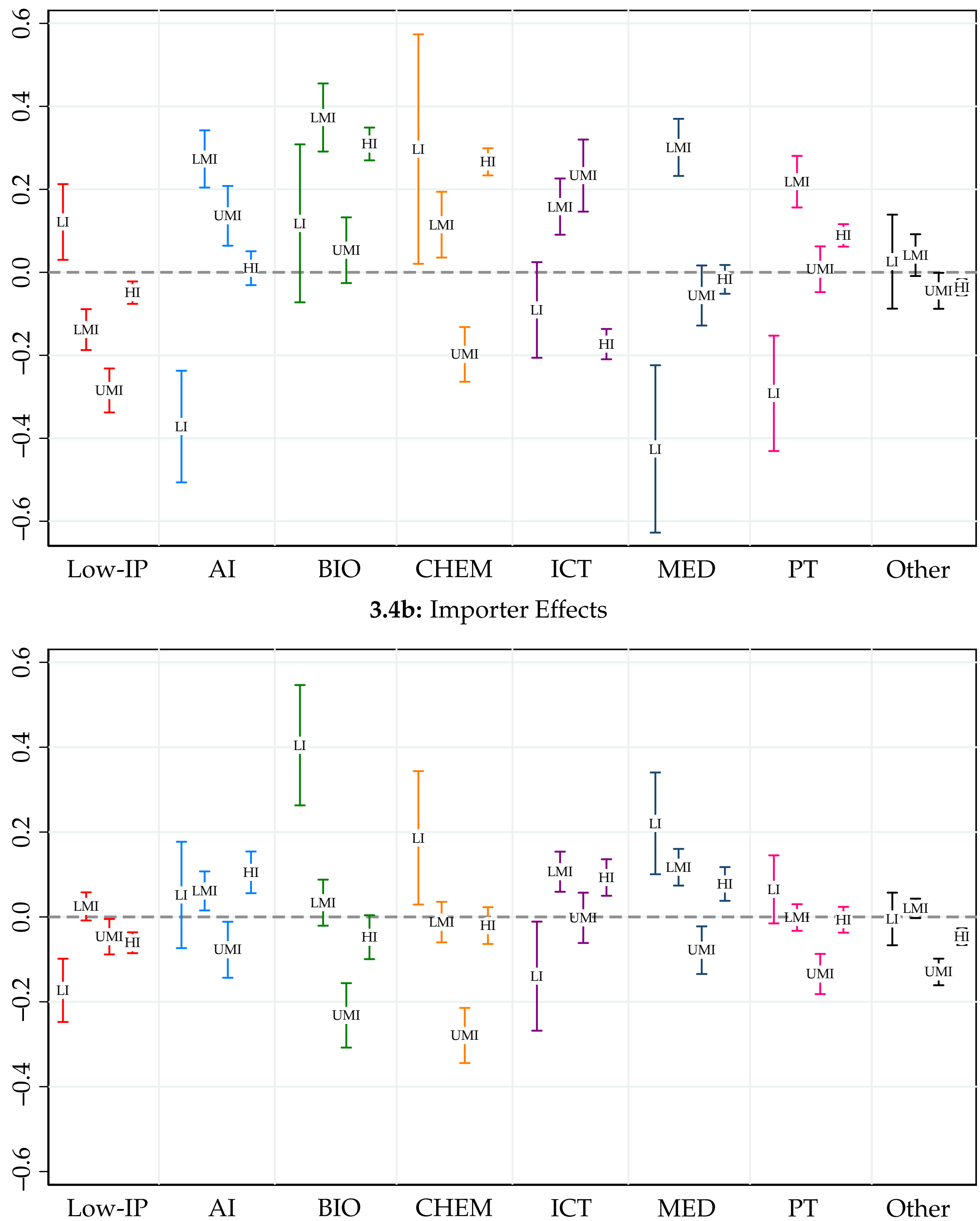
	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Importer effects								
log(GDP)	0.287**							
	(0.009)							
Sector × log(GDP)		0.008	–0.045***	0.085***	–0.044***	–0.035***	0.011***	–0.022***
		(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)	(0.003)
Sector × LI × IPA	–0.173***	0.052	0.405***	0.186**	–0.140**	0.221***	0.065	–0.005
	(0.038)	(0.064)	(0.072)	(0.080)	(0.066)	(0.061)	(0.041)	(0.032)
Sector × LMI × IPA	0.025	0.061***	0.034	–0.012	0.107***	0.117***	–0.001	0.020*
	(0.017)	(0.023)	(0.028)	(0.024)	(0.024)	(0.022)	(0.016)	(0.012)
Sector × UMI × IPA	–0.047**	–0.077**	–0.232***	–0.279***	–0.002	–0.078***	–0.135***	–0.130***
	(0.021)	(0.034)	(0.039)	(0.033)	(0.030)	(0.029)	(0.024)	(0.016)
Sector × HI × IPA	–0.061***	0.105***	–0.048*	–0.020	0.093***	0.078***	–0.007	–0.046***
	(0.013)	(0.025)	(0.026)	(0.022)	(0.022)	(0.020)	(0.016)	(0.010)
Sector × LI × TRIPS	0.039**	–0.159***	–0.057*	0.023	–0.123***	–0.157***	–0.131***	–0.051***
	(0.018)	(0.025)	(0.030)	(0.026)	(0.025)	(0.023)	(0.018)	(0.013)
Sector × LMI × TRIPS	0.030*	0.094***	0.272***	0.220***	0.153***	0.117***	0.054***	0.087***
	(0.016)	(0.024)	(0.026)	(0.022)	(0.023)	(0.021)	(0.016)	(0.011)
Sector × UMI × TRIPS	–0.085***	0.010	0.010	0.061**	0.066**	–0.068**	–0.093***	–0.061***
	(0.021)	(0.031)	(0.032)	(0.025)	(0.027)	(0.029)	(0.021)	(0.012)
Sector × HI × TRIPS	0.120***	0.149***	0.120***	0.022	0.184***	0.208***	0.142***	0.156***
	(0.017)	(0.030)	(0.036)	(0.033)	(0.027)	(0.028)	(0.023)	(0.015)
Observations								4,221,104
No. of country pairs								27,892
Country trends								✓
Group-sector-year FEs								✓
Pair FEs								✓

Notes: The dependent variable is the count of 6-digit HS commodities within each sector, excluding bilateral linkages with current and future IPR-related PTA partners. Each of the columns reports coefficients from a single regression, delineated by sector. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Figure 3.4: Extensive Margin Effects of IPR-related PTA Accession, by Income Group and Sector

3.4a: Exporter Effects

3.4b: Importer Effects



Notes: For each subsector, the label in the center of the confidence band indicates the location of the point estimate of the coefficient on *IPA* for countries in the indicated income group. The confidence bands correspond to the 95% confidence intervals on the estimates of each coefficient.

that member countries in these income groups exhibited substantial gains in the intensive margin of their exports to partners outside of the PTA. That the extensive margin effects only materialize in a small subset of sectors (or are estimated as being negative) suggests that the change in exports occurs within already-traded varieties. Stronger IPRs bolster an already existing comparative advantage in these sectors, but do not push these countries to export new varieties.

Similarly, the estimates on the extensive margin import effects match the original intensive margin results in some ways, and in other ways diverge. For LI countries, there are significant increases in the number of varieties imported in pharmaceuticals (49.9%), chemicals (20.4%), and medical devices (24.7%). Recall that it was in these categories that the intensive margin of imports of LI countries expanded most sharply, suggesting that not only do these PTA partners import more of these commodities in value terms, but they also import a wider variety of these commodities in response to IPRs-upgrading.

Another noteworthy result can be seen in the imports of UMI countries in every subsector but ICT. This paints a drastically different picture from the intensive margin results, where hardly any significant effects were evident. The immediate driver of this effect is not clear, but it is plausible that a strengthening in the IPRs regimes of these countries bolsters domestic production in these sectors, which results in fewer commodities in these industries needing to be imported from abroad. Finally, effects for LMI and HI countries are generally positive, but not systematic.

The way in which these results fit with each other—strong positive effects for some income groups, strong negative effects for others, or nonexistent effects—is not immediately apparent. While it may seem convenient to point to the ambiguity of the theory while emphasizing potential channels, no single narrative carries the day in the results depicted here. Comparative advantage effects consistent with a strengthening of institutional quality seem to be a reasonable fit for many of the positive export results, while on the other hand, there seem to be cases where either market power or market expansion effects drive the changes. Or, it could be that unobserved shifts in FDI—MNEs deciding to serve a market through domestic production rather than exports—drive some of the results. While this is admittedly a shortcoming of this reduced-form analysis, it remains apparent that third-country trade along the extensive margin is materially impacted by IPR-related PTA accession in ways that sometimes mimic, but in other ways differ, from the effects on the intensive margin.

3.6 The Origins and Destinations of Third-Country Trade

IPR-related PTA accession is associated with changes in the composition of countries' trade with partners outside of the PTA along both the intensive and extensive margin. As a final extension on the previous analyses, this section explores which types of bilateral linkages these changes are manifested in. For instance, when high-income countries in IPR-related PTAs export more IPR-intensive commodities, such as analytical instruments or production technology, what types of countries are they exporting these commodities to? Or, when low-income countries import more high-IP goods such as pharmaceuticals and medical devices, where are they importing these goods from? I now consider the source or destination of the third-country trade undertaken by countries in IPR-related PTAs. In particular, to avoid adding even more complicated subsector-level results to an already cumbersome analysis, wereturn to the original analysis of the value of low-IP and high-IP trade.

Equation (3.2) is modified by interacting the IPA policy effects with the income group of the partner in a given bilateral linkage. To illustrate, instead of having a series of interactions along the lines of $\sum_g \beta_{5g}\, Group_i^g \times Low\text{-}IP_s \times IPA_{it}$, where β_{5g} yielded the impact of IPA on the low-IP exports of an IPR-related PTA member country i belonging to income group g, now such a term will have an additional layer of complexity according to the export destination's income group. The new analogous term becomes $\sum_g \sum_{g'} \beta_{5g}\, Group_i^g \times Group_j^{g'} \times Low\text{-}IP_s \times IPA_{it}$, where g' indexes which of the four income groups to which partner j belongs. Alternatively for the IPA_j effects, a term is added to the interaction indicating the group to which the export partner i of IPR-related PTA member j belongs, and the relevant set of interactions here is $\sum_g \sum_{g'} Group_j^g \times Group_i^{g'} \times Low\text{-}IP_s \times IPA_{jt}$. I transform each of the IPA interactions in such a way, for both exporters and importers and for the low-IP and high-IP sectors:[26]

$$
\begin{aligned}
T_{ijst} = \exp\Big\{ & \beta_1 \log\left(GDP_{it}\right) + \beta_{2s}\, High\text{-}IP_s \times \log\left(GDP_{it}\right) \\
& + \beta_3 \log\left(GDP_{jt}\right) + \beta_{4s}\, High\text{-}IP_s \times \log\left(GDP_{jt}\right) \\
& + \sum_g \sum_{g'} \beta_{5gg'}\, Group_i^g \times Group_j^{g'} \times Low\text{-}IP_s \times IPA_{it} + \sum_g \sum_{g'} \beta_{6gg'}\, Group_i^g \times Group_j^{g'} \times High\text{-}IP_s \times IPA_{it} \\
& + \sum_g \beta_{7g}\, Group_i^g \times Low\text{-}IP_s \times TRIPS_{it} + \sum_g \beta_{8gg'}\, Group_i^g \times High\text{-}IP_s \times TRIPS_{it} \\
& + \sum_g \sum_{g'} \beta_{9gg'}\, Group_j^g \times Group_j^{g'} \times Low\text{-}IP_s \times IPA_{jt} + \sum_g \sum_{g'} \beta_{10gg'}\, Group_j^g \times Group_j^{g'} \times High\text{-}IP_s \times IPA_{jt} \\
& + \sum_g \beta_{11g}\, Group_j^g \times Low\text{-}IP_s \times TRIPS_{jt} + \sum_g \beta_{12gs}\, Group_j^g \times High\text{-}IP_s \times TRIPS_{jt} \\
& + \alpha_i\, t + \alpha_j\, t + \alpha_{g_i st} + \alpha_{g_j st} + \alpha_{ij} \Big\} + \nu_{ijst}.
\end{aligned} \tag{3.5}
$$

I first conduct this analysis for high-IP versus low-IP trade. In addition to reporting the numerical results of the regression (shown Table 3.4), which necessitates the presentation of four times as many coefficients for IPA as in the original analysis, I also present the estimation results graphically in Figure 3.5. Subfigures 3.5a and 3.5b depict the results for the low-IP and high-IP exports of IPR-related PTA members, respectively, while Subfigures 3.5c and 3.5d show the corresponding results for the imports of IPR-related PTA members.

It was shown earlier that low-IP exports declined for IPR-related PTA members in LMI, UMI, and HI income groups, while the high-IP exports of these countries increased. In both sectors, the exports of LI countries were seemingly unaffected in any significant way. When examining the direction of exports in Subfigure 3.5a, the types of bilateral linkages in which these impacts materialize becomes apparent. UMI exporters—the countries with the strongest estimated negative impacts of IPR-related PTA accession on low-IP exports—see their exports of such commodities to LMI, UMI, and HI partners decline substantially. For LMI countries, these negative effects are limited to their low-IP exports to countries in the middle of the income distribution, with the strongest negative effect occurring on their exports to LMI countries. And finally, HI countries witness a modest decline in their low-IP exports to UMI countries.

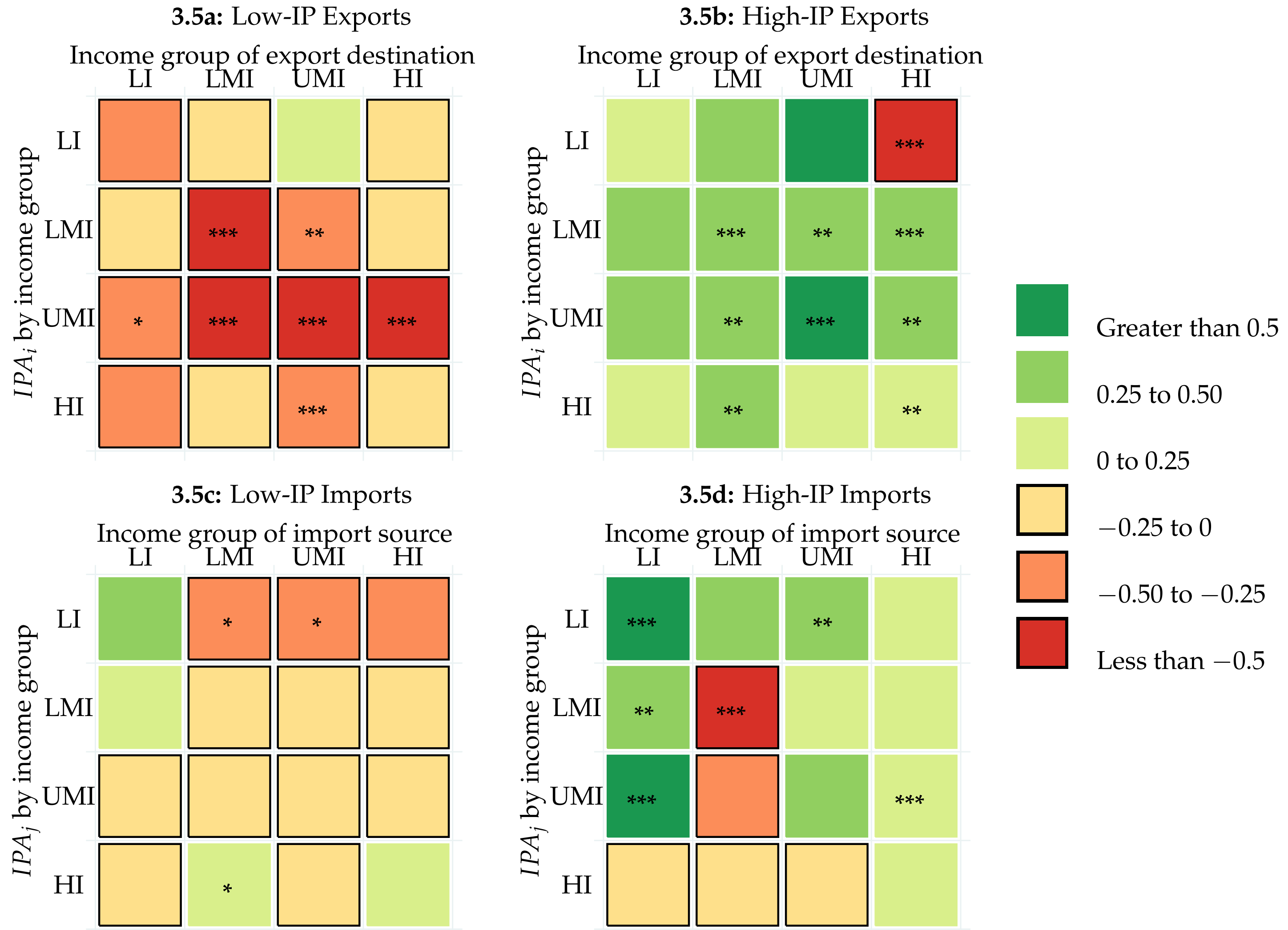
[26]For brevity, reporting of the TRIPS coefficients is suppressed for this analysis.

Table 3.4: Effects of IPR-related PTA Accession by Income Group of Trade Partner

	Exporter effects				Importer effects			
	Income group of export destination ($Group_j^{g'}$)				Income group of import source ($Group_i^{g'}$)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LI	LMI	UMI	HI	LI	LMI	UMI	HI
LI × Low-IP × IPA	−0.446	−0.193	0.213	−0.197	0.335	−0.440*	−0.453*	−0.374
	(0.412)	(0.181)	(0.442)	(0.126)	(0.220)	(0.259)	(0.251)	(0.279)
LMI × Low-IP × IPA	−0.028	−0.620***	−0.291**	−0.095	0.196	−0.045	−0.019	−0.181
	(0.257)	(0.141)	(0.147)	(0.110)	(0.126)	(0.092)	(0.137)	(0.141)
UMI × Low-IP × IPA	−0.307*	−1.090***	−0.874***	−0.786***	−0.120	−0.094	−0.011	−0.086
	(0.163)	(0.139)	(0.276)	(0.184)	(0.182)	(0.121)	(0.222)	(0.146)
HI × Low-IP × IPA	−0.318	−0.173	−0.429***	−0.152	−0.037	0.186*	−0.030	0.004
	(0.273)	(0.146)	(0.117)	(0.138)	(0.141)	(0.107)	(0.123)	(0.126)
LI × High-IP × IPA	0.243	0.343	0.530	−1.647***	0.548***	0.392	0.442**	0.063
	(0.273)	(0.222)	(0.363)	(0.334)	(0.151)	(0.283)	(0.224)	(0.144)
LMI × High-IP× IPA	0.288	0.420***	0.442**	0.355***	0.298**	−0.593***	0.082	0.094
	(0.287)	(0.147)	(0.202)	(0.134)	(0.117)	(0.217)	(0.130)	(0.091)
UMI × High-IP × IPA	0.433	0.435**	0.657***	0.419**	0.561***	−0.294	0.327	0.248***
	(0.389)	(0.189)	(0.224)	(0.184)	(0.194)	(0.295)	(0.324)	(0.087)
HI × High-IP × IPA	0.140	0.266**	0.121	0.194**	−0.096	−0.207	−0.034	0.019
	(0.121)	(0.117)	(0.088)	(0.083)	(0.103)	(0.166)	(0.203)	(0.076)
Observations								1,055,276
No. of country pairs								27,892
Country trends								✓
Group-sector-year FEs								✓
Pair FEs								✓

Notes: The dependent variable is bilateral trade flows excluding trade with future/current IPR-related PTA partners. Each of the columns reports coefficients from a single regression, delineated by income group of the trading partner. Controls for GDP and TRIPS are included in the estimation, but their coefficient estimates are omitted from the reporting. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Figure 3.5: Effects of IPR-related PTA Accession by Income Group of Trade Partner



Notes: Estimation method is PPML using the full sample of bilateral trade data, including zeroes. Outlined cells indicate a negative coefficient estimate. The p-value on the estimate of each interaction coefficient is indicated in the relevant cell of each figure. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

In high-IP exports, the pattern is slightly different. On average, both LMI and HMI countries see their exports of high-IP commodities expand significantly to countries at middle and high levels of income. For HI countries, this effect is limited to LMI and HI destinations. And strikingly, despite the average effect on the high-IP exports of LI countries originally being found to be insignificant, when disaggregating the effects by the income group of the destination country, substantial decreases are observed in LI countries' high-IP exports to HI countries.

What spurs these changes in the destination of exports? As before, I am unable to deduce the exact underlying mechanism given the nature of the analysis, but the prior intuition informs the understanding of the results to some extent. The patterns of trade are again consistent with a shift in comparative advantage. Countries with stronger IPRs tend to export more (in value terms) IPRs-intensive goods.

This is not the case, however, for every permutation of relative levels of development. For instance, LMI countries export fewer low-IP goods to other middle-income economies, while at the same time, their low-IP exports to HI partners are unaffected. This could perhaps reflect LMI countries retaining a role as suppliers of non-IPR-intensive commodities to advanced economies as part of the global supply chain, even as they specialize relatively more in IPR-intensive activities. UMI countries, on the other hand, do see their low-IP exports decline to their most-developed trading partners, suggesting a more significant restructuring of these PTA members' patterns of trade. Also of note is the significant decline in the exports of LI countries to advanced trading partners. This seemingly anomalous result could arise for several reasons, such as stronger IPRs restricting the flow of parallel imports from these countries.

With regard to import effects, the insignificant estimates that were found in the first low-IP versus high-IP analysis generally carry over to the origin-and-destination analysis. For low-IP imports, I find few significant effects, none of which are significant at the 95% level. High-IP imports, however, show more promise, though the particular nature of the results might elicit surprise. On average, LI, LMI, and UMI PTA members see their imports in IPR-intensive sectors rise, with the strongest effects coming from their imports from LI sources. This result might contrast with expectations about what the effect should be, given that more advanced economies tend to be the producers and exporters of advanced manufactures and other knowledge-intensive products.

And while the least-developed PTA members do see their high-IP imports from UMI countries increase, it is only UMI countries that import more IPR-intensive goods from HI partners.

Ultimately, the mechanisms underlying this exercise might come across as even more opaque than the previous mechanisms. That this further refinement reveals effects that were previously hidden, however, suggests that a consideration of who exports to whom—and who imports from whom—is an element of the analysis worth considering.

One potentially revealing aspect of this analysis relates to the link between IPRs and technology transfer. Because IPRs determine the extent to which foreign IP-owners' assets are protected, they also determine the extent to which proprietary knowledge and processes from advanced trading partners can diffuse through an economy. And while technology transfer arising from imports from advanced partners has generally been found to be less significant than that arising from FDI, a substantial increase in high-IP imports from HI partners would give evidence for the existence of such a channel.[27]

Such an increase fails to materialize for countries on the bottom half of the income distribution, but it is evinced for UMI PTA members. These countries import more IPR-intensive commodities from HI sources, and the expansion in access to a greater number of IPR-intensive manufactures, and the knowledge that these commodities embody, imply that the IPR effects here facilitate such a channel—but only for importers at a sufficiently high level of development. And, while, the caveat must again be offered that this analysis only uncovers effects on trade, the effects that it does reveal could have implications beyond this single outcome.

3.7 Conclusion

IPRs have become a point of emphasis in PTAs, especially so for those agreements negotiated by the US and Europe, whose need for an avenue through which to implement their policy goals in a forum besides the WTO drives the inclusion of substantive chapters on IPRs in trade agreements. In mandating IPR standards that go beyond what PTA member countries would effect on their own (and which go beyond the basic minimum requirements of TRIPS), PTAs serve an

[27] For instance, Delgado et al. (2013) interpreted their finding of an expansion in developing countries' imports of high-tech goods from advanced partners as evidence of an import-based channel for technology transfer.

increasingly important role as a mechanism through which developed economies "export" their policies to trading partners.

Going forward, new PTAs promise to usher in a new era of regulatory harmonization between many of the world's largest economies, particularly with regard to IPRs. What impacts these massive agreements will have on trade, investment, innovation, and any number of other outcomes are sure to be substantial, and the profound breadth of their regulatory coverage suggests the agreements will have nuanced effects.

Given that the IPRs provisions adopted by PTA members are generally applied equally to fellow PTA and non-PTA members' knowledge assets alike, they present a way through which PTAs could directly impact trade with non-PTA members. This study takes a first step in exploring the effects of these agreements, focusing on the IPR-related PTAs negotiated by the US, the EU, or EFTA possessing substantive provisions relating to IPRs and investigating the ensuing impact on PTA members' third-country trade—trade with third countries outside of the PTA.

These agreements tend to contain language on IPRs by default, and thus member countries are required to comply with the IPR provisions required by the US or Europe—this creates an effectively exogenous policy change that, based on the growing body of evidence in the literature, should impact economic relations with extra-PTA partners. And, while there are many outcomes that might be considered in appraising the full effects of these agreements' IPR provisions, trade agreements are foremost about trade, which is the outcome considered in this work. The relationship between IPRs and trade is theoretically ambiguous, and offers no consistent message on what the effects of IPRs-upgrading on trade should be. The channels posited in this study—comparative advantage, market power versus market expansion effects, and the activities of MNEs—go some way towards informing an expectation of what the overall effects might be, but the ultimate impacts can only be revealed empirically.

Based on results from a gravity approach, membership in IPR-related PTAs is associated with third-country export effects that are generally consistent with a strengthening of comparative advantages in IPRs-intensive industries for IPR-related PTA members. Countries in the middle and high end of the income distribution reap most of these benefits, with the intensive margin of their exports of IPR-intensive industries expanding considerably. The value of exports in non-IPR-intensive industries, on the other hand, declines on average for these countries. The estimates for imports are more nuanced, where significant effects only become apparent upon disaggregating IPR-intensive industries into a set of IPR-intensive subsectors. Results on this dimension of trade are more scattered, but several pronounced effects are evident: notably, sizable increases in the imports of pharmaceuticals, chemicals, and medical devices by low-income PTA members from extra-PTA sources, as well as increases in the pharmaceutical and chemical imports of high-income countries.

That the results break down along lines of PTA members' development levels and sectoral definitions is unsurprising. First, as these results relate to notions of comparative advantage, countries at higher levels of development are likely to be better equipped to realize the impacts of stronger IPRs: these countries have different endowment structures relative to less-developed countries, and the upgrading of IPRs per se for lower income countries might not have noticeable effects if other crucial institutions necessary for trade to take place are lacking. Second, given the exact wording of the agreements and the policies that they mandate—namely, TRIPS-Plus provisions relevant to pharmaceuticals, chemicals, and other specific sectors, along with requirements to accede to international treaties on specific areas of IPRs—certain sectors are more likely to be observably impacted than others. The fact that third-country pharmaceutical and chemical trade generally undergoes the largest impacts aligns with this aspect of the agreements. And, importantly, these effects are evident even upon controlling for TRIPS compliance, suggesting that IPRs-upgrading beyond the minimum requirements of TRIPS imparts its own array of effects distinct from existing policies.

It is important to highlight the limitations of this work, and to shed light on potentially rewarding directions for future research to take. As mentioned before, trade is but a single outcome of relevance: there is no reason to think that investment, innovation, or other outcomes are less important, or are less impacted by IPRs, than are exports and imports. Future work will hopefully shed light on these other outcomes, ideally in a framework that considers them jointly with trade. Further, while the direction of the empirical results in this study could be explained by an assortment of mechanisms hypothetically linking IPRs to trade, pinning down the particular mechanism is infeasible in this study's reduced-form analysis. Hopefully, the effects revealed by this work motivate thoughtful explorations of the structural linkages between IPRs and trade, whether in the context of IPR-related PTAs or in other settings.

As PTAs evolve and continue to grow in importance as a venue for policy-setting, their role in affecting important economic outcomes merits more and more consideration. IPRs are but one area of focus in newer PTAs: rules on investment, government procurement, environmental and labor standards, along with many other policy environments suggest far-reaching impacts on variables beyond those directly impacted by the traditional market access concessions of trade agreements. Future work in this area would consider the impacts of these other policies, and a nuanced consideration would consider them jointly—for instance, IPRs and investment rules might interact with each other to affect trade, innovation, or the way in which multinationals conduct FDI. Other outcomes beyond trade in goods likewise merit consideration. This work is a first step in the direction of exploring this increasingly important aspect of globalization, and the results suggest that ignoring the non-trade policy aspects of PTAs would be to ignore the full array of mechanisms through which PTAs impart their impacts.

Chapter 4

International Joint Ventures and Internal vs. External Technology Transfer: Evidence from China

International joint ventures (or IJVs—business partnerships between firms headquartered in different countries to form a new commercial entity) are a major vehicle by which FDI is conducted. Nowhere is the role of IJVs as prominent as in China, where in the wake of the country's opening to FDI in 1979, a flood of foreign investment has entered one of the world's largest economies. In 2015 alone, just over 6,000 new IJVs, amounting to $27.8 billion of FDI inflows, were established in China.[1] On the part of the host country, a major reason for favoring IJVs relative to wholly foreign-owned FDI is the idea that joint ventures generate more local technological learning, as well as access to intellectual property and foreign capital. Foreign firms benefit from IJVs because they can avoid some of the complexities—regulatory, cultural, and otherwise—inherent in entering the local market but need to balance this with the technology transfer through the joint venture, especially to any firm that might be a future competitor. Yet, while this trade-off and the prominence of IJVs have put them often at the forefront of economic policy discussions, to date there is little quantitative evidence on the technology transfer impact of IJVs.[2] Using administrative data on the universe of IJVs from China's Ministry of Commerce's *Name List of Foreign and Domestic Joint Ventures in China* matched to micro data on Chinese producers, I quantify the extent to which IJVs shape the development of the host country between 1998 and 2007, both inside and outside of the joint venture.

By matching the IJVs to micro data from China's National Bureau of Statistics (NBS), the analysis gives a comprehensive picture of the types of firms that shape both joint venture patterns and technology transfer as well as market outcomes (see Figure 4.1). First, there are the foreign and

[1] Data from China's Investment Promotion Agency (http://www.fdi.gov.cn).

[2] For example, in Spring of 2018 it has been argued by advisors to the Trump White House that U.S. firms are harmed by China's 'forced joint ventures' policy (https://www.cnbc.com/2018/03/26/kevin-hassett-us-firms-get-crushed-by-chinas-forced-joint-ventures.html). The issue has been central to calls for up to $150 billion in new trade taxes on China (https://www.wsj.com/articles/u-s-to-consider-another-100-billion-in-new-china-tariffs-1522970476).

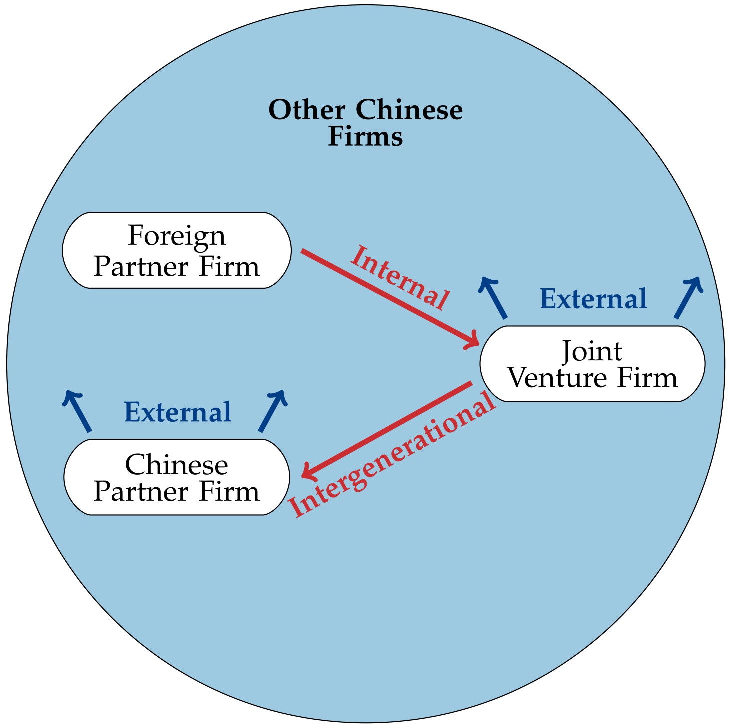
Chinese partner firms that agree on a new joint venture. Second, there is the joint venture firm itself, and third, there are other Chinese firms that are not associated with the joint venture. I begin by isolating the characteristics of firms, be it market share, stock of technology, or regulatory expertise, that are conducive to being picked as Chinese partners by foreign investors seeking to enter the Chinese market. Next, I quantify the effects of the IJV subsequent to the creation of the joint venture. To begin with, there is the technology transfer from foreign firm to joint venture, an internalized effect. Furthermore, there are externalities generated by IJVs to other Chinese firms, which can be positive (technology spillovers) or negative (such as market share rivalry). Finally, based on information on thousands of joint venture-Chinese partner firm pairs I quantify a new, intergenerational technology transfer effect: that some of the foreign technology transferred to the joint venture leaks to the Chinese partner firm that, together with the foreign firm, set the joint venture up to begin with.

The first set of findings examines what foreign investors are looking for in Chinese joint venture partners. Generally, foreigners favor profitable, large, and highly productive firms, and high rates of export participation and patenting are other advantages. In addition, firms that receive subsidies are attractive, while government ownership in general does not matter. Second, after their creation I find that joint ventures benefit from international technology transfer, an internalized effect that is manifested by higher sales, productivity, export sales, product innovation, and patenting. Furthermore, I present evidence for indirect technology transfer: in fact, the formation of the joint venture leads to better performance of the Chinese partner firm as well.

Third, IJVs generate positive externalities to local Chinese firms that operate in the same industry. Economically, productivity spillovers from joint ventures appear to be larger than those from wholly-owned FDI, and even Chinese partner firms generate positive productivity spillovers to other Chinese firms in the same industry.[3] Strikingly, while purely domestic firms benefit from these externalities, joint ventures benefit even more from externalities from other joint ventures, indicating that the joint venture's advanced technology makes them relatively receptive to benefit from the advanced technology of other firms. External effects from joint ventures are highest in R&D-intensive industries, and, on average, investors from the U.S. typically generate higher ben-

[3] An exception is patenting, where I find a negative net external effect.

Figure 4.1: Joint Venture Formation and Technology Transfer



efits than investors from Japan or Hong Kong, Macau, and Taiwan. Finally, I find little evidence for positive joint venture spillovers in China for sectors that cover activities where joint ventures are explicitly prohibited.

This study makes a number of contributions. First, with the arrival of the new paradigm in the late 1970s that international openness facilitates economic development, a large literature on the impact of international trade and FDI on host country performance has emerged. With early studies at the country or industry level showing general correlations, the recent availability of data sets with firm-level data has enabled researchers to ask not only whether attracting FDI leads to benefits but also whether these effects are internal or external to the investing firm. This study provides a unified analysis by shedding light both on internal and external effects from FDI, which matters because the policy case for public subsidies to attract FDI rests on positive externalities (see Keller 2010). One challenge in quantifying spillovers is that they are typically inferred from the extent of FDI or foreign presence in an industry or sector rather than directly measured through a firm-to-firm link (Van Reenen and Yueh 2012). Recently, progress has been made by Javorcik and Spatareanu (2009) who employ information on whether local firms sell to a foreign multinational for a sample of Czech firms, and to the best of my knowledge, this is the first study to employ information on the ownership link between two specific firms. The information on pairs of joint venture and partner firms from the *Name List of Foreign and Domestic Joint Ventures in China* allows us to assess the importance of firm-to-firm links for generating spillovers to the host country. If the foreign investor transfers technology to the joint venture firm it may also trigger technology leakage gains for the Chinese partner firm, given its link to the joint venture.[4] I will refer to this as intergenerational technology transfer.[5]

Second, while there are hundreds of papers on the benefits of either trade or FDI, quantitatively I still know quite little on the effects of international joint ventures.[6] Much of the literature presents qualitative characterizations of the incentives and organizational issues underlying partner selection (Kogut 1988, Geringer 1991), and discussions of the benefits and costs from the IJV for the foreign investor and Chinese partner firm.[7] The analysis goes beyond this by examining quantitatively the empirical determinants of joint venture choice (see also Arnold and Javorcik 2009 on the choice of FDI targets). Furthermore, with few exceptions (e.g., Geringer and Hebert 1991, Reuer and Koza 2000, Howell 2018) work on the effects of joint ventures on firm performance is lacking, and to the extent that it exists it tends to derive its principal empirical findings from descriptive evidence or small data samples applied in non-econometric settings. In contrast, I employ a comprehensive data set together with a difference-in-difference estimation strategy to show a number of new results, including that industry spillovers from joint ventures are large compared to those typically estimated for wholly-owned foreign direct investment.[8]

Third, I produce a number of important new results for the case of China. Based on existing

[4]Outside the context of FDI spillovers, there have recently been advances in the analysis of firm-to-firm relationships in production networks (e.g., Tintelnot, Kikkawa, Mogstad, and Dhyne 2017).

[5]In development economics, intergenerational transfers are typically thought of as in-kind or monetary transfers from children to their parents, perhaps in exchange for prior human capital investments made by the parents (e.g. Raut and Tran 2005).

[6]The survey by Harrison and Rodríguez-Clare (2010) alone discusses 175 studies on the benefits of openness (mostly trade) and 47 studies of FDI spillovers.

[7]Other countries in which joint ventures have played a major role for FDI include India, South Africa, and Malaysia (UNCTAD 2003).

[8]The result that IJV industry spillovers are relatively large is consistent with Van Reenen and Yueh (2012) who can directly compare the impact on productivity of international technology transfer to joint ventures versus to wholly foreign-owned firms, finding that the former is larger.

work there appear to be tangible impacts from FDI on local outcomes, with the results suggesting that industry-level heterogeneity and the ownership structure of FDI matter. One advantage of this study is that I employ several sources of administrative micro data to create a sample that covers not only financial but also operative and technological dimensions of FDI in China, in contrast to more aggregated data that may obscure the true effects of FDI.[9] Some of the earliest empirical research in this area examines productivity spillovers from FDI in China's electronics and textile industries, showing negative effects on domestic firms in the short-run aftermath of FDI penetration that diminish in the long run as foreign firms' technology and know-how are eventually diffused to domestic firms (Hu and Jefferson 2002). More recent work has produced mixed results on FDI externalities,[10] which is in part because FDI generates both negative (market share rivalry) and positive (technology spillovers) externalities for domestic firms (Bloom, Schankerman, and Van Reenen 2013, Lu, Tao, and Zhu 2017). In addition to shifting the focus on joint ventures this analysis goes some way to incorporate joint venture selection into the analysis, I study several outcomes of joint venture formation, including productivity, exporting, and innovation, and I examine heterogeneity by industry and foreign investor.[11] Compared to recent work on the impact of joint ventures in China (Van Reenen and Yueh 2012), the most important difference is that the analysis encompasses externalities generated by these joint ventures in addition to internal effects. Externalities, it has been suggested, might be even more important than internal effects for economic development (e.g., Greenstone, Hornbeck, and Moretti 2010, Van Reenen and Yueh 2012).

The remainder of the study is organized as follows. In Section 4.1 I give background on the policy environment for FDI and IJVs in China, and describe the firm-level data set. In Section 4.2, 4.3 and 4.4, I empirically explore various aspects of IJVs, first estimating the determinants of domestic partner selection and characterizing the types of Chinese firms most likely to be picked to form a joint venture with a foreign partner. I then turn to estimating the role of joint venture status in firms' performance with regard to several outcomes, quantifying the technology transfer effects internal to joint ventures as well as the externalities on other Chinese firms that arise from

[9] As argued, for example, by Buckley, Wang, and Clegg (2007).

[10] For example, Huang (2004) finds evidence for neither intra-industry nor inter-industry FDI spillovers on productivity, while Wei and Liu (2006) finds both.

[11] See also Buckley, Wang, and Clegg (2007). A handful of papers have examined the impact of FDI on innovation in China (Cheung and Lin 2004, Ito, Yashiro, Xu, Chen, and Wakasugi 2012).

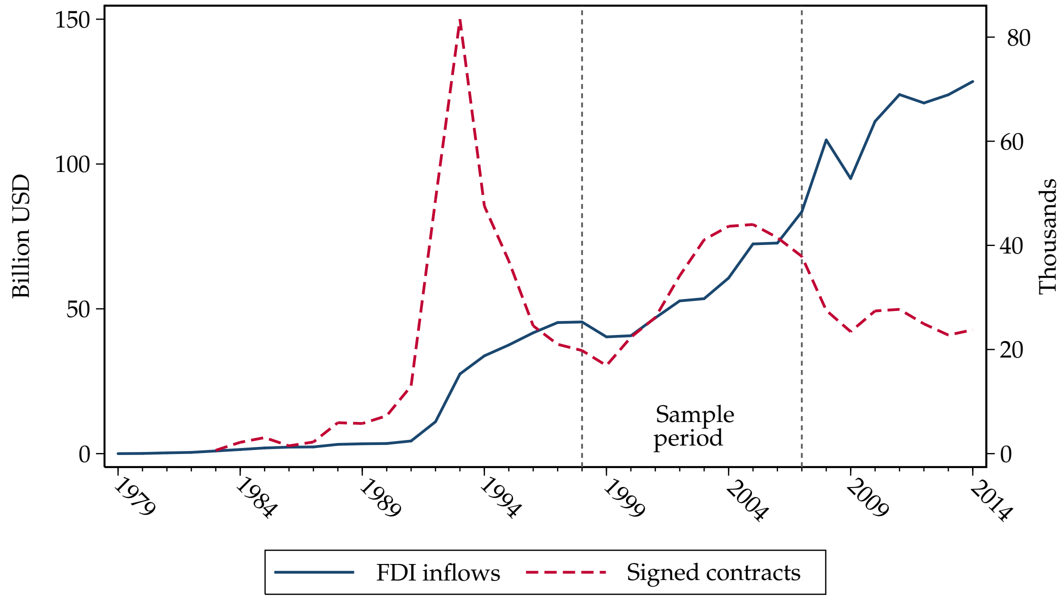
the proliferation of IJVs. I then break the empirical analysis down along several dimensions of heterogeneity, considering the foreign investor's country-of-origin and differences across industries, and evaluate the role of China's restrictions on foreign investment in specific economic activities in determining the magnitude of technology transfer from IJVs. Section 4.6 provides a concluding discussion and elucidates the policy implications of the findings.

4.1 FDI and IJVs in China

As part of a broad effort to enact economic reforms, China started to open to foreign investment in 1979. Only in the early 1990s, however, did FDI enter the country in significant volumes, in the wake of reforms enacted by Deng Xiaoping; namely, the gradual relaxation of rules on FDI and the establishment of special economic zones which offered favorable regulatory environments to foreign investment (OECD 2000). Today China is one of the world's top destinations for FDI. Figure 4.2 shows the evolution of foreign investment in China over the last four decades. The left-hand vertical axis is the value of FDI inflows (in billion USD), while the right-hand axis corresponds to the number of signed foreign investment contracts (in thousands). The value of inflows has expanded unabated since the beginning of the 1990s, while the number of new contracts (after the spike around 1993 resulting from the establishment of several new special economic zones to attract foreign investment) has generally settled at between 20 and 30 thousand projects registered per year. The sample period I cover, from 1998 to 2007, is a time of steady expansion in the value of FDI inflows, and an overall upward trend in the number of new projects. Figure 4.3 illustrates the number of IJV partnerships in the sample by the origin countries of the foreign partners. The large majority of foreign IJV partners originate from three sources: Hong Kong, Macau, and Taiwan (HMT for short), Japan, and the United States, with other high-income countries comprising most of the remainder.[12] In the empirical analysis, I will consider the role of the foreign partner's origin in determining the magnitude of intra-industry spillovers.

[12] A sizable portion of the recorded FDI into China from Hong Kong actually initially originates from China—a process known as "round-tripping," wherein outward capital flows re-enter the Chinese market via Hong Kong for the purpose of, for example, avoiding regulation, high taxes, trade barriers, and other administrative obstacles. The data set does not allow us to discern the initial origin of capital that is being repatriated to China; rather, I only observe the foreign origin of the FDI.

Figure 4.2: Chinese FDI Inflows, 1979 to 2014



Data source: Chinese Ministry of Commerce

Table 4.1: Mode of FDI in China (Realized FDI value in current billion USD)

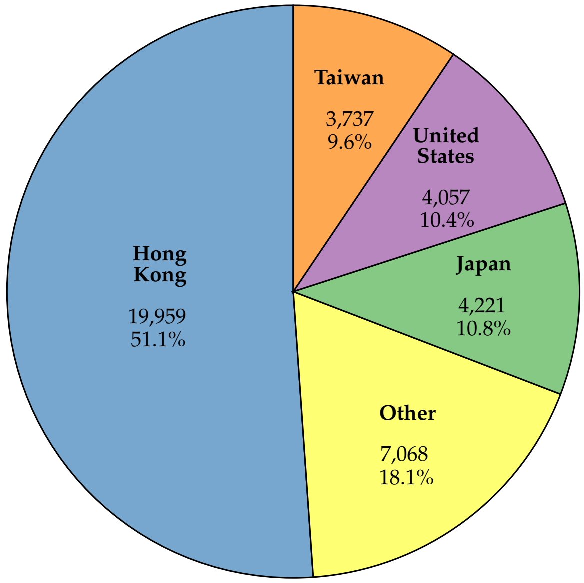
	1997	**2002**	**2007**	**2012**
Equity joint venture	19.5	15.0	15.6	21.7
% of total FDI flows	43.1	28.4	20.9	19.4
Contractual joint venture	8.9	5.1	1.4	2.3
% of total FDI flows	19.7	9.6	1.9	2.1
Wholly foreign-owned enterprise	16.2	31.7	57.3	86.1
% of total FDI flows	35.8	60.2	76.6	77.1
Share company with foreign investment	0.3	0.5	0.7	1.6
% of total FDI flows	0.6	0.9	0.9	1.4
Total FDI	45.3	52.7	74.8	111.7

Data Source: China Statistical Yearbook

Since foreign investment began to flow into China, there have been three principle modes under which FDI has entered the Chinese market: equity joint ventures, contractual joint ventures, and wholly foreign-owned enterprises (WFOEs).[13] Table 4.1, which summarizes the value of each

[13]Equity joint ventures differ from contractual joint ventures in a number of ways. Unlike equity joint ventures, contractual joint ventures need not be separate legal entities from their parents. Equity joint ventures require a minimum share of foreign ownership to be classified as such, whereas contractual joint ventures require no such provision. In contractual joint ventures, profits are shared between partners on a contractually-agreed upon basis (as opposed to in proportion to each partner's capital contribution). Further, in contractual joint ventures the degree of foreign control embedded in the structure of the joint venture—management, voting, staffing rights, etc.—can be negotiated over, and not necessarily allocated based on equity shares.

Figure 4.3: Composition of IJV Partnerships in China by Partner's Origin 1998 to 2007



Notes: The top number in each slice gives the number of unique IJVs by origin and the bottom number is the share of the total number of IJVs. The top 5 places of origin in the Other category by number of joint ventures are, in order, South Korea, Singapore, Germany, the United Kingdom, and Macau.

of these types of FDI inflows into China at 5-year intervals from 1997 to 2012, breaks down the numbers on these respective modes. Equity joint ventures were the dominant form of FDI until the end of the 1990s, but have since been supplanted by WFOEs.[14] WFOEs today account for around 78% of all FDI flows into China, their increasing prevalence owing to both the occasional mistrust by foreign investors of Chinese joint venture partners and the regulatory liberalization resulting from China's 2001 accession to the World Trade Organization, which allowed greater scope for both the establishment of green-field investments and for the acquisition of Chinese firms. Despite this shift, IJVs continue to account for a sizable portion of all Chinese FDI inflows.

What makes joint ventures an attractive mode for FDI? In the case of China, the reasons reflect both the regulatory environment along with the general benefits arising from joint ventures. Though the regulations on foreign investment have been liberalized in recent years, China's foreign investment policy still mandates that foreign firms bring on board a local partner to conduct

[14]FDI has also increasingly been conducted via share companies with foreign investment, i.e. publicly traded companies established in China by foreign companies, though the volume of FDI flows conducted via this mode is still dwarfed by other types of FDI.

business in restricted industries, while in some industries (typically those dealing with national security or other critical areas) foreign investment remains strictly off limits. China's Catalogue of Industries for Foreign Direct Investment classifies industries based on four categories: "encouraged," "restricted," "prohibited," and "permitted" (the last of which refers to industries for which special rules of operation for foreign firms are not explicitly mentioned). It is in the restricted activities (which include endeavors such as, for example, the production of various chemicals and pharmaceuticals, the manufacture of certain electronics and machinery, such as cameras or car engines, and the operation of rail and freight companies) that foreign firms are legally required to partner with a domestic firm in a Sino-foreign joint venture. Today, the number of "restricted" economic activities—those in which Sino-foreign partnerships are mandated for foreign investors—stands at 38. This figure is considerably lower than it was in the recent past; for the period covered by the sample, the requirement of partial domestic ownership was much more pervasive. I will show results on these various categories of FDI policy below.

Data and Sample

The data set is constructed using three main sources. The *Above-scale Industrial Firms Panel 1998–2007* (ASIFP), provided by China's National Bureau of Statistics (NBS), covers all state-owned enterprises and non-state-owned enterprises with annual sales of at least 5 million RMB in China's mining and logging, manufacturing, and utilities industries, and provides financial data and other firm-specific information, including for each company its name, address, industry, age, and ownership structure. Brandt, Van Biesebroeck, and Zhang (2014) show that the coverage of ASIFP is identical to the corresponding information derived from the Chinese Statistical Yearbook. The list of newly setup IJVs and the corresponding domestic parent firms, together with the foreign firms that are partner to the joint ventures, is from the *Name List of Foreign and Domestic Joint Ventures in China* (Name List Database, for short). The Name List Database is released by China's Ministry of Commerce. The Name List Database contains a multitude of details on each joint venture, such as its name, address, industry code, year of establishment, contracted operation duration, and importantly, the name of the Chinese partner firm that established the joint venture. For the domestic partner firms, the Name List Database provides each firm's industry code and physical address in addition to the name of the firm. I also use information on the patent applications associated with each firm, data which are obtained from China's State Intellectual Property Office (SIPO) patent database. The SIPO database provides complete information on all patent applications and grants in China, including the application and publication number of the patent, application and grant year, classification number, type of patent, and assignee of the patent.

To obtain the sample, I merge these three databases together for the empirical analysis. First, I match the Name List Database to ASIFP to identify both the IJV and the domestic IJV partner firms in the ASIFP database, which allows us to observe information on their firm-level attributes. The match quality is important for the empirical findings. Fortunately, according to the Company Law of the People's Republic of China, a firm must have a unique identifier, and this identifier must contain four elements in the order of administrative region (above county level), the firm's name, its industrial sector, and a legal entity identifier; for instance, a particular firm's identifier might be Chongqing (administrative region) Changan (name) Automobile (industrial sector) Co., Ltd. (legal entity identifier). Firms in the same industrial sector cannot use the same name. Moreover, firms have an exclusive right to their names on a regional basis. Therefore, if the firm's name, location, and industry code are entered the same in both the ASIFP and Name List databases, this information identifies the same entity. Because of this, I use company name, location, and industry code to identify both the joint venture firms and the domestic IJV partner firms in the ASIFP database and the Name List Database year by year. Then, I match the ASIFP and SIPO data together to incorporate information on each firm's patenting activities. I employ data matching strategies from the NBER Patent Data Project to ensure the accuracy of the matching. Specifically, I use firm name, location (at the municipal level), and the 2-digit Chinese Industrial Classification (CIC) industry code to merge the data sets with each other. The empirical results are based on IJVs in China's mining and logging, manufacturing, and utilities industries observed between 1998 and 2007; specifically, the study covers all domestic partner firms with annual sales of at least 5 million RMB in operation at any point between 1998 and 2007. Based on the description above, the data strongly relies on the representativeness of the ASIFP database. I compare the data in the ASIFP data for 2004 to the 2004 Chinese Economic Census—the earliest year in which the Economic Census was conducted, and which covers all firms in China. Based on the Census, the total sales in 2004 for all industrial firms totaled 218 billion RMB, whereas the sales for all industrial firms in the ASIFP data totaled 196 billion RMB. The enterprises covered by the ASIFP thus account for almost all (more than 91%) of the total sales of all industrial firms in China in 2004. This evidence is consistent with other work, e.g. Brandt, Van Biesebroeck, and Zhang (2014).

The sample of IJV firms covers all of the industries in the full ASIFP database, ensuring the representativeness of the IJV sample.[15] The domestic partner firms chosen as IJV partners are more likely to come from either labor-intensive manufacturing industries such as textile goods (CIC 17) or high-tech industries such as electronic equipment manufacturing (CIC 39), with relatively fewer IJVs formed in resource extraction and utilities (owing to activities in these industries frequently being classified as prohibited or restricted).

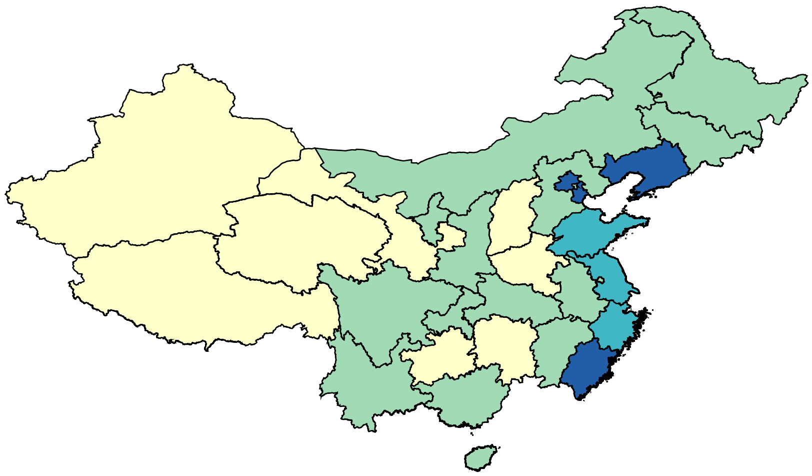
The firms involved in the formation of IJVs also vary in where they tend to be located. Figure 4.4 shows the geographical distribution of the partner firms at the provincial level. Immediately apparent is that IJV partner firms tend to be more common in highly developed coastal areas such as Guangdong, Jiangsu, Zhejiang, Shanghai and Shandong, with comparatively fewer partner firms located in the I stern, central, and northern areas of the country. To account for the regional component of IJV formation, I control for geographical characteristics in the empirical analysis.

Variable Definitions

I focus on several firm attributes in the analysis—some directly available in the data and some that I estimate. First, I consider total factor productivity (TFP). I measure TFP with two approaches: *TFP (OLS)* is the OLS residual from a log-linear production function and *TFP (OP)* is estimated following the methodology of Olley and Pakes (1996). Both methods are well-established in the firm productivity literature. The advantage of the latter is that it addresses both simultaneity caused by unobserved productivity shocks and non-random sample selection induced by different exit probabilities, at the cost of making a number of additional assumptions and, for example, strictly positive investment levels.

[15] The ASIFP data reports firms' industries by CIC Rev. 1994 code from 1998 to 2002, and CIC Rev. 2002 for observations from 2003 to 2007. CIC is itself based on the International Standard Industrial Classification of All Economic Activities (ISIC) industrial classification. Appendix Table A.10 shows the CIC industrial breakdown of the firms in the ASIFP database as well as domestic partner firms.

Figure 4.4: Share of Domestic Firms that are Joint Venture Partners by Province, 2002



Next, I focus on both technological output and commercialized output. *Patents* is the count of patent applications submitted at China's national patent office of all types in a particular year, which is used to measure total technological output, and *Invention* is the count of invention patent applications in a particular year. As mentioned before, the patent data are from SIPO, which compiles complete information for all patents filed in China since 1996. *New Product* is a firm's share of sales from new products of its total sales in a given year. Finally, to measure export activity, *Export Ratio* is the ratio of a firm's export volume in a given year over its total sales.

I also want to capture the domestic partners' ownership structures, and any political connections. *Foreign Share* is the ratio of equity owned by foreigners over total equity, while *Govt. Share* is the ratio of government-owned equity over total equity. In addition, I use *Subsidy*, a dummy variable equal to 1 if the domestic firm receives any subsidy from the government and 0 otherwise, to account for a domestic firm's political connections.

Three additional firm controls are included in the empirical model, including *Employment*, *Age*, and *Leverage*. *Employment* counts the total number of employees of the firm, a measure of firm size. *Age* measures the number of years a firm has been in operation. *Leverage* is equal to a firm's total liabilities over its total assets, which captures the extent to which a firm relies on credit.

To capture external effects of IJV formation, I construct measures of joint venture penetration as follows. For industry j and year t, define

$$SPILL_{jt}^{JV} = \frac{\sum_{i \in N_{jt}} JV_i \times Sales_{it}}{\sum_{i \in N_{jt}} Sales_{it}}, \qquad SPILL_{jt}^{PT} = \frac{\sum_{i \in N_{jt}} PT_{it} \times Sales_{it}}{\sum_{i \in N_{jt}} Sales_{it}},$$

where N_{jt} is the set of firms in industry j in year t, JV_i is an indicator variable which is equal to one if firm i was formed as a joint venture between a Chinese and a foreign firm and zero otherwise, and PT_{it} is an indicator variable equal to one for firms that are the domestic partner in an IJV in that year and zero otherwise.[16] The measures capture the sales-weighted importance of joint ventures and Chinese partner firms in an industry, respectively. Analogous to the well-known (within-industry) FDI spillover measures, the variables $SPILL_{jt}^{JV}$ and $SPILL_{jt}^{PT}$ capture the idea that the potential for externalities may be higher in industries where joint ventures are relatively common.

The summary statistics for the above variables are presented in Table 4.2 for the full sample of Chinese firms, joint venture firms, domestic IJV partners, and other (non-JV, non-partner) Chinese firms. All of the variables are winsorized at the 1st and 99th percentiles to eliminate the effect of outliers. It is apparent that there appear to be underlying pre-existing differences between IJV firms and non-IJV firms. Domestic IJV partners are on average older, larger, have smaller government ownership stakes, are more export-oriented, and patent more that non-IJV partners; I will control for these underlying differences in firm attributes when estimating the determinants of selection as well as within-firm effects of IJV formation.

Figure 4.5 shows the evolution of productivity across different firms in an event-study type of display. On the horizontal axis I depict time in terms of years after the formation of the IJV, while on the vertical axis I have an index of average total factor productivity.[17] The figure shows evidence for TFP growth for all three types of firms: the joint ventures themselves, the Chinese joint venture partner firms, and also Chinese firms not related to joint ventures. TFP gains for joint

[16]Note that JV_i has no time subscript, while PT_{it} does. This is because a joint venture firm is *always* a joint venture firm from its inception, whereas a joint venture partner firm switches from being a non-partner firm to being a partner firm at some point in time.

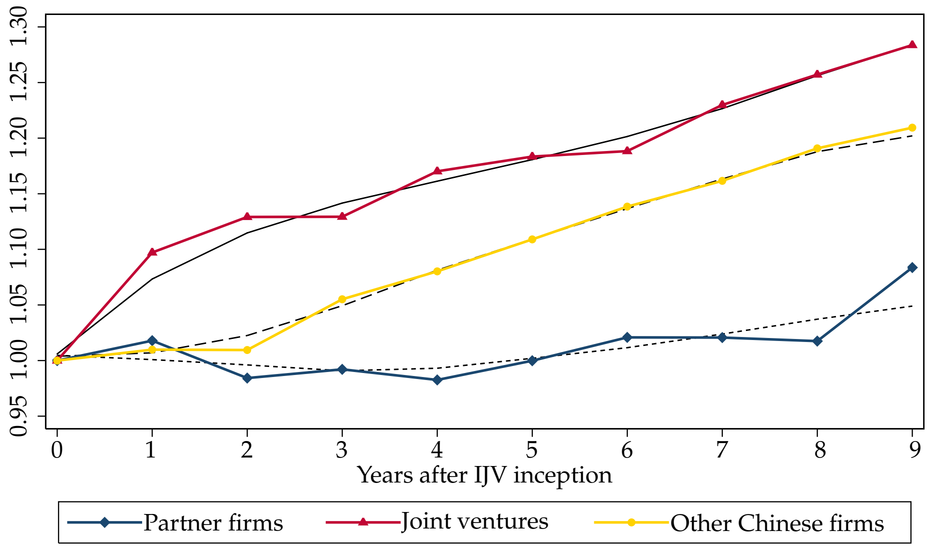
[17]Data shown is TFP based on the Olley and Pakes (1996) method, normalized to equal one in the year of the IJV's inception. To compute the statistics of the 'Other Chinese firms' I have applied the actual frequency of joint venture formation in a given industry and year.

Table 4.2: Sample Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Variable	Obs.	Mean	Std. Dev.
Panel A: Full Sample				**Panel B: Joint Venture Firms**			
Age	1,979,502	9.25	7.67	Age	25,857	8.37	4.2
Employment	1,979,746	280.3	1,371.54	Employment	25,857	321.18	603.47
Foreign Share	1,979,746	0.02	0.1	Foreign Share	25,857	0.24	0.28
Govt. Share	1,978,942	0.14	0.33	Govt. Share	25,856	0.12	0.24
Export Ratio	1,723,524	0.12	0.3	Export Ratio	22,754	0.26	0.63
Net Profits	1,979,746	4,368.23	193,694.92	Net Profits	25,857	12,746.16	100,582.17
TFP (OLS)	1,863,425	0.01	1.2	TFP (OLS)	24,432	0.39	1.18
TFP (OP)	1,863,301	2.69	1.38	TFP (OP)	24,432	2.91	1.32
Patents	1,979,746	0.11	5.88	Patents	25,857	0.41	7.42
Invention Patents	1,979,746	0.03	5.01	Invention Patents	25,857	0.15	5.77
Sales	1,979,746	73,834.92	769,441.53	Sales	25,857	206,236.67	1,209,433.02
Total Assets	1,979,746	84,269.81	1,145,572.97	Total Assets	25,857	192,087.02	806,783.77
Panel C: Joint Venture Partner Firms				**Panel D: Other Chinese Firms**			
Age	170,229	10.68	6.58	Age	1,783,416	9.13	7.79
Employment	170,240	594.95	2,859.34	Employment	1,783,649	249.67	1,136.62
Foreign Share	170,240	0.12	0.22	Foreign Share	1,783,649	0.01	0.07
Govt. Share	170,215	0.12	0.28	Govt. Share	1,782,871	0.14	0.34
Export Ratio	151,350	0.32	0.42	Export Ratio	1,549,420	0.1	0.27
Net Profits	170,240	9,913.43	136,299.36	Net Profits	1,783,649	3,717.51	199,294.58
TFP (OLS)	160,915	0.09	1.16	TFP (OLS)	1,678,078	0	1.2
TFP (OP)	160,907	2.77	1.36	TFP (OP)	1,677,962	2.68	1.38
Patents	170,240	0.37	15.64	Patents	1,783,649	0.08	3.76
Invention Patents	170,240	0.14	13.92	Invention Patents	1,783,649	0.02	2.98
Sales	170,240	183,208.70	1,409,458.67	Sales	1,783,649	61,476.38	666,911.12
Total Assets	170,240	239,380.61	1,832,475.15	Total Assets	1,783,649	67,902.30	1,060,165.53

Notes: Panel A gives summary statistics for the entire sample. Panel B limits the sample to joint venture firms. Panel C limits the sample to domestic IJV partners that are partners in an IJV during the observation year. Panel D limits the sample to non-joint venture, non-partner firms.

Figure 4.5: Evolution of Productivity by Firm Type: TFP (OP)



venture firms are highest, followed by those of other Chinese firms, and then the joint venture partner firms. The figure suggests a temporal interpretation: international technology transfer rapidly raises the TFP of the joint venture, while other Chinese firms benefit only with a lag of about three years. Note that the former is an internal effect, the latter an external effect. Finally, the figure is consistent with Chinese partner firms beginning to benefit from the joint venture in terms of their own TFP about six years after JV inception. Why might it take longer for Chinese partner firms to benefit from the joint ventures, even though as the firms who set up joint ventures they are in a sense more closely related to them? One reason might be that Chinese partner firms are, as I show below, relatively large and close to the technology frontier compared to other Chinese firms, so it takes longer until technology transferred from the joint venture leads to a net increase in the productivity of Chinese partner firms.

Note that the evolution of productivity of these firms is affected by a multitude of other factors, and in the econometric analysis below I will seek to isolate the part that is caused by joint ventures.

4.2 The Choice of Joint Venture Partner

This section examines the determinants of international joint venture partner choice in China. I start by specifying an equation describing the selection of some firm i as an IJV partner as a function of the firm's characteristics in year t:

$$PT\_Select_{it} = f\left(\boldsymbol{X}'_{it}\gamma, \lambda_j, \lambda_r, \lambda_t, \varepsilon_{it}\right), \tag{4.1}$$

where j and r respectively index an observation's 2-digit CIC industry and the province of China in which the partner firm is headquartered. The dependent variable PT_Select_{it} is equal to one if Chinese firm i is selected as an IJV partner in year t, and zero otherwise (note that it differs from the previously defined IJV partner variable PT_{it}, which is equal to one in every year following and including the year of the IJV's inception). Firms that partnered to form an IJV previous to the observation year are omitted from the estimation (e.g. if firm i partnered in an IJV in year t, it is omitted from the sample used in the selection estimation for years $t+1$, $t+2$, etc.). To construct the sample of "control firms" (firms that never act as partners in a joint venture in the sample) in the selection estimation, for each IJV "treatment" firm I randomly select five firms from the ASIFP database which never enter into an IJV, taken from the same region and industry as the matched IJV firm. $\boldsymbol{X}_{it}$ is a vector of firm-level attributes that might affect IJV selection, including underlying productivity, innovativeness, size, and the firm's financial characteristics, while λ_j, λ_r, and λ_t represent unobserved characteristics specific to, respectively, the firm's industry, the region in which it operates, and the year. Finally, ε_{it} is a well-behaved error term. Shown in Table 4.3 are results from logistic regressions of this equation.[18] I include various covariates one by one in order to isolate their influence.

Larger firms are more likely to be chosen as IJV partners (column 1), as are younger firms (column 2). One might expect a large amount of heterogeneity across years, provinces, and industries, and I include fixed effects in these dimensions in column 3. The results pool across characteristics in all years *prior* to IJV selection; the inclusion of year fixed effects shows that this does not

[18]Employing probit regressions I find broadly similar results.

Table 4.3: Logit Regression of IJV Partner Selection on Firm Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Employment	0.691***	0.719***	0.837***	0.838***	0.823***	0.805***	0.790***	0.672***	0.692***
	(0.038)	(0.037)	(0.042)	(0.042)	(0.040)	(0.040)	(0.039)	(0.036)	(0.036)
Age		–0.159***	–0.144***	–0.139***	–0.112***	–0.115***	–0.114***	–0.077	–0.076
		(0.039)	(0.040)	(0.040)	(0.042)	(0.042)	(0.044)	(0.050)	(0.051)
Foreign Share					2.886***	2.878***	2.703***	2.398***	2.328***
					(0.615)	(0.618)	(0.627)	(0.604)	(0.600)
Govt. Share					–0.123	–0.144	–0.114	0.073	0.111
					(0.115)	(0.117)	(0.119)	(0.120)	(0.119)
Subsidy						0.381***	0.399***	0.337***	0.348***
						(0.071)	(0.071)	(0.073)	(0.076)
Export Ratio							0.635***	0.715***	0.722***
							(0.130)	(0.127)	(0.126)
Net Profit								0.143***	0.103***
								(0.016)	(0.020)
TFP (OLS)									0.192***
									(0.048)
Observations	11,692	11,692	11,692	11,692	11,692	11,692	11,692	11,692	11,692
Pseudo R^2	0.106	0.108	0.132	0.137	0.147	0.149	0.154	0.165	0.167
Industry FEs	✗	✗	✓	✓	✓	✓	✓	✓	✓
Province FEs	✗	✗	✓	✓	✓	✓	✓	✓	✓
Year FEs	✗	✗	✓	✓	✓	✓	✓	✓	✓
JV Age FEs	✗	✗	✗	✓	✓	✓	✓	✓	✓

Notes: Employment, Age, and Net Profit are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

strongly affect the results (column 4).

IJV partner selection is higher for Chinese firms that are partly foreign-owned, while government ownership does not enter significantly (column 5). Firms that are subsidized are more likely to be chosen to be a JV partner (column 6), as are firms that sell a large fraction of their output abroad (column 7). Foreigners interested in Chinese JV partners prefer profitable firms (column 8); note that the coefficient on subsidization falls, consistent with the idea that subsidization increases the profitability of the firm. The final column in Table 4.3 shows that conditional on size, industry, and profitability, firms that are more productive are significantly more likely to be picked as partners (column 9).[19]

The role of past innovation for IJV partner choice in China is also of interest, and is depicted in Table 4.4. The first variable is the sum of all invention, design, and utility model patent applications, cumulative over the three years preceding (and inclusive of) the observation year; I see that a higher level of patenting activity raises the chance that a Chinese firm is picked as a joint venture partner (column 1). Invention patents are also positively correlated with IJV selection (see column 2), although not quite as strongly as the lower R^2 indicates. It is plausible that utility patents also matter for an emerging economy such as China. Furthermore, does product innovation matter for partner choice? The results show that firms with a relatively high ratio of new products in their total sales make for more likely joint venture partners for international firms (column 3). The new product ratio and patent measures capture different aspects of the innovation activity of these firms, with the results being somewhat stronger for the broad patent measure (see columns 4 and 5).[20]

I will take column 4 as the baseline specification in the following analysis.

4.3 Joint Ventures and Firm Performance

How does entering into a joint venture partnership with a foreign firm affect the performance of Chinese firms? The following analysis distinguishes between effects (1) on the newly set-up

[19] The main results are robust across OLS and OP methods of computing firm productivity.

[20] I have also considered the firm's return on assets, leverage, and total assets as determinants of international joint venture choice; no clear picture emerges, presumably because these factors are correlated with other variables already included in the regression.

Table 4.4: Logit Regression of IJV Partner Selection on Firm Characteristics, Including Innovation and Financial Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Employment	0.659***	0.683***	0.681***	0.651***	0.675***	0.573***	0.651***	0.054
	(0.036)	(0.037)	(0.036)	(0.035)	(0.036)	(0.041)	(0.035)	(0.055)
Age	–0.085	–0.078	–0.077	–0.085	–0.078	–0.091*	–0.085	–0.089
	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.053)	(0.052)	(0.054)
Foreign Share	2.306***	2.349***	2.345***	2.289***	2.330***	2.156***	2.289***	1.703***
	(0.564)	(0.577)	(0.573)	(0.556)	(0.569)	(0.504)	(0.555)	(0.435)
Govt. Share	0.089	0.098	0.064	0.058	0.066	0.005	0.058	–0.202*
	(0.124)	(0.121)	(0.121)	(0.125)	(0.121)	(0.126)	(0.126)	(0.111)
Subsidy	0.343***	0.352***	0.342***	0.334***	0.343***	0.269***	0.334***	0.194**
	(0.073)	(0.075)	(0.073)	(0.073)	(0.075)	(0.078)	(0.073)	(0.081)
Export Ratio	0.755***	0.745***	0.747***	0.761***	0.750***	0.783***	0.761***	1.022***
	(0.120)	(0.121)	(0.121)	(0.120)	(0.121)	(0.114)	(0.120)	(0.119)
Net Profit	0.099***	0.104***	0.104***	0.098***	0.103***	0.150***	0.098***	0.034*
	(0.020)	(0.020)	(0.021)	(0.020)	(0.021)	(0.023)	(0.020)	(0.018)
TFP (OLS)	0.177***	0.183***	0.183***	0.173***	0.179***	0.216***	0.173***	0.056
	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)	(0.049)	(0.048)	(0.046)
Patents	0.640***			0.631***		0.625***	0.631***	0.540***
	(0.135)			(0.135)		(0.134)	(0.135)	(0.124)
Invention		1.390***			1.347***			
		(0.383)			(0.359)			
New Prod.			0.878***	0.855***	0.868***	0.813***	0.855***	0.628***
			(0.239)	(0.239)	(0.238)	(0.239)	(0.239)	(0.229)
ROA						–2.895***		
						(0.637)		
Leverage							0.004	
							(0.069)	
Total Assets								0.683***
								(0.057)
Observations	11,692	11,692	11,692	11,692	11,692	11,691	11,691	11,692
Pseudo R^2	0.172	0.168	0.169	0.174	0.171	0.181	0.174	0.213
Industry FEs	✓	✓	✓	✓	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓	✓	✓
JV Age FEs	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Employment, Age, Patents, Invention, and Total Assets are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

joint venture, (2) on the established Chinese joint venture partner firm, and (3) on other Chinese firms. I adopt a linear specification where y_{it} is the outcome of interest for firm i in year t, and is related to the indicator for whether a domestic firm is a joint venture, JV_i:

$$y_{it} = \alpha + \beta_1 \, JV_i + \boldsymbol{X}'_{it}\gamma + \lambda_j + \lambda_r + \lambda_t + \varepsilon_{it}. \tag{4.2}$$

The vector $\boldsymbol{X}_{it}$ includes the following variables: employment (as a measure of firm size), firm age, the share of government ownership, the share of foreign ownership, and whether the firm receives government subsidies. Notice that the joint venture is only observed after its creation—JV_i is not time-varying—implying that I cannot include firm fixed effects in this specification (as in Van Reenen and Yueh 2012). At the same time, I will include fixed effects in the analysis of Chinese partner firms and industry spillovers below. Of key interest is the coefficient β_1, which reveals whether, after controlling for firm characteristics ($\boldsymbol{X}_{it}$), the outcome y_{it} differs for a joint venture firm and other firms in the same industry, province, and year.[21]

The first outcome I consider is the firm's TFP. I show results employing two methods (OLS and Olley-Pakes) of estimating firm-level TFP figures. According to either method, joint ventures have a productivity that is about 30% higher than comparable non-joint venture firms. This indicates beneficial technology transfer from the foreign IJV partner to the joint venture firm. I also see that joint venture firms have higher sales as well as higher export and new-product ratios. These results are important not only because they constitute new quantitative evidence for international technology transfer through joint ventures but also because in principle, other Chinese firms may either benefit from this technology transfer (positive spillovers) or they could be harmed by it, for example because the new international technology transfer makes joint ventures more formidable competitors and lowers sales of other Chinese firms.[22] I also see that joint ventures patent significantly more than comparable non-joint ventures, with a coefficient of 2.2%. This evidence across several dimensions is consistent with beneficial international technology transfer to joint venture

[21] I constrain the sample for the estimation to include only those firms that have at least five observations, for the purpose of making valid within-firm before-and-after outcome comparisons. The results are robust to changing this restriction on the sample.

[22] Bloom, Schankerman, and Van Reenen (2013) highlight these effects.

Table 4.5: Internal Effects of Technology Transfer on Joint Ventures

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
JV	0.327***	0.256***	0.022***	0.011***	0.491***	0.025***
	(0.025)	(0.021)	(0.007)	(0.002)	(0.029)	(0.009)
Employment	0.074***	–0.059***	0.037***	0.010***	0.866***	0.030***
	(0.010)	(0.019)	(0.006)	(0.002)	(0.026)	(0.004)
Age	–0.112***	–0.042**	–0.004**	–0.002***	–0.142***	–0.008***
	(0.011)	(0.019)	(0.002)	(0.001)	(0.012)	(0.003)
Foreign Share	0.500***	0.344***	0.009	0.010***	0.792***	0.293***
	(0.064)	(0.053)	(0.008)	(0.003)	(0.107)	(0.029)
Govt. Share	–0.823***	–0.900***	–0.015***	0.005***	–0.811***	–0.036***
	(0.046)	(0.037)	(0.004)	(0.002)	(0.039)	(0.007)
Subsidy	0.091***	0.048**	0.036***	0.015***	0.193***	0.011***
	(0.017)	(0.018)	(0.006)	(0.002)	(0.018)	(0.004)
Observations	970,913	970,861	851,995	899,072	1,015,192	899,072
JV Firms	2,717	2,717	2,748	2,749	2,749	2,749
R^2	0.163	0.339	0.052	0.049	0.571	0.266
Industry FEs	✓	✓	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✗	✗	✗	✗	✗	✗

Notes: Dependent variables are given in each column heading. Estimation method is OLS. Patents, Sales, Employment, and Age are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

firms.

Turning to the firm characteristics, I find that larger firms typically have better outcomes, while firm age is associated with lower performance. A high government ownership share tends to be associated with lower performance, while on the other hand a high share of foreign ownership comes with improved firm outcomes. Finally, there is evidence that firms that receive subsidies perform better than firms that do not.

I now move from these newly 'born' joint venture firms to the Chinese IJV partner firms. Typically, these firms are considerably larger than the joint venture firms (see Table 4.2), and while international firms have an incentive to transfer technology to the joint venture, this incentive does not to the same extent exist with regard to the Chinese partner firm. Thus, to the extent that there is internal technology transfer to Chinese partner firms, this could be a purely external effect that also exists for non-partner, non-joint venture firms, or it may be associated with a leakage effect that I refer to as intergenerational technology transfer. I estimate the same specification as in equation (4.2) above except that the indicator variable for a joint venture, JV_i, is replaced by the indicator variable PT_{it} which is one for a Chinese joint venture partner firm in that year, and zero otherwise:

$$y_{it} = \alpha + \beta_1 PT_{it} + \boldsymbol{X}'_{it}\gamma + \lambda_j + \lambda_r + \lambda_t + \varepsilon_{it}. \tag{4.3}$$

I emphasize two strategies that help to identify the causal impact of joint venture formation instead of spurious factors. First, I account for differences in the probability that a Chinese firm is picked to form a joint venture by applying inverse probability weights (IPWs) to each observation in the regression (known as inverse probability weighting with regression adjustment, IPWRA). These weights are constructed with the predicted values from the logistic regression in Table 4.4, column 4, with each variable averaged at the firm level for the entire sample of firms (including firms that became partners in joint ventures prior to the beginning of the sample period), and are defined as follows:

$$IPW_{it} = \frac{PT_{it}}{\hat{p}_i} + \frac{1 - PT_{it}}{1 - \hat{p}_i}, \tag{4.4}$$

where $\hat{p}_i$ is the predicted probability of observing firm i as the partner in a joint venture given its average characteristics over the sample period. The weights in equation (4.4) are formulated in such a way that the firms with the largest sampling weights are those that (1) are estimated as being *unlikely* to be picked for a joint venture, but were picked (i.e. $\hat{p}_i$ is low, so $\frac{PT_{it}}{\hat{p}_i}$ is high when $PT_{it} = 1$), and (2) are estimated as being *likely* to have been picked for a joint venture, but were *not* picked (i.e. $\hat{p}_i$ is high, so $\frac{1-PT_{it}}{1-\hat{p}_i}$ is high when $PT_{it} = 0$). As detailed in Imbens and Wooldridge (2009), the estimation of $\hat{p}_i$ captures the differences between firms in their propensity to be chosen to partner with a foreign firm to form an IJV.

The IPWs account for the fact that relatively larger, innovative, and exporting firms (among the other determinants of selection that I control for) are more likely to be observed as partners in joint ventures. Given these weights, the regression adjustment component of the analysis compares the average differences in outcomes between "treated" firms (IJV partners) and "untreated"

Table 4.6: Intergenerational Technology Transfer: Chinese Partner Firms

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
PT	0.052***	0.021	0.008**	0.007***	0.234***	0.013**
	(0.015)	(0.020)	(0.003)	(0.001)	(0.030)	(0.006)
Employment	0.077***	–0.053***	0.041***	0.008***	0.854***	0.029***
	(0.009)	(0.018)	(0.006)	(0.002)	(0.025)	(0.004)
Age	–0.114***	–0.053**	–0.005**	–0.002*	–0.161***	–0.011***
	(0.017)	(0.025)	(0.002)	(0.001)	(0.020)	(0.004)
Foreign Share	0.565***	0.432***	0.009	0.000	0.837***	0.240***
	(0.104)	(0.078)	(0.016)	(0.005)	(0.172)	(0.033)
Govt. Share	–0.666***	–0.756***	–0.014***	0.011***	–0.622***	–0.043***
	(0.046)	(0.042)	(0.005)	(0.003)	(0.042)	(0.009)
Subsidy	0.111***	0.069***	0.041***	0.018***	0.213***	0.026***
	(0.020)	(0.017)	(0.007)	(0.002)	(0.033)	(0.004)
Observations	944,177	944,125	810,902	854,986	966,072	854,986
Partner Firms	19,242	19,241	19,233	19,240	19,240	19,240
R^2	0.117	0.297	0.053	0.043	0.535	0.242
Industry FEs	✓	✓	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✗	✗	✗	✗	✗	✗

Notes: Dependent variables are given in each column heading. Estimation method is OLS. Each specification uses inverse probability weights as sampling weights in the estimation. Patents, Sales, Employment, and Age are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

firms (non-IJV partners), conditioning on the firm-level variables that influence the outcome variable as in a standard OLS regression, while placing more weight in the regression on treated (untreated) firms that are most similar to typical untreated (treated) firms in terms of selection probability.[23] Second, the inclusion of fixed effects implies that the specification compares the joint venture partner firms to otherwise "similar" firms, where similar is defined as operating in the same industry and province.

Results are shown in Table 4.6. First of all, I see that the joint venture partner variable PT_{it} enters with a positive coefficient that is typically also significantly different from zero. For example, Chinese IJV partner firms have about 23% higher sales than other firms (column 5). The

[23]Results without inverse probability weighting are shown in Table A.9 of the Appendix.

inclusion of firm employment as regressor means that this amounts to a substantial premium not only in sales but also (revenue-based) labor productivity, and note that the TFP (OLS) advantage is still around 5% (column 1). This is consistent with a sizable intergenerational technology transfer effect. It is identified mostly from a comparison with the Chinese firms that are not associated with joint ventures, given their relatively large number. The finding of a productivity advantage of Chinese partner firms over other Chinese firms is interesting in light of Figure 4.5 which shows that TFP of other firms rises faster than that of IJV partner firms. The results are not inconsistent, however, and can be resolved by taking into account externalities generated by joint ventures, as I will show below.

Second, note that the productivity effects on Chinese partner firms are smaller than those on the joint ventures themselves. Comparing columns 1 and 2 in Tables 4.5 and 4.6, respectively, I see that the TFP effect of Chinese partner firms using OLS is about one sixth of that of the joint venture, and the TFP effect using the Olley-Pakes approach is not significant (Table 4.6, column 2). Similar results are found for the other outcomes (sales, new product ratio, export ratio, and patents). For example, the Chinese partners show 0.8% higher patenting whereas joint venture firms patent at a 2.2% higher rate. This is because, first, foreign partners have a strong incentive to transfer technology to the joint venture (and no incentive to transfer technology to the partner firm), and second, the partner firm will generally be large, so that whatever new technology they indirectly obtain from the foreign joint venture partner is going to have a relatively small impact on their productivity. And yet it is striking that even these well-established firms benefit from forming an international joint venture through intergenerational technology transfer.

I extend the analysis by replacing industry and region fixed effects with firm fixed effects, which imply that the results are identified by comparing outcomes for a given firm before and after it becomes partner in an international joint venture.[24] Results are given in Table 4.7.[25]

It can be seen that the productivity point estimates continue to be positive, in fact larger than before, although they are no longer significant. Significant effects from Chinese partner firms are

[24]Firm fixed effects have proven to be a powerful way to address various sources of endogeneity when estimating causal impacts on firm performance because the fixed effects eliminate determinants of firm performance that are (approximately) fixed over time (Mundlak 1961).

[25]Analogous results for the joint venture effect itself cannot be shown because the joint venture effect is not separately identified from the firm fixed effect.

Table 4.7: Intergenerational Technology Transfer: Firm Fixed Effect Results

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
PT	0.078	0.078	0.065*	0.006	0.136***	0.011*
	(0.058)	(0.059)	(0.033)	(0.006)	(0.031)	(0.006)
Employment	0.055**	–0.012	0.014***	0.006***	0.597***	0.014***
	(0.021)	(0.022)	(0.004)	(0.001)	(0.019)	(0.002)
Age	0.097**	0.091**	–0.012***	–0.004	0.119***	0.001
	(0.039)	(0.040)	(0.004)	(0.003)	(0.029)	(0.003)
Foreign Share	–0.032	–0.033	–0.006	0.005	–0.018	0.022***
	(0.040)	(0.041)	(0.011)	(0.005)	(0.029)	(0.007)
Govt. Share	–0.115***	–0.109***	–0.017**	0.002	–0.110***	–0.003
	(0.031)	(0.032)	(0.007)	(0.002)	(0.018)	(0.002)
Subsidy	0.056***	0.049***	0.015***	0.008***	0.069***	0.009***
	(0.010)	(0.010)	(0.004)	(0.002)	(0.007)	(0.002)
Observations	944,177	944,125	810,902	854,986	966,072	854,986
Partner Firms	19,242	19,241	19,233	19,240	19,240	19,240
R^2	0.591	0.697	0.507	0.553	0.884	0.824
Industry FEs	✗	✗	✗	✗	✗	✗
Province FEs	✗	✗	✗	✗	✗	✗
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓	✓	✓

Notes: Dependent variables are given in each column heading. Estimation method is OLS. Each specification uses inverse probability weights as sampling weights in the estimation. Dependent variables are given in each column header. Patents, Sales, Age, and Employment are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

present for patenting, export ratio, and sales. With productivity effects weaker, the patent coefficient larger, and the export coefficient roughly the same, the firm effects results are not clearly smaller (or larger), but generally support the earlier findings shown in Table 4.6. Overall, the results provide evidence supporting the hypothesis that technology transfer through international joint ventures leads to positive technology transfer effects for the joint venture and to intergenerational technology transfer to the Chinese firm that is the domestic partner of the international joint venture.

Table 4.8: Technology Transfer Over Time

	(1) Joint Ventures	(2) Partner Firms
Trend	0.014***	0.006**
	(0.003)	(0.002)
Employment	0.022	0.055**
	(0.018)	(0.021)
Age	0.137***	0.088**
	(0.025)	(0.038)
Foreign Share	0.018	–0.033
	(0.020)	(0.039)
Govt. Share	–0.133***	–0.114***
	(0.020)	(0.031)
Subsidy	0.041***	0.055***
	(0.007)	(0.010)
Observations	970,800	944,177
R^2	0.627	0.591
Year FEs	✓	✓
Firm FEs	✓	✓

Notes: Dependent variable: TFP (OLS). Estimation method is OLS. Age and Employment are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Productivity Dynamics of Joint Ventures and Partner Firms

I have also examined the dynamics of technology transfer to the joint venture and Chinese partner firms. *Trend* is a linear time trend for joint ventures or partner firms over the years following the inception of the joint venture (specifically, $Trend^{JV}$ and $Trend^{PT}$ are the interactions of JV_i and PT_{it}, respectively, with the age of the joint venture). Table 4.8 shows that both technology transfer to the joint venture and the intergenerational effect are increasing over time, with the dynamic effect on joint venture firms estimated to be more than double that on partner firms.

These findings are important because they show that technology transfer associated with joint ventures can account for part of the evolution of firm performance as seen in Figure 4.5 above.

4.4 Joint Ventures and Industry-Level Spillovers

So far I have provided evidence that joint ventures receive new technology from the international partner, and that Chinese partner firms benefit from new technology as well. This section extends the analysis of technology externalities arising from joint venture relationships in China. To approach this issue I define the variable $SPILL^{JV}_{jt}$ as the share of joint venture firms in total sales in the industry j of firm i and year t. This measure picks up so-called intra-industry (or horizontal) spillovers. While not directly capturing actual firm-to-firm linkages, it is hypothesized that a greater presence of joint venture firms in an industry may increase the chance of positive technology spillover effects (as found in, e.g., Keller and Yeaple 2009). At the same time, the greater presence of joint venture firms might increase the intensity of competition, thereby reducing sales and other measures of firm performance. The estimating equation becomes

$$y_{it} = \alpha + \beta_2 \, SPILL^{JV}_{jt} + \boldsymbol{X}'_{it}\boldsymbol{\gamma} + \lambda_t + \lambda_i + \varepsilon_{it}, \tag{4.5}$$

where λ_i is a firm fixed effect. I perform an analogous analysis for externalities arising from Chinese joint venture partner firms. From the Chinese firms that have set up the joint ventures, the variable $SPILL^{PT}_{jt}$ is defined as the share of Chinese partner firms in total sales in the industry j of firm i and year t:

$$y_{it} = \alpha + \beta_1 \, PT_{it} + \beta_2 \, SPILL^{PT}_{jt} + \boldsymbol{X}'_{it}\boldsymbol{\gamma} + \lambda_t + \lambda_i + \varepsilon_{it}. \tag{4.6}$$

One difference between equations (4.5) and (4.6) is that coefficient β_1 is identified because partner firms exist before and after the creation of the joint venture firms. Results are presented in Table 4.9; on the left are results for the effects from joint ventures, on the right for externalities from the Chinese partner firms that set up the joint ventures. Given the discussion above, the main focus now is the variable $SPILL$.

Tables 4.9 and 4.10 give the respective estimates from equations (4.5) and (4.6). I find evidence that both joint ventures and Chinese partner firms affect other firms. Note that most of the coefficients are positive, indicating that technology spillovers outweigh competition effects. In

Table 4.9: Joint Ventures and Industry Spillovers

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
$SPILL^{JV}$	1.003**	1.035**	–0.049	0.014	1.316***	0.007
	(0.419)	(0.454)	(0.104)	(0.015)	(0.336)	(0.028)
Employment	0.022	–0.050***	0.014***	0.007***	0.565***	0.014***
	(0.018)	(0.018)	(0.003)	(0.001)	(0.011)	(0.002)
Age	0.139***	0.130***	–0.006**	–0.000	0.178***	0.010***
	(0.025)	(0.024)	(0.003)	(0.001)	(0.020)	(0.002)
Foreign Share	0.018	0.004	–0.000	0.004	0.088***	0.018***
	(0.020)	(0.021)	(0.006)	(0.003)	(0.010)	(0.004)
Govt. Share	–0.133***	–0.130***	–0.016***	0.002*	–0.127***	–0.003**
	(0.020)	(0.020)	(0.004)	(0.001)	(0.013)	(0.001)
Subsidy	0.041***	0.035***	0.010***	0.006***	0.063***	0.008***
	(0.007)	(0.006)	(0.002)	(0.001)	(0.006)	(0.001)
Observations	970,800	970,748	851,950	898,995	1,015,117	898,995
R^2	0.627	0.725	0.516	0.555	0.894	0.842
Industry FEs	✗	✗	✗	✗	✗	✗
Province FEs	✗	✗	✗	✗	✗	✗
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓	✓	✓

Notes: Dependent variables are given in each column heading. Estimation method is OLS. Patents, Sales, Employment, and Age are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

particular, the estimate for joint venture productivity externalities, $SPILL^{JV}$, is around 1. This figure is high compared to existing estimates for wholly-owned FDI spillovers. For example, Keller and Yeaple (2009) estimate FDI spillovers of about 0.5, roughly half the size of the joint venture spillovers, and Keller and Yeaple's estimates are larger than found in most papers. Second, the results show that externalities from joint ventures tend to be larger than externalities from joint venture partner firms. This result is in line with the earlier finding that the direct, internalized effect of technology transfer from the international firm to the joint venture is stronger than the intergenerational effect, because the relatively strong internalized transfer translates into a relatively high intra-industry externality. The largest gains are for sales, followed by increases in productivity. In contrast I find negative coefficients in the patenting equations, significantly so for Chinese

Table 4.10: Joint Venture Partners and Industry Spillovers

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
PT	0.047	0.050	0.058**	0.005	0.069**	0.008
	(0.041)	(0.041)	(0.028)	(0.005)	(0.031)	(0.005)
$SPILL^{PT}$	0.431**	0.472***	–0.066**	–0.016**	0.543***	0.001
	(0.196)	(0.165)	(0.032)	(0.007)	(0.188)	(0.012)
Employment	0.022	–0.050***	0.014***	0.007***	0.566***	0.014***
	(0.018)	(0.018)	(0.003)	(0.001)	(0.011)	(0.002)
Age	0.142***	0.133***	–0.007***	–0.001	0.181***	0.010***
	(0.024)	(0.023)	(0.002)	(0.001)	(0.019)	(0.002)
Foreign Share	0.017	0.003	–0.000	0.004	0.087***	0.018***
	(0.020)	(0.020)	(0.006)	(0.003)	(0.010)	(0.004)
Govt. Share	–0.131***	–0.128***	–0.017***	0.001*	–0.124***	–0.003**
	(0.020)	(0.020)	(0.004)	(0.001)	(0.013)	(0.001)
Subsidy	0.041***	0.034***	0.010***	0.006***	0.063***	0.008***
	(0.007)	(0.006)	(0.002)	(0.001)	(0.006)	(0.001)
Observations	970,800	970,748	851,950	898,995	1,015,117	898,995
R^2	0.627	0.725	0.516	0.555	0.894	0.842
Industry FEs	✗	✗	✗	✗	✗	✗
Province FEs	✗	✗	✗	✗	✗	✗
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓	✓	✓

Notes: Dependent variables are given in each column heading. Estimation method is OLS. Patents, Sales, Employment, and Age are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(joint venture) partner firms. One explanation for this may be the role of competition, which may be particularly strong because patent races are by definition winner-takes-all events.

An important question is whether all Chinese firms benefit to the same extent from these industry-level externalities. To see whether there is evidence for heterogeneous effects I have re-estimated these specifications for several subsamples. Generally, I find that the joint ventures themselves benefit most from the externalities of other joint ventures and the more established Chinese partner firms. Table 4.11 gives the $SPILL$ coefficients in the TFP (OLS) regression for four different samples.

Table 4.11: Industry-Level Externalities by Sample

	JV Firms Partner Firms Other Firms	Partner Firms Other Firms	JV Firms Other Firms	Other Firms
$SPILL$ from Joint Ventures	1.003**	0.967**	1.054**	1.003**
	(0.419)	(0.416)	(0.435)	(0.433)
$SPILL$ from Partner Firms	0.431**	0.422**	0.444**	0.430**
	(0.196)	(0.197)	(0.199)	(0.199)

Notes: Dependent variable: TFP (OLS). Estimation method is OLS with firm and year fixed effects. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The coefficients in the table's first column repeat the results from the first columns in Tables 4.9 and 4.10. Across all four samples in Table 4.11 the TFP coefficient is estimated quite similarly, which is not surprising since the non-JV, non-Partner firms are the large majority of the sample.[26] While the estimates across samples are not significantly different in a statistical sense, nevertheless the point estimates provides useful information on the size of spillovers to different firms (Table 4.11, first row). If I drop the joint venture firms, the point estimate falls from 1 to 0.97, whereas if instead I drop the Chinese partner firms the point estimate increases to 1.05. The latter is evidence that spillovers from joint ventures benefit *other* joint ventures most strongly, while the former suggests that other Chinese firms benefit from joint venture spillovers more than the more established partner firms. Turning to spillovers from Chinese partner firms, I also see here evidence that other Chinese firms and in particular joint ventures benefit more than other Chinese partner firms (Table 4.11, row 2). Thus, there is evidence for two-way technology transfer between joint ventures and Chinese partner firms. Partner firms benefit from intergenerational technology transfer from the joint venture they set up, while joint ventures benefit from industry-level externalities generated by Chinese partner firms.

Why might joint venture firms themselves be the greatest beneficiaries from positive technology externalities through joint ventures in China? One explanation is the notion of the so-called absorptive capacity. Cohen and Levinthal (1990) argue that there are two reasons why firms make technology investments: first, because they want to innovate, and second, because they want to be able to benefit from the innovation efforts of others—Cohen and Levinthal's notion of absorptive

[26] I include the other Chinese firms in all samples because it provides a useful benchmark.

capacity. Joint ventures in China are typically technologically advanced and innovative through the technology transfer from their international partner. Those firms will tend to have a higher absorptive capacity to benefit from technological developments external to the firm than the average Chinese firm, and consequently, they benefit more strongly from industry-level spillovers.

4.5 Heterogeneity in Joint Venture Effects

Foreign Country of Investor

Joint venture effects might vary across several dimensions. It may be that firms in particular industries are impacted differently from those in other industries, or that the country from which the foreign partner in an IJV originates matters. In this section I examine whether the country of origin of a firm's joint venture partner plays a role in determining the magnitude of the effects uncovered in the previous section. I distinguish three sources of foreign joint venture partner that account for the large majority (see Figure 4.3 in Section 4.1) of all joint ventures in China: (1) Hong Kong, Macau, and Taiwan (HMT); (2) Japan; and (3) the United States of America. As will be seen, the effects vary substantially across the country of origin of the joint venture partner. I begin with the technology transfer to joint ventures. The results are shown in Table 4.12.

I first show the average productivity premium for joint venture firms as measured by TFP (OP) (as in Table 4.5, column 2). The point estimate for joint ventures with a Hong Kong, Macau, or Taiwan partner is negative (not significant), suggesting that technology transfer from an international partner in these economies is below-average (column 2). The interaction coefficient for Japanese partners is positive but small, while in contrast the U.S. coefficient is positive and significant (columns 3 and 4). According to the estimates, U.S. partners roughly double the productivity gains of joint ventures, relative to non-U.S. foreign partners. One explanation for this is that U.S. firms tend to be closer to the world's technology frontier than non-U.S. firms, and as a consequence they transfer more (or better) technology to their Chinese joint venture.

Turning to the industry externalities generated by joint ventures with foreign partners from various origins, there are both similarities and differences (Table 4.13). Specifically, I see that joint ventures formed with U.S. partners generate higher positive spillovers than joint ventures with

Table 4.12: Internal Effects of Joint Ventures: Foreign Investor Heterogeneity

	(1) Baseline	(2) HMT	(3) Japan	(4) USA
JV	0.256***	0.281***	0.255***	0.235***
	(0.021)	(0.025)	(0.021)	(0.019)
JV × HMT		–0.061		
		(0.037)		
JV × Japan			0.009	
			(0.033)	
JV × USA				0.297***
				(0.069)
Observations	970,861	970,861	970,861	970,861
R^2	0.339	0.339	0.339	0.339
Industry FEs	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓

Notes: Dependent variable: TFP (OP). Estimation method is OLS; other variables included as in Table 4.5. HMT stands for Hong Kong/Macau/Taiwan. Column 1 Baseline as in Table 4.5 column 2. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4.13: External Effects of Joint Ventures: Foreign Investor Heterogeneity

	(1) Baseline	(2) HMT	(3) Japan	(4) USA
Spill^{JV}	1.035**	0.984***	1.605***	0.433
	(0.454)	(0.293)	(0.541)	(0.518)
Spill^{JV}_{HMT}		0.194		
		(1.532)		
$\text{Spill}^{JV}_{Japan}$			–3.744*	
			(2.167)	
Spill^{JV}_{USA}				3.213**
				(1.537)
Observations	970,748	970,748	970,748	970,748
R^2	0.725	0.725	0.725	0.725
Year FEs	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓

Notes: Dependent variable: TFP (OP). Estimation method is OLS; other variables included as in Table 4.9. HMT stands for Hong Kong/Macau/Taiwan. Column 1 Baseline as in Table 4.9 column 2. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4.14: International Joint Ventures and Exporting: Internal Effects by Investor

	(1) Baseline	(2) HMT	(3) Japan	(4) USA
JV	0.025***	0.015	0.021***	0.028***
	(0.009)	(0.010)	(0.007)	(0.009)
JV × HMT		0.026**		
		(0.010)		
JV × Japan			0.038*	
			(0.021)	
JV × USA				–0.038
				(0.024)
Observations	899,072	899,072	899,072	899,072
R^2	0.266	0.266	0.266	0.266
Industry FEs	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓

Notes: Dependent variable: Export Ratio. Estimation method is OLS; other variables included as in Table 4.5. HMT stands for Hong Kong/Macau/Taiwan. Column 1 Baseline as in Table 4.5 column 6. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

partners from other foreign countries (column 4); this is in line with the relatively strong technology transfer to the joint venture. In fact, the results show that in the absence of U.S. joint ventures there would be no significantly positive spillover effect from joint ventures in China. At the same time, the external effect from Japanese joint ventures is significantly lower than the average, and the point estimate is negative at around –2.1 (= –3.7 + 1.6, column 3). This result indicates that in the case of Japanese joint ventures the negative competition effects outweigh positive technology spillovers. The result could also be due to the structure of Japanese joint ventures, which may be different given Japan's relative geographic proximity to China in comparison with the U.S., or it could be related to the industry composition of Japanese versus U.S. joint ventures in China if positive spillovers vary by industry. I will turn to industry effects below.

In Table 4.14 I examine the propensity to export as an alternative performance measure. I see that joint ventures set up with either HMT or with Japanese partners are more likely to increase exporting activity, compared to joint ventures with U.S. firms. This result is likely related to the supply chain of these firms, specifically, that the purpose of HMT and Japanese joint ventures

Table 4.15: International Joint Ventures and Exporting: External Effects by Investor

	(1) Baseline	(2) HMT	(3) Japan	(4) USA
SPILL^{JV}	0.007	0.026	–0.048	0.033
	(0.028)	(0.042)	(0.037)	(0.041)
SPILL^{JV}_{HMT}		–0.071		
		(0.123)		
$\text{SPILL}^{JV}_{Japan}$			0.364*	
			(0.195)	
SPILL^{JV}_{USA}				–0.142
				(0.249)
Observations	898,995	898,995	898,995	898,995
R^2	0.842	0.842	0.842	0.842
Year FEs	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓

Notes: Dependent variable: Export Ratio. Estimation method is OLS; other variables included as in Table 4.9. HMT stands for Hong Kong/Macau/Taiwan. Column 1 Baseline as in Table 4.9 column 6. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

in China is to some extent to produce intermediate goods that are shipped to Japan and HMT, which is less likely in the case of the United States given the greater distance. This provides some evidence that the structure of joint ventures with partners from different foreign countries is different in part due to geographic factors.

From Table 4.15 I see that in the case of Japanese joint ventures there are positive industry externalities that favor exporting in addition to the internalized effects (column 3). A starting point to explain this could be that export-oriented Japanese joint ventures have input-output links with other Chinese firms, and it may reflect to some extent that industries with a strong presence of Japanese joint ventures generate learning effects for other Chinese firms about how to break into the Japanese market.

I have also considered differences by foreign investor country for Chinese partner firm effects. Generally, there is less evidence for significant differences across countries, in part because the intergenerational transfer effects are smaller to begin with (see above). At the same time, the patterns of point estimates are consistent with stronger technology transfers from the U.S. than from Japan or HMT.[27] This indicates that the relatively strong technology transfer effects from U.S. firms to their joint ventures in China carry over to relatively strong intergenerational effects to the Chinese joint venture partner firms.

Industry Heterogeneity

A large literature examines heterogeneity of FDI spillovers across industries. The extent of the internal and external technology transfer effects of joint ventures might depend on the characteristics of particular industries, such as the degree to which firms in a given industry possess the absorptive capacity to benefit from foreign know-how.[28] A well-known result in the area of intra-industry spillovers is that they are increasing with the R&D intensity of the industry (Keller and Yeaple 2009). In this section I provide evidence on industry variation in both internalized and external effects of Chinese joint ventures.

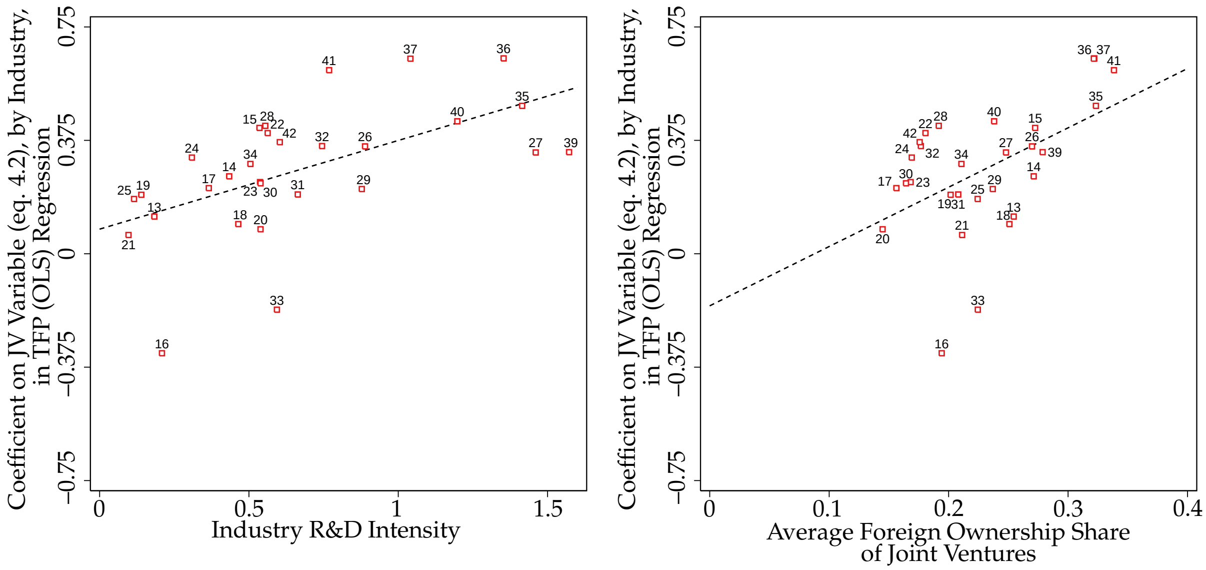
Figure 4.6 shows industry variation in the effects of international technology transfer to joint ventures, analogous to the results of Table 4.5. On the left side there is evidence for stronger international technology transfer to joint ventures in more R&D-intensive industries. This is plausible because it is these industries, especially in manufacturing, in which the technology gap between foreign and local firms tends to be largest. Furthermore, on the right I see that technology transfer to the joint venture is increasing in the foreign ownership share. A likely reason for this is that a relatively high foreign ownership share means less technology leakage from the point of view of the foreign investor; alternatively, a higher degree of foreign ownership might further incentivize the foreign investor to transfer more know-how to the joint venture.

I have seen above that there are positive industry externalities from both Chinese partner firms and the joint ventures they set up with foreign partners. The source of the partner firm effects is the intergenerational transfer effect from joint venture to Chinese partner firm, which, in turn, depends on the technology transfer between foreign firm and joint venture. An impor-

[27] For example, the point estimates for the U.S., Japan, and HMT for Chinese partner firm effects analogous to the joint venture effects of Table 4.12 are 0.193, 0.005, and 0.004, respectively.

[28] Howell (2018) is a recent study of joint venture effects in China's automobile industry. Estimating the impact of higher fuel efficiency standards starting in 2009 on innovative activity, she finds that Chinese partners to IJVs fall behind compared to foreign firms because the partner firms re-direct their focus on lower-quality cars while leaving at the same time the high-quality market segment with higher fuel efficiency to their joint venture.

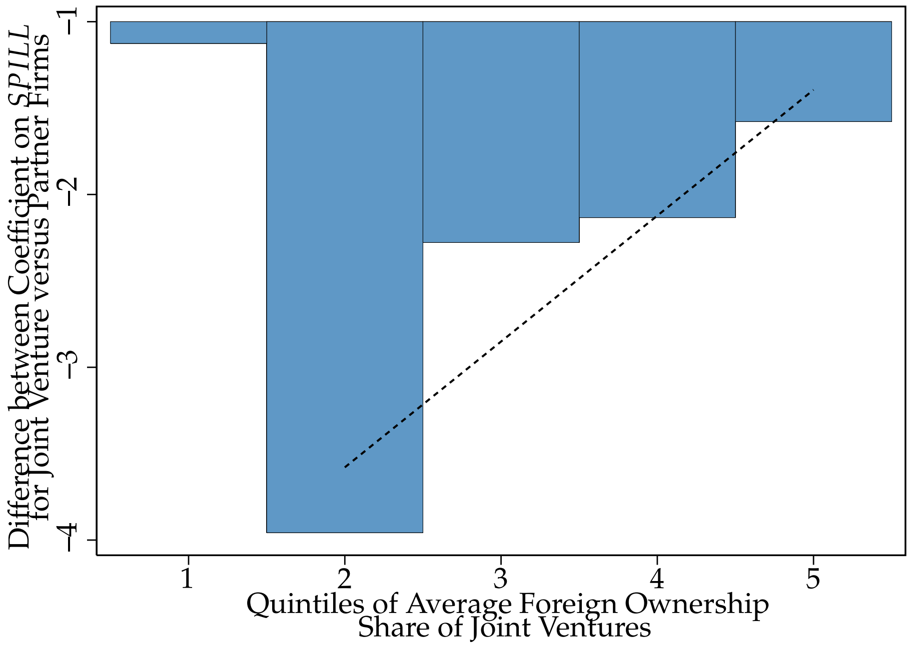
Figure 4.6: Industry R&D Intensity, Foreign Ownership Shares of Joint Ventures, and Technology Transfer to Joint Ventures in Manufacturing



CIC Manufacturing Industries

13 - Food processing	28 - Chemical fiber
14 - Food manufacturing	29 - Rubber products
15 - Beverage manufacturing	30 - Plastic products
16 - Tobacco processing	31 - Non-metallic mineral products
17 - Textiles	32 - Production and processing of ferrous metals
18 - Apparel	33 - Production and processing of non-ferrous metals
19 - Leather and fur products	34 - Metal products
20 - Wood products and processing	35 - General purpose machinery
21 - Furniture	36 - Special purpose machinery
22 - Paper and paper products	37 - Transportation equipment
23 - Printing and reproduction of recorded media	39 - Electrical machinery and equipment
24 - Cultural, educational, and sporting goods	40 - Communication, computer, and electronic equipment
25 - Processing of petroleum, coking, and nuclear fuel production	41 - Measuring, analyzing, and control instruments
26 - Raw chemicals and chemical products	42 - Miscellaneous Manufacturing
27 - Pharmaceuticals	

Figure 4.7: Foreign Ownership of Joint Ventures and External Effects of Joint Ventures



tant question concerns the relative size of the technology transfers, and whether they depend on characteristics such as foreign ownership share. Figure 4.7 shows evidence on this. Depicted is the difference between the partner spillover TFP effect and the joint venture spillover TFP effect across industries (by quintiles). This difference is generally negative, confirming the result from above that joint ventures generate larger industry externalities than partner firms. However, the figure also shows that except for a small set of industries in which foreign ownership is essentially ruled out by law, quintile 1, there is a positive relationship between the relative partner effect and foreign ownership. This means that while high foreign ownership of the joint venture is associated with relatively high levels of foreign technology transfer to the joint venture, which is plausible from an internalization perspective, it is also associated with relatively high technology leakage as evidenced by relatively high industry externalities generated by Chinese partner firms. Overall, this result highlights that foreign firms' optimal investment strategies in China have to balance a number of key factors, including the amount of technology transfer and foreign ownership share.

Table 4.16: Joint Ventures and Industry Spillovers: Pre- and Post-WTO Accession

	Joint Venture Firms		Partner Firms	
	(1)	(2)	(3)	(4)
	[1998,2001]	[2002,2007]	[1998,2001]	[2002,2007]
PT			0.059*	–0.127
			(0.031)	(0.305)
SPILL	–0.123	0.969*	–0.006	0.531***
	(0.313)	(0.543)	(0.192)	(0.185)
Employment	–0.190***	–0.090***	–0.190***	–0.089***
	(0.017)	(0.020)	(0.017)	(0.020)
Age	0.159***	0.253***	0.159***	0.258***
	(0.018)	(0.029)	(0.018)	(0.028)
Foreign Share	0.054	–0.017	0.054	–0.018
	(0.047)	(0.023)	(0.047)	(0.023)
Govt. Share	–0.059***	–0.062***	–0.059***	–0.059***
	(0.015)	(0.015)	(0.015)	(0.015)
Subsidy	0.037***	0.026***	0.037***	0.025***
	(0.009)	(0.006)	(0.009)	(0.006)
Observations	289,167	649,430	289,167	649,430
R^2	0.829	0.757	0.829	0.757
Year FEs	✓	✓	✓	✓
Firm FEs	✓	✓	✓	✓

Notes: Dependent variable: TFP (OP). Estimation method is OLS. Patents, Sales, Employment, and Age are expressed in natural logarithms. The results in columns (1) and (3) only use observations from the period 1998–2001, while the results in columns (2) and (4) only use observations from the period 2002–2007. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

China's Entry into the World Trade Organization

The entry of China into the WTO in December 2001 led to a number of changes in FDI policy.[29] Here I are interested in whether the WTO accession has affected the magnitude of industry-level spillovers in China. To address this issue I perform separate regressions for the years 1998 to 2001 and 2002 to 2007. This sample split is natural given that 2002 was China's first full year of WTO membership, even though there may have been some anticipation effects before 2002, as well as other effects that manifest themselves only with a short lag.

Table 4.16 shows the results, with results for industry spillovers generated by joint ventures

[29] Lu, Tao, and Zhu (2017), for example, have studied the impact of FDI on firm productivity in China by exploiting the fact that China opened up an additional 24% of manufacturing industries to FDI.

on the left and those generated by Chinese partner firms on the right. I see that as before, productivity spillovers generated by the joint venture firms are larger than those due to Chinese partner firms. The key finding of Table 4.16, however, is that both industry externalities are much larger (and significant) in the post-WTO entry period. There might be a number of reasons for this. One possibility may be that externalities increased due to new sectoral composition, given that China opened up additional sectors to FDI, although it is hard to see that composition effects explain the entire finding. Another possibility is that China's entry into the WTO reduced uncertainty about a future policy change towards a more restrictive regime. Finally, given the well-established result that Chinese firm performance has improved with China's accession to the WTO, another explanation for the results is an absorptive capacity argument: China's stronger firms have become more successful in benefiting from industry-level technology externalities.

These explanations, of course, are not mutually exclusive and it will be important in future research to distinguish between these explanations.

Joint Ventures and Chinese FDI Policy

It is interesting to examine technology transfer effects of joint ventures in relation to China's stated policy of (1) encouraging, (2) restricting, and (3) prohibiting foreign investment in particular activities according to its Catalogue for the Guidance of Foreign Investment Industries (a fourth category, 'Permitted', refers to activities not explicitly supported or restricted by China's government). As discussed above, I have mapped China's joint venture policy into three variables defined as the counts of the number of activities within a given CIC industry that are classified in the three explicitly listed categories. For example, $Encouraged_{jt}$ is the count of the number of products within a particular 2-digit industry j that China's government has classified as 'Encouraged' in an observation year's most recent iteration of the investment catalogue; $Restricted_{jt}$ and $Prohibited_{jt}$ are defined analogously. Industries with greater numbers of activities classified as Encouraged are those in which foreign investment is conducted most openly, with added incentives for foreign investors such as lower tax rates. Conversely, those industries comprised of more Restricted activities are those in which joint ventures are most often required for foreign firms, while the prevalence of numerous Prohibited activities indicates industries that are relatively more closed

Table 4.17: International Technology Transfer and Chinese Investment Policy

	(1) Internal		(2) External
JV	0.327***	$SPILL^{JV}$	2.018**
	(0.025)		(0.824)
JV × Encouraged	0.018	$SPILL^{JV}$ × Encouraged	0.133
	(0.019)		(0.153)
JV × Restricted	0.006	$SPILL^{JV}$ × Restricted	0.100
	(0.039)		(0.309)
JV × Prohibited	–0.277***	$SPILL^{JV}$ × Prohibited	–2.141*
	(0.062)		(1.230)
Observations	970,913		970,913
R^2	0.163		0.161
Industry FEs	✓		✓
Province FEs	✓		✓
Year FEs	✓		✓

Notes: Dependent variable: TFP (OLS). Estimation method is OLS. For column 1, other variables included as in Table 4.5, column 1. For column 2, other variables included as in Table 4.9, column 1. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

to foreign entrants. The interactions of each of these variables with either JV or $SPILL^{JV}$ captures the role of China's policy within an industry on the internal and external effects of joint ventures. For the former effect, conditional on being a joint venture firm, how does the magnitude of the internal technology transfer effect of joint venture status change as the degree of restrictiveness of foreign policy in that industry changes? Alternatively for the latter effect, given a value of $SPILL^{JV}$, how do the external effects of joint venture penetration respond to differences in joint venture policy? column 1 in Table 4.17 shows evidence that technology transfer due to international joint ventures occurs only in broad sectors which are generally open to international joint ventures, and they do not occur in sectors characterized by frequent joint venture prohibitions, even if the particular activity of a foreign firm is not prohibited.

As column 2 of Table 4.17 shows, I find parallel results for positive industry externalities from joint ventures. They essentially do not materialize in sectors that include activities in which joint ventures are prohibited. One interpretation of this is that China's policy towards certain types of foreign investment effectively deters international technology transfer.

4.6 Conclusion

IJVs comprise a major channel for FDI, particularly for multinationals that establish operations in China. The effects of IJV formation are multifaceted, and I delineate the analysis in several ways. Importantly, the empirical approach allows me to distinguish the Chinese firm forming the joint venture from the newly set-up joint venture firm itself in a comprehensive data set of Chinese firms. I have investigated the attributes of firms, be it market share, stock of technology, or regulatory expertise, that are conducive to being picked as Chinese partners to foreign investors seeking to enter the Chinese market. Generally, foreign investors seek out profitable, large, and highly productive firms, as well as firms that demonstrate high rates of export participation and patenting. Firms that receive government subsidies—implicitly, those firms with well-developed political connections—also tend to be more likely to be chosen as joint venture partners. While the existing literature has explored such issues in partner choice, the fact that I approach the question with a novel data set in an econometric framework deepens the existing understanding of the empirical determinants of selection.

I then explore the effects that materialize subsequent to the creation of the joint venture, not only on the joint venture itself but also on the domestic partner and other Chinese firms. The firms created by IJVs benefit from their foreign parentage, as evidenced by their enhanced performance along multiple dimensions, including in their sales, productivity, and innovation activities—compelling evidence for the internal effect of international technology transfer arising from joint ventures. Further, I find evidence for the existence of indirect technology transfer (a phenomenon that I characterize as the intergenerational technology transfer effect) whereby the domestic partners of joint ventures themselves perform better after the inception of the joint venture.

Extending this analysis to the industry level, I show that joint venture firms—beneficiaries of advanced foreign technology and know-how—generate positive externalities to domestic firms that operate in the same industry. Foreign technology diffuses beyond the confines of the joint venture, and the resulting productivity spillovers from joint ventures I find to be larger than those arising from other forms of FDI. The Chinese partner firms in IJVs likewise generate positive spillovers when they operate in the same industry, though this effect is more muted than that arising from the joint venture firms themselves (which accords with the finding of the intergenerational technology transfer effect being smaller than the direct internal effect). Both types of externalities are realized most strongly by the joint venture firms, suggesting that their advanced technology bolsters their absorptive capacity to benefit from such spillovers. I also consider several aspects of heterogeneity in how these effects are transmitted. In line with previous literature, external effects from joint ventures are highest in R&D-intensive industries, and the largest externalities tend to arise in industries with a large concentration of joint ventures with a U.S. partner. Finally, with regard to Chinese policy towards foreign investment, I show that positive technology externalities are effectively negated in industries with a large number of prohibitions on what types of foreign investment are allowed.

Ultimately, IJVs occupy an important role in the arena of foreign investment. Based on the findings here, the unique nature of such arrangements between domestic firms and foreign partners generates far-reaching impacts manifest themselves both for the firms within the arrangements, and for firms outside the joint venture. The literature on multinationals has expended significant effort in quantifying the effects of FDI; however, the specific role of joint ventures has remained underexplored. At a broad level, these results serve to inform the understanding of effective foreign investment policy. As China has liberalized its foreign investment environment, encouraging the establishment of WFOEs and opening more sectors to foreign entry, the ensuing reduction in the utilization of joint ventures promises to impact the way in which knowledge is transmitted between firms. While channels for learning and technology transfer might arise from WFOEs (perhaps via labor turnover, intermediate input sourcing, or broader learning effects), the fact that domestic firms play no direct role in this type of investment shuts down the potential international technology transfer effects revealed in joint venture firms and the intergenerational effects accruing to partner firms. Additionally, WFOEs are likely to be better equipped to safeguard their intellectual property and proprietary technologies from being disseminated to domestic firms, dampening the innovation externalities that I find evidence for, while potentially sapping market share from domestic competitors—in other words, the move away from IJVs might amplify the negatives and attenuate the positives arising from foreign investment. Future work might consider the effects of the various modes of foreign investment jointly, particularly in light of the explosion of WFOEs in China in recent years.

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Appendix A

Data Sources and Alternative Estimates

Data Sources

The data sources are described in Table A.1. To construct the measures of bilateral trade flows by sector (high-IP vs. low-IP, and then broken down into more detailed sectors within the high-IP classification), I start with commodity-level bilateral trade data from CEPII (see Gaulier and Zignago 2010) classified by 6-digit Harmonized System (HS) codes. Because the high-IP vs. low-IP industry classifications from Delgado et al. (2013) and US Department of Commerce (2012) are delineated by SITC industries, I map (in a one-to-one fashion) the 6-digit HS trade data to a corresponding SITC code based on a concordance from the EU RAMON database (Eurostat, 2017). From here the value of bilateral trade flows is aggregated according to the high-IP versus low-IP industry classifications.

Table A.1: Data Sources and Description

Variable	Description	Data Source
Intensive (T_{ijst}) and extensive (X_{ijst}) margins of trade	Bilateral 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 US Department of Commerce (2012)

Table A.2: 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 A.3: 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)	***Medical Devices (MED)***
Laboratory instruments: 87325, 8742–3	Diagnostic substances: 54192–3, 59867–9
Optical instruments: 8714, 8744	Medical equipment and supplies: 59895, 6291, 774 872, 8841
Process instruments: 8745–6, 8749	
Biopharmaceuticals (BIO)	***Production Technology (PT)***
Medicinal and pharmaceutical products: 5411–6, 54199, 542	Materials and tools: 2772, 2782, 69561–2, 69564
	Process and metalworking machinery: 711, 7248, 726, 7284–5, 73
Chemicals (CHEM)	
Chemically-based ingredients: 5513, 5922, 5972, 59899	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
Dyeing and package chemicals: 531–2, 55421, 5977	
Organic chemicals: 5124, 5137, 5139, 5145–6, 5148, 5156	
Information and Communications Technology (ICT)	
Communications equipment: 7641, 76425, 7643, 76481, 7649, 77882–4	
Computers and peripherals: 752, 75997	
Office machines: 7511–2, 7519, 75991–5	
Electrical and electronic components: 5985, 7722–3, 7731, 7763–8, 77882–4	
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	Miscellaneous: Prefabricated buildings (811–2), travel goods (83), and apparel and accessories (84)
Lubricants, mineral fuels, and related materials: 32–4	

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

Table A.4: Bilateral Trade in Low-IP and High-IP Sectors, Omitting Trade between Trade Partners both in an IPR-related PTA

	Exporter effects		Importer effects	
	Original Sample (1)	Additional Restriction (2)	Original Sample (3)	Additional Restriction (4)
log(GDP)	0.129***	0.077	0.533***	0.577***
	(0.036)	(0.047)	(0.032)	(0.039)
High-IP × log(GDP)	0.373***	0.372***	0.023	0.009
	(0.033)	(0.042)	(0.034)	(0.039)
LI × Low-IP × IPA	–0.131	–0.096	–0.264*	–0.203
	(0.107)	(0.128)	(0.154)	(0.213)
LMI × Low-IP × IPA	–0.265***	–0.463***	–0.003	0.112
	(0.097)	(0.139)	(0.066)	(0.097)
UMI × Low-IP × IPA	–0.748***	–0.656***	–0.062	0.028
	(0.143)	(0.166)	(0.099)	(0.122)
HI × Low-IP × IPA	–0.222**	–0.321***	0.029	–0.026
	(0.100)	(0.123)	(0.079)	(0.105)
LI × High-IP × IPA	–0.064	–0.536*	0.298**	–0.073
	(0.215)	(0.283)	(0.134)	(0.147)
LMI × High-IP× IPA	0.388***	0.392***	0.019	–0.114
	(0.111)	(0.140)	(0.078)	(0.081)
UMI × High-IP × IPA	0.471***	0.679***	0.258***	–0.273
	(0.155)	(0.199)	(0.082)	(0.219)
HI × High-IP × IPA	0.173***	0.319***	–0.031	0.019
	(0.067)	(0.089)	(0.068)	(0.098)
Observations	1,055,276	791,876	1,055,276	791,876
No. of country pairs	27,892	21,050	27,892	21,050
Country trends	✓	✓	✓	✓
Group-sector-year FEs	✓	✓	✓	✓
Pair FEs	✓	✓	✓	✓

Notes: The dependent variable is bilateral trade flows excluding trade with future/current IPR-related PTA partners, as well as countries that are (or will be) both party to an IP-related PTA with the US or both party to an IP-related PTA with Europe. Regressions include controls from TRIPS compliance. Columns (1) and (3), and columns (2) and (4), present exporter and importer coefficients from the same regressions, with columns (1) and (3) representing the results using the original sample restriction and columns (2) and (4) incorporating the further restriction on the sample. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.5: Bilateral Trade in Low-IP and High-IP Sectors, with and without TRIPS Controls

	Exporter effects		Importer effects	
	No TRIPS Controls (1)	With TRIPS Controls (2)	No TRIPS Controls (3)	With TRIPS Controls (4)
log(GDP)	0.108***	0.129***	0.512***	0.533***
	(0.036)	(0.036)	(0.033)	(0.032)
High-IP × log(GDP)	0.371***	0.373***	0.024	0.023
	(0.030)	(0.033)	(0.032)	(0.034)
LI × Low-IP × IPA	–0.130	−0.131	–0.365***	−0.264*
	(0.106)	(0.107)	(0.126)	(0.154)
LMI × Low-IP × IPA	–0.399***	−0.265***	0.089	−0.003
	(0.087)	(0.097)	(0.077)	(0.066)
UMI × Low-IP × IPA	–0.725***	−0.748***	0.008	−0.062
	(0.131)	(0.143)	(0.111)	(0.099)
HI × Low-IP × IPA	–0.228**	−0.222**	0.061	0.029
	(0.098)	(0.100)	(0.079)	(0.079)
LI × High-IP × IPA	0.006	−0.064	0.287**	0.298**
	(0.205)	(0.215)	(0.128)	(0.134)
LMI × High-IP× IPA	0.914***	0.388***	–0.059	0.019
	(0.128)	(0.111)	(0.095)	(0.078)
UMI × High-IP × IPA	0.582***	0.471***	0.233**	0.258***
	(0.170)	(0.155)	(0.091)	(0.082)
HI × High-IP × IPA	0.152**	0.173***	–0.070	−0.031
	(0.068)	(0.067)	(0.067)	(0.068)
LI × Low-IP × TRIPS		−0.298***		0.230**
		(0.077)		(0.107)
LMI × Low-IP × TRIPS		−0.561***		0.146**
		(0.084)		(0.058)
UMI × Low-IP × TRIPS		−0.488***		−0.173**
		(0.077)		(0.078)
HI × Low-IP × TRIPS		0.451***		0.068
		(0.102)		(0.096)
LI × High-IP × TRIPS		0.595***		0.354***
		(0.115)		(0.097)
LMI × High-IP × TRIPS		1.428***		−0.079
		(0.154)		(0.049)
UMI × High-IP × TRIPS		1.130***		0.137**
		(0.163)		(0.055)
HI × High-IP × TRIPS		0.150**		0.012
		(0.074)		(0.059)
Observations	1,055,276	1,055,276	1,055,276	1,055,276
No. of country pairs	27,892	27,892	27,892	27,892
Country trends	✓	✓	✓	✓
Group-sector-year FEs	✓	✓	✓	✓
Pair FEs	✓	✓	✓	✓

Notes: The dependent variable is bilateral trade flows excluding trade with future/current IPR-related PTA partners. Columns (1) and (3), and columns (2) and (4), present exporter and importer coefficients from the same regressions—one version without controls for TRIPS compliance, the other with such controls. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.6: High-IP and Low-IP Trade, Alternative Samples

	Exporter effects			Importer effects		
	(1) All trade	(2) No partner trade	(3) No US or Europe trade	(4) All trade	(5) No partner trade	(6) No US or Europe trade
log(GDP)	0.127***	0.129***	0.100**	0.552***	0.533***	0.527***
	(0.034)	(0.036)	(0.047)	(0.033)	(0.032)	(0.047)
High-IP × log(GDP)	0.302***	0.373***	0.392***	0.014	0.023	–0.090**
	(0.027)	(0.033)	(0.047)	(0.031)	(0.034)	(0.044)
Low-IP × LI × IPA	–0.169*	–0.131	–0.290*	0.277	–0.264*	0.019
	(0.090)	(0.107)	(0.151)	(0.305)	(0.154)	(0.209)
Low-IP × LMI × IPA	–0.453***	–0.265***	–0.002	0.037	–0.003	0.191*
	(0.084)	(0.097)	(0.145)	(0.057)	(0.066)	(0.106)
Low-IP × UMI × IPA	–0.973***	–0.748***	–0.440**	0.002	–0.062	–0.058
	(0.112)	(0.143)	(0.182)	(0.078)	(0.099)	(0.151)
Low-IP × HI × IPA	–0.242***	–0.222**	0.129	–0.005	0.029	–0.015
	(0.083)	(0.100)	(0.203)	(0.069)	(0.079)	(0.110)
High-IP × LI × IPA	–0.609***	–0.064	0.211	–0.031	0.298**	0.103
	(0.174)	(0.215)	(0.243)	(0.183)	(0.134)	(0.146)
High-IP × LMI × IPA	0.398***	0.388***	0.163	–0.012	0.019	0.009
	(0.094)	(0.111)	(0.162)	(0.043)	(0.078)	(0.088)
High-IP × UMI × IPA	0.387***	0.471***	0.336*	–0.040	0.258***	0.530***
	(0.146)	(0.155)	(0.183)	(0.113)	(0.082)	(0.143)
High-IP × HI × IPA	0.159***	0.173***	0.062	–0.004	–0.031	–0.012
	(0.057)	(0.067)	(0.184)	(0.053)	(0.068)	(0.128)
Low-IP × LI × TRIPS	–0.394***	–0.298***	–0.246***	0.188*	0.230**	–0.002
	(0.080)	(0.077)	(0.090)	(0.108)	(0.107)	(0.122)
Low-IP × LMI × TRIPS	–0.549***	–0.561***	–0.524***	0.132***	0.146**	0.087
	(0.072)	(0.084)	(0.100)	(0.051)	(0.058)	(0.077)
Low-IP × UMI × TRIPS	–0.482***	–0.488***	–0.414***	–0.060	–0.173**	–0.239***
	(0.061)	(0.077)	(0.088)	(0.069)	(0.078)	(0.089)
Low-IP × HI × TRIPS	0.468***	0.451***	0.567***	0.109	0.068	0.208*
	(0.102)	(0.102)	(0.125)	(0.088)	(0.096)	(0.111)
High-IP × LI × TRIPS	0.720***	0.595***	0.495***	0.380***	0.354***	0.604***
	(0.108)	(0.115)	(0.137)	(0.098)	(0.097)	(0.113)
High-IP × LMI × TRIPS	1.301***	1.428***	1.130***	–0.098**	–0.079	0.056
	(0.132)	(0.154)	(0.182)	(0.044)	(0.049)	(0.086)
High-IP × UMI × TRIPS	0.844***	1.130***	1.060***	0.041	0.137**	0.277***
	(0.164)	(0.163)	(0.203)	(0.044)	(0.055)	(0.081)
High-IP × HI × TRIPS	0.052	0.150**	0.129	–0.007	0.012	–0.067
	(0.085)	(0.074)	(0.108)	(0.057)	(0.059)	(0.114)
Observations	1,120,596	1,055,276	720,040	1,120,596	1,055,276	720,040
No. of country pairs	29,525	27,892	19,114	29,525	27,892	19,114
Country trends	✓	✓	✓	✓	✓	✓
Group-sector-year FEs	✓	✓	✓	✓	✓	✓
Pair FEs	✓	✓	✓	✓	✓	✓

Notes: Robust standard errors clustered by bilateral pair are reported in parentheses. Samples used: *All trade*, columns (1) and (4): full dataset, including PTA linkages; *No partner trade*, columns (2) and (5): excluding bilateral linkages with current or future IPR-related PTA partners (baseline results); *No US/EU/EFTA trade*, columns (3) and (6): excluding all bilateral linkages with US, EU, and EFTA countries regardless of partner status. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.7a: Bilateral Trade in Low-IP and High-IP Subsectors, Exports (All bilateral trade flows, including with current and future IPR-related PTA partner)

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Exporter effects								
log(GDP)	0.123***							
	(0.033)							
Sector × log(GDP)		0.549***	0.190***	0.313***	0.206***	0.479***	0.454***	0.321***
		(0.048)	(0.060)	(0.037)	(0.039)	(0.063)	(0.033)	(0.025)
Sector × LI × IPA	−0.108	−1.039**	−1.446**	−1.192**	−0.749***	−0.500	−1.649***	−0.540*
	(0.101)	(0.495)	(0.654)	(0.527)	(0.250)	(0.770)	(0.361)	(0.289)
Sector × LMI × IPA	−0.430***	0.879***	1.115***	0.023	−0.298	0.812***	0.995***	0.582***
	(0.085)	(0.194)	(0.256)	(0.157)	(0.191)	(0.230)	(0.129)	(0.083)
Sector × UMI × IPA	−0.939***	1.287***	1.043**	−0.353	0.117	1.425***	0.549**	0.511***
	(0.118)	(0.240)	(0.423)	(0.300)	(0.261)	(0.194)	(0.224)	(0.096)
Sector × HI × IPA	−0.235***	0.322***	0.896***	0.415***	−0.428***	0.132	0.481***	0.207***
	(0.083)	(0.121)	(0.175)	(0.088)	(0.109)	(0.159)	(0.098)	(0.052)
Sector × LI × TRIPS	−0.416***	0.463***	0.019	0.016	1.736***	−0.129	0.325**	0.337***
	(0.082)	(0.170)	(0.260)	(0.181)	(0.149)	(0.236)	(0.151)	(0.112)
Sector × LMI × TRIPS	−0.549***	0.830***	1.157***	0.715***	2.323***	1.906***	1.200***	1.030***
	(0.071)	(0.262)	(0.239)	(0.209)	(0.157)	(0.205)	(0.178)	(0.131)
Sector × UMI × TRIPS	−0.482***	0.694**	1.222***	1.154***	1.036***	0.736**	1.528***	0.679***
	(0.063)	(0.276)	(0.206)	(0.147)	(0.216)	(0.296)	(0.183)	(0.142)
Sector × HI × TRIPS	0.446***	0.118	0.577***	0.179	−0.381**	0.713***	0.342***	0.251***
	(0.103)	(0.187)	(0.204)	(0.131)	(0.176)	(0.246)	(0.120)	(0.060)
				⋮				

Table A.7b: Bilateral Trade in Low-IP and High-IP Subsectors, Imports (All bilateral trade flows, including with current and future IPR-related PTA partner)

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Importer effects								
log(GDP)	0.546***							
	(0.033)							
Sector × log(GDP)		0.108***	0.035	0.043	−0.052	0.118**	0.055*	0.029
		(0.038)	(0.046)	(0.030)	(0.051)	(0.048)	(0.033)	(0.026)
Sector × LI × IPA	0.371	−0.791**	1.984***	0.097	−0.891***	0.259	−0.527	0.299
	(0.302)	(0.360)	(0.437)	(0.311)	(0.204)	(0.418)	(0.341)	(0.201)
Sector × LMI × IPA	0.043	−0.194*	0.046	−0.236***	0.007	0.020	−0.215***	0.032
	(0.058)	(0.109)	(0.170)	(0.077)	(0.113)	(0.117)	(0.070)	(0.043)
Sector × UMI × IPA	−0.003	−0.471**	−0.131	−0.431***	0.208	−0.498**	−0.430**	−0.030
	(0.079)	(0.217)	(0.253)	(0.098)	(0.210)	(0.253)	(0.190)	(0.078)
Sector × HI × IPA	−0.004	−0.068	0.100	0.326***	−0.165	0.067	−0.039	0.046
	(0.068)	(0.114)	(0.160)	(0.099)	(0.120)	(0.166)	(0.093)	(0.051)
Sector × LI × TRIPS	0.162	0.191	−0.924***	0.290**	1.395***	−0.322*	0.228	0.086
	(0.108)	(0.157)	(0.263)	(0.133)	(0.179)	(0.196)	(0.149)	(0.086)
Sector × LMI × TRIPS	0.134***	−0.130	−0.442***	0.246***	0.381***	−0.509***	−0.344***	−0.139***
	(0.051)	(0.105)	(0.130)	(0.063)	(0.119)	(0.098)	(0.072)	(0.044)
Sector × UMI × TRIPS	−0.063	0.136*	−0.104	0.074	0.227**	0.079	−0.064	−0.020
	(0.068)	(0.079)	(0.142)	(0.097)	(0.115)	(0.153)	(0.081)	(0.037)
Sector × HI × TRIPS	0.088	−0.200	0.282**	−0.308***	0.077	0.299*	−0.350***	0.005
	(0.086)	(0.149)	(0.134)	(0.100)	(0.158)	(0.179)	(0.113)	(0.064)
Observations								4,481,584
No. of country pairs								29,520
Country trends								✓
Group-sector-year FEs								✓
Pair FEs								✓

Notes: The dependent variable is unidirectional bilateral trade flows, including bilateral linkages with current and future IPA partners. Each of the columns report coefficients from a single regression, delineated by sector. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.8a: Bilateral Trade in Low-IP and High-IP Subsectors, Exports (Excluding all US, EU, and EFTA trade)

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Exporter effects								
log(GDP)	0.115**							
	(0.046)							
Sector × log(GDP)		0.597***	0.133***	0.412***	0.315***	0.590***	0.679***	0.402***
		(0.071)	(0.040)	(0.062)	(0.057)	(0.070)	(0.062)	(0.044)
Sector × LI × IPA	−0.245	0.083	−1.438***	−0.285	−0.181	1.037	0.318	0.471*
	(0.156)	(0.488)	(0.395)	(0.485)	(0.530)	(0.776)	(0.394)	(0.281)
Sector × LMI × IPA	0.004	−0.838***	1.590***	−0.047	−0.104	1.274***	−0.379	0.170
	(0.146)	(0.313)	(0.260)	(0.196)	(0.346)	(0.345)	(0.239)	(0.162)
Sector × UMI × IPA	−0.416**	1.274***	1.339***	0.200	0.087	1.513***	0.136	0.411**
	(0.182)	(0.341)	(0.244)	(0.222)	(0.328)	(0.372)	(0.204)	(0.160)
Sector × HI × IPA	0.112	−0.116	0.761***	0.275	0.538**	−0.237	−0.178	−0.193
	(0.202)	(0.229)	(0.278)	(0.252)	(0.235)	(0.238)	(0.219)	(0.165)
Sector × LI × TRIPS	−0.260***	0.210	0.187	−0.094	1.600***	−0.531**	−0.419**	0.173
	(0.091)	(0.253)	(0.162)	(0.255)	(0.167)	(0.241)	(0.198)	(0.151)
Sector × LMI × TRIPS	−0.527***	0.292	0.972***	0.645**	2.663***	1.833***	0.930***	0.824***
	(0.099)	(0.277)	(0.191)	(0.259)	(0.244)	(0.307)	(0.230)	(0.171)
Sector × UMI × TRIPS	−0.412***	1.628***	0.921***	1.282***	1.873***	1.455***	1.476***	0.627***
	(0.089)	(0.246)	(0.159)	(0.215)	(0.267)	(0.277)	(0.195)	(0.173)
Sector × HI × TRIPS	0.552***	0.289	0.737***	−0.039	−0.339**	0.336	0.268*	0.222*
	(0.126)	(0.197)	(0.240)	(0.138)	(0.168)	(0.251)	(0.149)	(0.118)
				⋮				

Table A.8b: Bilateral Trade in Low-IP and High-IP Subsectors, Imports (Excluding all US, EU, and EFTA trade, cont.)

	(1) Low-IP	(2) AI	(3) BIO	(4) CHEM	(5) ICT	(6) MED	(7) PT	(8) Other
Importer effects								
log(GDP)	0.525***							
	(0.047)							
Sector × log(GDP)		0.001	−0.231***	0.008	−0.108	0.052	−0.035	−0.086**
		(0.047)	(0.046)	(0.041)	(0.066)	(0.052)	(0.039)	(0.039)
Sector × LI × IPA	0.098	−0.256	0.807**	0.658**	−0.927***	0.520*	0.218	0.397***
	(0.216)	(0.265)	(0.350)	(0.318)	(0.281)	(0.305)	(0.223)	(0.151)
Sector × LMI × IPA	0.190*	−0.589***	0.155	0.401*	−0.369	0.364**	−0.190*	0.109
	(0.105)	(0.196)	(0.233)	(0.214)	(0.234)	(0.175)	(0.108)	(0.081)
Sector × UMI × IPA	−0.096	0.223	0.196	−0.191	0.944***	−0.046	0.128	0.303***
	(0.160)	(0.200)	(0.271)	(0.222)	(0.237)	(0.164)	(0.129)	(0.111)
Sector × HI × IPA	−0.018	0.045	0.038	0.285	0.056	0.065	0.426***	−0.136
	(0.110)	(0.146)	(0.297)	(0.180)	(0.253)	(0.151)	(0.151)	(0.111)
Sector × LI × TRIPS	−0.024	0.231	−0.233	0.174	1.552***	−0.190	0.160	0.318***
	(0.121)	(0.167)	(0.255)	(0.185)	(0.191)	(0.190)	(0.144)	(0.098)
Sector × LMI × TRIPS	0.083	0.032	−0.037	0.535***	0.574***	−0.458**	−0.192*	−0.044
	(0.077)	(0.188)	(0.230)	(0.110)	(0.208)	(0.196)	(0.107)	(0.085)
Sector × UMI × TRIPS	−0.241***	0.405***	−0.138	0.414***	0.908***	0.105	0.142	0.000
	(0.089)	(0.137)	(0.221)	(0.151)	(0.153)	(0.133)	(0.098)	(0.076)
Sector × HI × TRIPS	0.207*	−0.199	0.177	−0.254	−0.150	0.250	−0.182	−0.025
	(0.111)	(0.244)	(0.345)	(0.219)	(0.200)	(0.178)	(0.216)	(0.121)
Observations								2,879,360
No. of country pairs								19,109
Country trends								✓
Group-sector-year FEs								✓
Pair FEs								✓

Notes: The dependent variable is unidirectional bilateral trade flows, excluding all bilateral linkages with the US, the EU, or EFTA, regardless of whether a country in a particular linkage forms a PTA with one of these partners. Each of the columns report coefficients from a single regression, delineated by sector. Robust standard errors clustered by bilateral pair are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.9: Intrafirm Effects of Joint Venture Partner Status, Unweighted OLS

	(1) TFP (OLS)	(2) TFP (OP)	(3) Patents	(4) New Prod.	(5) Sales	(6) Export Ratio
PT	0.110***	0.070***	0.026***	0.008***	0.274***	0.114***
	(0.013)	(0.013)	(0.005)	(0.002)	(0.022)	(0.008)
Employment	0.071***	–0.061***	0.036***	0.009***	0.857***	0.026***
	(0.010)	(0.019)	(0.006)	(0.002)	(0.026)	(0.004)
Age	–0.117***	–0.045**	–0.005**	–0.002***	–0.151***	–0.011***
	(0.011)	(0.019)	(0.002)	(0.001)	(0.012)	(0.002)
Foreign Share	0.480***	0.346***	–0.015	0.004	0.637***	0.169***
	(0.075)	(0.063)	(0.009)	(0.003)	(0.112)	(0.024)
Govt. Share	–0.818***	–0.896***	–0.014***	0.006***	–0.799***	–0.031***
	(0.046)	(0.037)	(0.004)	(0.002)	(0.039)	(0.007)
Subsidy	0.090***	0.047**	0.036***	0.015***	0.190***	0.010***
	(0.017)	(0.018)	(0.006)	(0.002)	(0.018)	(0.003)
Observations	970,913	970,861	851,995	899,072	1,015,192	899,072
Partner Firms	19,900	19,899	20,144	20,146	20,147	20,146
R^2	0.162	0.339	0.053	0.049	0.572	0.280
Industry FEs	✓	✓	✓	✓	✓	✓
Province FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Firm FEs	✗	✗	✗	✗	✗	✗

Notes: Estimation method is unweighted OLS. Dependent variables are given in each column header. Patents, Sales, Employment, and Age are expressed in natural logarithms. Robust standard errors clustered by 2-digit industry in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.10: 2-digit CIC Industry Distribution of Full Sample by Firm Type

		Full Sample		**Joint Ventures**		**Partner Firms**		**Other Firms**	
CIC	Industry description	Freq.	%	Freq.	%	Freq.	%	Freq.	%
6	Coal mining	41,161	2.08	21	0.08	338	0.2	40,802	2.29
7	Oil and gas extraction	1,120	0.06	0	0.00	80	0.05	1,040	0.06
8	Iron ore mining	12,760	0.64	0	0.00	92	0.05	12,668	0.71
9	All other metal ore mining	13,564	0.69	17	0.07	142	0.08	13,405	0.75
10	Nonmetallic mineral mining and quarrying	19,624	0.99	32	0.12	529	0.31	19,063	1.07
11	Other mining and quarrying	168	0.01	1	0.01	4	0.00	163	0.01
12	Logging and transport of timber	2,194	0.11	2	0.01	147	0.09	2,045	0.11
13	Food processing	116,160	5.87	737	2.85	7,587	4.46	107,836	6.05
14	Food manufacturing	44,706	2.26	604	2.34	4,502	2.64	39,600	2.22
15	Beverage manufacturing	32,238	1.63	515	1.99	2,529	1.49	29,194	1.64
16	Tobacco processing	2,395	0.12	39	0.15	225	0.13	2,131	0.12
17	Textiles	157,876	7.97	1,899	7.34	15,184	8.92	140,793	7.89
18	Apparel	80,900	4.09	1,440	5.57	15,072	8.85	64,388	3.61
19	Leather and fur products	39,784	2.01	457	1.77	6,622	3.89	32,705	1.83
20	Wood products and processing	37,435	1.89	422	1.63	2,776	1.63	34,237	1.92
21	Furniture	19,792	1.00	271	1.05	2,260	1.33	17,261	0.97
22	Paper and paper products	55,545	2.81	536	2.07	3,794	2.23	51,215	2.87
23	Printing and reproduction of recorded media	39,104	1.98	621	2.40	3,653	2.15	34,830	1.95
24	Cultural, educational, and sporting goods	20,537	1.04	447	1.73	3,817	2.24	16,273	0.91
25	Processing of petroleum, coking, and nuclear fuel production	13,818	0.70	78	0.30	806	0.47	12,934	0.73
26	Raw chemicals and chemical products	139,117	7.03	1,861	7.20	10,362	6.09	126,894	7.11
27	Pharmaceuticals	38,532	1.95	786	3.04	4,565	2.68	33,181	1.86
28	Chemical fiber	9,870	0.50	229	0.89	1,137	0.67	8,504	0.48
29	Rubber products	21,207	1.07	307	1.19	1,882	1.11	19,018	1.07
30	Plastic products	80,521	4.07	1,169	4.52	9,153	5.38	70,199	3.94
31	Non-metallic mineral products	164,012	8.28	1,308	5.06	9,615	5.65	153,089	8.58
32	Production and processing of ferrous metals	45,139	2.28	255	0.99	1,689	0.99	43,195	2.42
33	Production and processing of non-ferrous metals	36,270	1.83	395	1.53	2,091	1.23	33,784	1.89
34	Metal products	102,424	5.17	1,131	4.37	8,601	5.05	92,692	5.20
35	General purpose machinery	139,566	7.05	1,594	6.16	8,536	5.01	129,436	7.26
36	Special purpose machinery	77,047	3.89	947	3.66	5,270	3.10	70,830	3.97
37	Transportation equipment	83,558	4.22	1,759	6.80	6,224	3.66	75,575	4.24
39	Electrical machinery and equipment	105,627	5.34	1,979	7.65	10,008	5.88	93,640	5.25
40	Communication, computer, and electronic equipment	49,280	2.49	2,329	9.01	9,119	5.36	37,832	2.12
41	Measuring, analyzing, and controlling instruments	23,375	1.18	776	3.00	3,397	2.00	19,202	1.08
42	Miscellaneous manufacturing	37,776	1.91	415	1.60	5,294	3.11	32,067	1.80
43	Recycling and disposal of waste	1,855	0.09	4	0.02	55	0.03	1,796	0.10
44	Electric, gas and sanitary services	47,036	2.38	385	1.49	2,353	1.38	44,298	2.48
45	Gas production and distribution	3,719	0.19	50	0.19	331	0.19	3,338	0.19
46	Water supply	22,934	1.16	39	0.15	399	0.23	22,496	1.26
Total		1,979,746	100	25,857	100	170,240	100	1,783,649	100