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Abstract: International standards in the protection of intellectual property rights (IPRs) are increasingly guided by bilateral and regional preferential trade agreements (PTAs). In this paper, we estimate the effect of these IP-related PTAs on US offshoring behavior in developing countries. We utilize a difference-in-difference empirical methodology that addresses several possible sources of endogeneity and exploits industry variation in the importance of IPRs to identify the effect of these PTA-induced IPR reforms. We find that IP-related PTAs are associated with a substantial increase in US offshoring in IPR-intensive industries relative to non-IPR-intensive industries. This increase occurs both within the boundaries of the multinational firm and through arm's-length contracts with domestic firms. We do not find strong evidence for a compositional shift towards either type of offshoring. These findings provide direct empirical evidence that PTA-induced IPR reform stimulates multinational activity in developing countries.

Keywords: Intellectual property rights; Patents; Preferential trade agreements; Offshoring; Outsourcing; Subcontracting; Multinational firms

JEL Classification: F13; F23; O33; O34

*The views expressed in this paper are those of the authors only and do not necessarily represent those of CaixaBank.

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1 Introduction

The past three decades have witnessed a fundamental shift in the international regulation of intellectual property rights (IPRs) into the realm of multilateral trade system. Following a concerted lobbying effort by several developed countries, the Uruguay Round of GATT negotiations introduced the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement into the framework of the newly created WTO. Unprecedented in its scope, the TRIPS Agreement required all WTO member countries to adhere to a common set of minimum standards in the regulation and legal protection of patents, copyrights, and trademarks.[1]

Many developing countries fiercely opposed the institutional reforms mandated by TRIPS, arguing that imposing stronger IPRs would reduce access to technological innovations and increase the monopoly rents of IP holding multinational firms (MNFs) based in developed countries. Proponents of TRIPS countered that a more secure international IPRs regulatory environment would stimulate MNF investment and technology transfer overseas. While the overall economic impact of TRIPS remains contested, key elements of its central justification have enjoyed support from a large body of empirical literature. Numerous studies have concluded that TRIPS related IPR reforms in developing countries have generated increased trade flows (Delgado et al., 2013), technological licensing (Ivus et al., 2017), and MNF activity including investment, R&D, and offshoring (Branstetter et al., 2006, 2011; Canals and Şener, 2014; Naghavi et al., 2015; Klein, 2018).

Armed with this evidence, developed countries continued to push aggressively for international standards in IPRs beyond TRIPS requirements. With gridlock in WTO negotiations in the years following TRIPS, developed countries turned to bilateral and regional preferential trade agreements (PTAs) with developing countries to secure commitments to strengthen IPRs. Throughout the early 21st century, the US, EU, and European Free Trade Association (EFTA) each signed several PTAs with developing countries that included chapters related to IPRs specifying so-called "TRIPS-plus" standards. These routinely include requirements for strengthened patent protection, enhanced penalties for trademark infringement, and more comprehensive copyright protection for digital goods (Kohl et al., 2016; Campi and Dueñas, 2019). Moreover, these agreements remove much of the legal flexibility afforded to developing countries under TRIPS (Sell, 2010). As a consequence, IP-related PTAs are "increasingly guiding the design of IPRs systems and strengthening IP protection worldwide, despite being, in principle, a trade policy" (Campi and Dueñas, 2019).

Indeed, the relevance of IP-related PTAs has been highlighted during the long trade dispute between the US and China that began in 2018 and resulted in the imposition of tariffs on large imports flows during 2018 and 2019. In January 2020, the two sides signed a preliminary phase one trade deal. In addition to tariff reductions and China's commitment to substantially increase its purchases of US goods and services, the entire first chapter of the agreement is devoted to IPR protections. Specifically, the agreement requires that China strengthen its intellectual property

[1] The TRIPS Agreement was officially implemented by the WTO in 1995, and allowed a minimum 5-year transition period for member countries. For further a comprehensive overview of the timing and requirements of TRIPS, see Maskus (2000).

rights regime along several dimensions including: broadening the scope of business information under the protection of existing trade secret regulations, extending patent duration in cases of delays to patent issuance, and increasing enforcement of counterfeit products sold on e-commerce platforms.[2] As this trade dispute continues, IPR considerations are expected to remain critical.

Despite their importance to the international IPRs regulatory regime, the economic impact of the IPR reforms required by PTAs has received little empirical attention. Three notable exceptions are Maskus and Ridley (2016), Ridley (2018) and Campi and Dueñas (2019), which all examine the effect of these IPR reforms on bilateral trade flows. These analyses find that the IPR requirements included in PTAs are associated with a significant increase in the trade of IP-intensive products. However, it remains unclear if the same broad set of economic effects observed following TRIPS apply to the PTA-induced IPR reform in developing countries. As Campi and Dueñas (2019) argue, it is unlikely that the benefits to developing countries of increased trade alone offset the considerable costs associated with strengthening IPRs to meet TRIPS-plus standards. To the best of our knowledge, a key channel of benefits used to justify TRIPS-related reforms, namely expanded MNF activity, has not yet been analyzed in the context of IPR reform required by PTAs.

In this paper, we begin to fill this gap by examining the relationship between IP-related PTAs with developing countries and US MNF intra-industry offshoring intensity. First, we identify 25 developing countries that implemented an IP-related PTA at some point during the post-TRIPS period of 2002-2012 with the US, EU or EFTA using data from Kohl et al. (2016) and Maskus and Ridley (2016). Next, we construct three different measures of industry level US offshoring to each reforming country. We define total offshoring intensity as the value of intermediate goods that a US industry imports from the same industry of a foreign country to produce one dollar worth of output, following the methodology in Canals and Şener (2014). Then, we decompose total offshoring into related and non-related party offshoring based on whether the offshoring activity takes place within the boundaries of the firm or through arm's-length contracts with local firms. This decomposition allows us to separately estimate the effect of IP-related PTAs on both the total intensity and composition of US offshoring to reforming countries.

We employ an econometric methodology that addresses several common challenges to identifying the effect of IPR reforms in developing countries. First, since IPR reforms in developing countries are typically implemented as part of a broader set of concurrent policy changes, it is difficult to isolate the effect of IPRs from the confounding effects of other policies. We address this concern by exploiting industry level variation in the importance of IPRs to US MNFs based on the reported intellectual property usage of US firms in surveys conducted by the National Science Foundation. Specifically, we estimate the differential effect on offshoring in IPR intensive (High-IP) versus non-IPR-intensive (Low-IP) industries before and after an IP-related PTA takes effect using a difference-in-difference empirical framework. In addition, we follow Bilir (2014) and Maskus and Yang (2018) and estimate versions of all our regressions that include country-year pair fixed effects.

[2] Full text of the agreement can be accessed at `https://ustr.gov/sites/default/files/files/agreements/phase%20one%20agreement/Economic_And_Trade_Agreement_Between_The_United_States_And_China_Text.pdf`

In this way, we account for the impact of any concurrent policy changes that have a common effect across industries.

Second, there is the potential for endogeneity if developing countries select into an IP-related PTA because of factors related to their relationship with US offshoring. We address this concern in two ways. First, we consider an identification strategy in the spirit of Ridley (2018). In particular, we include estimates of all specifications using a restricted sample that excludes countries that sign an IP-related PTA with the US. Thus, the restricted sample consists of countries that sign PTAs with only the EU, EFTA, or both. In other words, these countries have signed a *non*-US PTA. We argue that a country's selection into a non-US PTA is unlikely to be driven by its existing or projected offshoring relationship with the US. Nonetheless, under the TRIPS agreement, the reforms implemented as part of a non-US PTA will still affect the IPR policy faced by US firms. Finally, we corroborate our main results using an event study framework following Branstetter et al. (2006), Canals and Şener (2014), and Ivus and Park (2019). We show that US offshoring to High-IP and Low-IP industries exhibit similar trends in the years leading up to a PTA, followed by a clear divergence in trends in the post-PTA period. This finding further alleviates concern that our results reflect pre-existing industry-level trends in offshoring that may be unrelated to PTA-induced reform.

Our main empirical findings show that IP-related PTAs do not exert any significant effect on US offshoring in a typical industry. However, we find a substantial differential effect in High-IP versus Low-IP industries. We estimate that IP-related PTAs are associated with a 43.5% increase in total offshoring in High-IP industries relative to a statistically insignificant 11.3% decrease in Low-IP industries. Similarly, our main findings show that IP-related PTAs are associated with a 36.0% increase in related party offshoring in High-IP industries (at a significance level close to marginal significance) relative to the insignificant 12.3% decline in Low-IP industries. We also find that non-related party offshoring increases by about 38.3% in High-IP industries relative to the insignificant 8.4% decline in Low-IP industries. Moreover, we continue to find significant evidence that IP-related PTAs are associated with substantial relative increases in all three types of offshoring in High-IP industries under a number of alternate specifications. These include estimates from regressions using different approaches to classifying industries as IP intensive, and from an event study framework that explores the timing of changes to offshoring.

Interestingly, we do not find strong evidence that IP-related PTAs impact the composition of US offshoring in High-IP industries. That is, both related party and non-related party offshoring increase following an IP-related PTA, but their share of the corresponding total offshoring remain similar. In some specifications, we find evidence for a compositional shift towards related party offshoring, but the magnitude of the effect is relatively small (related party offshoring accounts for an approximately 3% larger share after the PTA takes effect). On the other hand, the absence of a strong compositional effect is in line with a growing theoretical literature that has identified competing effects and yielded ambiguous theoretical predictions (Ivus et al., 2016; Biancini and Bombarda, 2021; Kukharskyy, 2020). Moreover, our findings help alleviate concerns that the expansion of international activity following reform is concentrated within the boundaries of MNFs, which may imply limited technological spillovers to the domestic economy.

Finally, we use the magnitude of our primary results to explore the implied effective size of the PTA-induced IPR reform in our sample of developing countries. To accomplish this, we compare our baseline regression results to estimates from regressions that consider changes to the commonly-used country-level IPR protection index of Ginarte and Park as an indicator of IPR reform (Park, 2008). We show that the estimated impact of IP-related PTA reform on offshoring in High-IP industries is equivalent to the impact of about a one-unit increase in the IPR index. Given that the IPR index ranges from 0 to 5 with a standard deviation of 0.68 in our sample, this suggests that the IPR requirements included in PTAs may indeed be equivalent to major IPR reform in terms of its effect on US offshoring behavior.

2 Background and Main Concepts

2.1 PTAs and IPR reform

In principle, the primary function of PTAs is to allow countries to negotiate reductions in tariffs and other trade barriers in goods and services without extending the same reductions to non-signatories of the PTA. Although this goal is in direct conflict with the WTO's foundational most-favored nation requirement, PTAs are permissible under WTO rules provided they satisfy two key requirements. First, a PTA must not raise the overall level of trade protection against other WTO members. Second, it must liberalize "substantially all trade" among PTA members.[3] This latter requirement has an important implication for the present paper as it suggests that any effect on intermediate goods trade specifically from the tariff effect of signing a PTA should be common to High-IP and Low-IP industries. Although most PTAs do exempt some product categories from liberalization in practice, these exemptions comprise only about 7% of tariff lines and affect a relatively small proportion of overall trade (WTO, 2011).

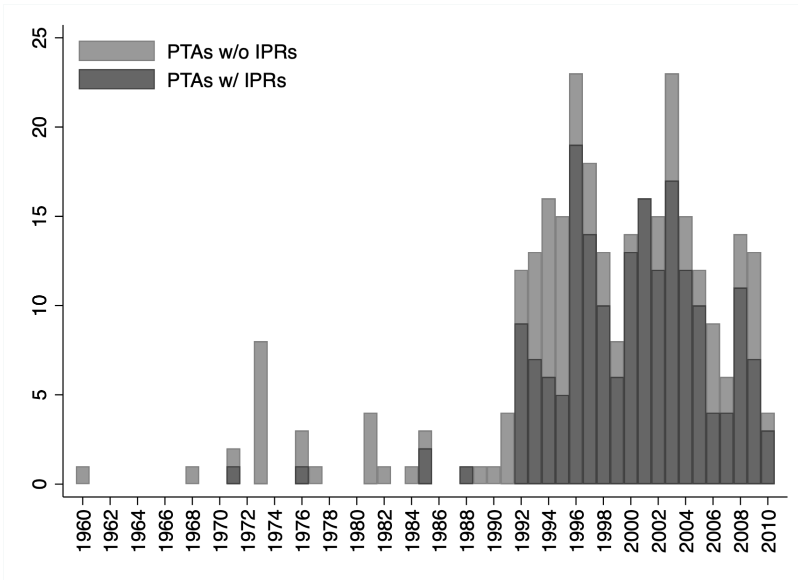
Of course, PTAs frequently go beyond trade liberalization and incorporate so called "deep" integration in the regulation of other areas including health and safety, labor, environmental standards, and IPRs. Critically, IPR protections implemented as part of a PTAs must also be extended to WTO member countries outside of the PTA under WTO rules. The TRIPS Agreement mandates that all IPR regulations be subject to most-favored nation and national treatment principles. In the context of the current study, this implies that the IP protection standards faced by US based MNFs are affected by PTA-induced IPR reform, even if the US is not directly party to the agreement.

To help illustrate the importance of PTAs to the global trade system, Figure 1 displays the number of PTAs signed worldwide from 1960-2010 using data from Kohl et al. (2016). Note both the sharp increase in the prevalence of PTAs beginning in the early 1990's, and the increase in the proportion of these PTAs that include specific IPR provisions following the implementation of TRIPS in 1995. However, Kohl et al. (2016) does not provide information on the relative strength

[3] See Article XXIV GATT for details regarding the WTO's official treatment of PTAs.

of IPR standards included in these agreements. To be sure, not all of these “IP-related” agreements contain comparable TRIPS-plus requirements. Approximately two-thirds of all PTAs are among developing countries (so called “South-South” agreements) (WTO, 2011). Even if these agreements include language related to IPRs, the associated requirements are often considerably less stringent than the regulatory standards favored by developed countries.

Figure 1: Signed PTAs (1960-2010)



Source: Authors’ construction using data from Kohl et al. (2016).

We address this issue by focusing our analysis on a subset of PTAs that are most likely to require substantial IPR reform. For this purpose, we restrict attention to IP-related agreements that include a developing country and either the US, EU, or EFTA as a signatory. These three trading blocks have consistently required core aspects of TRIPS-plus standards to be included in their agreements with developing countries (Maskus and Ridley, 2016). Examples of these requirements include test data confidentiality for pharmaceuticals and chemicals, patent protection for life forms, copyright protection for electronic content and digital goods, and extending the duration of patent and copyright protection. Moreover, these agreements eliminate much of the enforcement flexibility afforded to developing countries under TRIPS and often include requirements for criminal and civil penalties for infringement (Sell, 2010; Campi and Dueñas, 2019). Of course, even within this subset of PTAs, there is some variation in specific standards and the emphasis placed on different forms of IPRs. On the whole however, the IPR requirements included in this subset of PTAs are “clearly drivers of significant reform in developing countries” (Biadgleng and Maur, 2011).

Table 1 lists the IP-related PTAs included in the sample, their associated signatories, and the year each agreement enters into force. To construct our sample, we first considered all PTAs in the Kohl et al. (2016) dataset that incorporate specific IPR provisions and enter into force during our post-TRIPS estimation period of 2002-2012. Then, we identified all PTAs between a non-OECD country and either the US, EU, or EFTA.[4] Following Maskus and Ridley (2016) and Campi and Dueñas (2019), we add accession into the EU itself during the sample period as an IP-related PTA since the accession agreement includes strict IPR requirements. The resulting sample includes 25 countries that enter at least one IP-related PTA with either the US, EU, or EFTA during the post-TRIPS sample period of 2002-2012.

Table 1: IP-Related PTAs in Sample (2002-2012)

Agreement	Year
Jordan - EFTA, EU	2002
Singapore - EFTA, US	2003
EU Accession$^{(1)}$	Varies
Morocco - US	2004
Tunisia - EFTA	2005
CAFTA-US$^{(2)}$	2006
Egypt - EFTA	2007
CARIFORUM-EU$^{(3)}$	2008
SACU - EFTA$^{(4)}$	2008
Cote d'Ivoire - EU	2009
Peru - US	2009
Cameroon - EU	2009
Colombia - EFTA	2011

(1) Sample countries: Cyprus (2004), Lithuania (2004), Malta (2004), Bulgaria (2007)
(2) Sample countries: El Salvador, Guatemala, Honduras, Nicaragua, Dominican Republic (2007), Costa Rica (2009)
(3) Sample countries: Dominican Republic, Jamaica, Guyana, Trinidad and Tobago
(4) Sample countries: Botswana, South Africa, Swaziland

2.2 Measuring Industry Intellectual Property Intensity

A fundamental challenge to assessing the impact of IPRs in developing countries is that changes to IPR systems are typically implemented as a part of a broader set of reforms. For example, the IPR requirements of TRIPS were only one component of the sweeping changes to the regulatory framework governing international trade from the creation of the WTO. Consequently, it is difficult to isolate the effects of IPR reform specifically from the confounding effects of concurrent policy changes. As mentioned in the previous section, this issue is relevant in the present paper as PTAs signed with developing countries routinely include not only tariff changes but also standards in labor, health, and environmental regulation.

Following a line of literature including Branstetter et al. (2006, 2011), Delgado et al. (2013),

[4] We reiterate that this restriction helps to ensure that the PTAs included in our sample require substantial IPR reform. In addition, our approach follows a line of empirical literature examining the impact of IPR reform in developing countries specifically, including Ivus et al. (2017) and Ivus and Park (2019) among others. Our focus on non-OECD reforming countries aligns with Sell (2010), who details the clear distinction between IPR institutions among countries within and outside of the OECD in the context of TRIPS-plus standards.

Canals and Şener (2014), and Ivus and Park (2019), we identify the effect of IPR reform on US offshoring by exploiting industry level variation in the importance of intellectual property to firms within the industry. That is, we estimate the differential effect of implementing an IP-related PTA within industries that are relatively IP intensive against a control group of industries with relatively low IP intensity. As long as other regulatory changes do not vary systematically across these two groups, this differential effect can be attributed to IPR reforms.

As our primary measure of industry intellectual property intensity, we use information from the"Research and Development Funding Expenditures" survey conducted by the National Science Foundation.[5] In particular, we use one of the questions in the Intellectual Property and Technology Transfer (section 6) regarding the importance of six types of intellectual property protection.[6] When asked about the importance of protection, companies can choose between three answers: "very important," "somewhat important" and "not important." We compute the percentage of firms within each industry that consider patent protection either "somewhat important" or "very important," and classify the industries according to these percentage (see results in Table 2).

Table 2: Industry IP Intensity

Industry	Patents imp. %
Computer and electronic products*	36.83
Chemicals*	34.90
Electrical equipment*	31.75
Miscellaneous manufacturing*	21.58
Machinery*	21.53
Petroleum and coal products*	19.38
Transportation equipment*	18.55
Plastics and rubber products*	17.53
Publishing	11.30
Paper products	10.55
Textile products	10.43
Apparel and accessories	10.43
Primary metals	10.03
Fabricated metal products	8.68
Nonmetallic mineral products	8.55
Food and kindred products	6.73
Furniture and related products	5.05
Printing and related activities	3.65
Wood products	3.45

Percentages denote the share of surveyed firms that indicate patent protection is "somewhat important" or "very important," averaged for the years 2008, 2009, 2010, and 2011. The $\star$ denotes classification as High-IP intensity in the primary specification.

[5] See `https://nsf.gov/statistics/questionnaires.cfm#ResearchandDevelopmentFundingandExpenditures`, under "Business R&D and Innovation Survey."

[6] The six types of intellectual property protection are: utility patents, design patents, trademarks, copyrights, trade secrets, and mask works (that is copyright protection for semiconductor products).

Using these percentages, we sort industries into two groups: a High-IP intensity treatment group and a Low-IP intensity control group. In our primary specification, we include all industries with reported patent importance above the overall average of 15.3% in the High-IP group. As indicated in Table 2, this results in 8 of the 19 total industries classified as High-IP. Average patent importance among High-IP industries is 25.25%, while the average among Low-IP industries is 8.08%. In Section 4.1, we explore alternative classification approaches and demonstrate that our main empirical results continue to hold.

2.3 Offshoring Intensity

We compute a measure of foreign outsourcing for each industry, country, year triplet based on trade in intermediate goods following Feenstra and Hanson (1996, 1999) and Canals and Şener (2014). Specifically, we define offshoring intensity as the value of intermediate goods that a US industry imports from a particular country to produce one dollar worth of output. We focus on intra-industry or "core" offshoring, which corresponds to Feenstra and Hanson's definition of narrow offshoring. As widely recognized in the literature since the influential work of Feenstra and Hanson, restricting attention to imports of intermediate goods within the same industry better captures production activities that could have been performed in the US but are outsourced to a foreign country, mainly for cost savings motives[7] Finally, we decompose this total core offshoring measure into "related party" and "non-related party" components based on whether production occurred within or outside the boundaries of the firm.

Ultimately, for each year and industry-country pair, we have three main measures of offshoring:

1. **Offshoring intensity between related parties:** value of intermediate goods that a US industry imports from a particular country *within* the boundaries of the firm and within the same industry to produce one dollar worth of output.

$$O_{ict}^{R} = a_{iit} \cdot \frac{M_{ict}^{R}}{C_{it}} \tag{2.1}$$

2. **Offshoring intensity between non-related parties:** value of intermediate goods that a US industry imports from a particular country *outside* the boundaries of the firm and within the same industry to produce one dollar worth of output.

$$O_{ict}^{NR} = a_{iit} \cdot \frac{M_{ict}^{NR}}{C_{it}} \tag{2.2}$$

3. **Total offshoring intensity:** value of intermediate goods that a US industry imports from a particular country, either *within or outside* the boundaries of the firm, and within the same

[7]See Egger and Egger (2006), Geishecker and Görg (2008), and Hijzen and Swaim (2010) among others.

industry to produce one dollar worth of output.

$$O^T_{ict} = a_{iit} \cdot \frac{M^R_{ict} + M^{NR}_{ict}}{C_{it}} \tag{2.3}$$

where a_{iit} denotes the dollar value of inputs that industry i gets from this same industry to produce one dollar worth of i output at time t, and C_{it} denotes total consumption of industry i in the US economy at time t. We obtain these data from the US input-output (IO) tables provided by the US Bureau of Economic Analysis (BEA). M^R_{ict} and M^{NR}_{ict} denote the total volume of imports of industry i from country c at time t from related and non-related parties respectively. Data on bilateral related and non-related party imports are obtained from related party trade data collected by the US Census Bureau from US customs declarations.[8]

Following Canals and Şener (2014), we extend the import proportionality assumption proposed by Feenstra and Hanson (1996, 1999). In this particular case, we assume that industry i uses inputs of this same industry i from country c in the same proportion as the economy-wide use of that particular input (both within and outside the boundaries of the firm, respectively). This extension has recently been adopted by the OECD in their Trade in Value Added (TiVA) calculations.[9] For example, suppose the computer manufacturing industry uses \$0.15 worth of computer parts as an input to produce \$1 worth of output ($a_{iit} = 0.15$), and 20% of all computer parts consumed in the US comes from related party sources within Singapore ($M^R_{cit}/C_{it} = 0.2$), then we estimate that to produce \$1 worth of US computers, 3 cents worth of Singapore computer parts from a related party relationship are used ($0.15 \cdot 0.2 = 0.03$). Thus, offshoring intensity measures are reported in cents per dollar of output produced.

2.4 Offshoring and IP-related PTAs

As a first look at trends in offshoring, Figure 2 plots the average offshoring intensity of sample countries before and after an IP-related PTA took effect. All averages are reported in cents per dollar of output. Panel (a) illustrates that average total offshoring across all industries increased by 35.3% following an IP-related PTA. Panel (b) decomposes total offshoring into high and low IP intensity industry groups. Prior to a PTA, offshoring is clearly concentrated in Low-IP industries. Following a PTA however, we see a clear shift in the intensity of offshoring towards High-IP industries relative to Low-IP industries. Average offshoring in High-IP industries increases by 150% in the post-PTA period, while offshoring in low-IP industries decreases slightly by 3.3%.

Figure 3 further decomposes average offshoring into related and non-related party subgroups. We focus first on Low-IP industries. Panel (c) shows that the bulk ($\sim 75\%$) of offshoring in these industries is conducted outside the boundaries of the firm. From panel (a) and (b), we see that both types of offshoring decrease modestly following a PTA, and non-related party offshoring continues

[8]See Ruhl (2013) for details on the related party trade data by the US Census.

[9]For details, see OECD (2012) and `http://www.oecd.org/sti/ind/TiVA_Guide_to_Country_Notes.pdf`. See Appendix A.1 for our approach to industry aggregation in the construction of offshoring measures.

Figure 2: Total Offshoring

(a) All Industries (b) IP Intensity

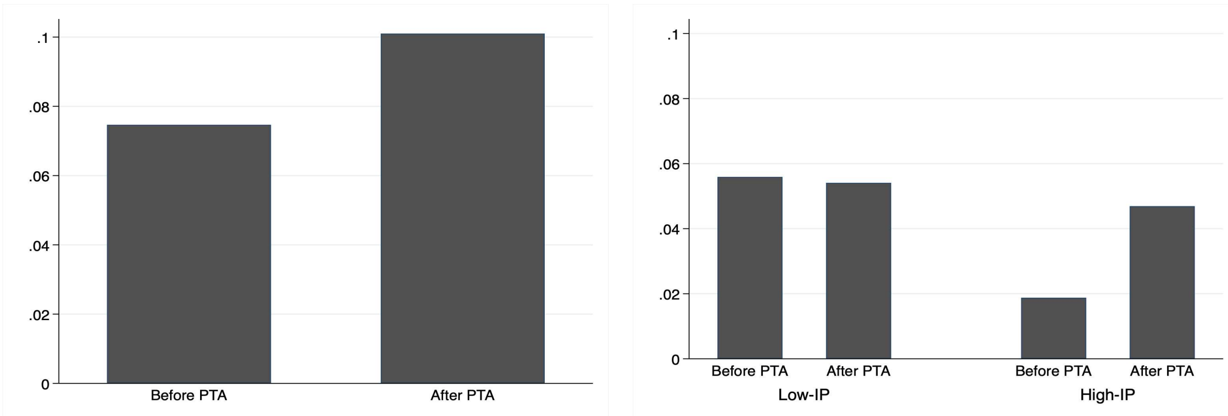


Figure 2 reports total offshoring combined among all industries included in the associated industry category and averaged across country-year observations in the before and after PTA periods. Averages are reported in cents per dollar of output.

to account for the majority of offshoring in Low-IP industries in the post PTA period. In High-IP industries however, panel (c) shows that non-related party offshoring accounts for just 40.3% of average total offshoring prior to a PTA. Furthermore, while both types of offshoring in in High-IP industries increase substantially following a PTA, the increase is clearly concentrated in related party offshoring. As displayed in panel (a) and (b), average related party offshoring increases 200%, while non-related party offshoring increases 75.5%. Consequently, the share of average total offshoring in High-IP industries conducted outside the boundaries of the firm decreases a full 12%, accounting for just 28.3% of the total in the post PTA period, as shown in panel (c).

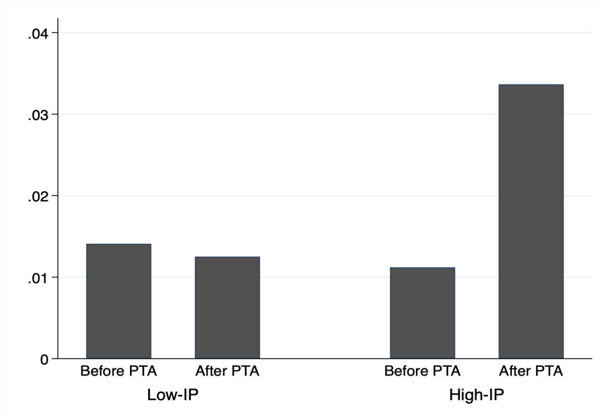
Finally, since our empirical strategy isolates the impact of the IPR reforms included in PTAs by estimating the differential effect of the PTA in Low-IP and High-IP industry groups, it is important to verify that these groups exhibit similar pre-event trends. We investigate this these pre-event trends more formally using an event study framework in Section 4.2. As a first look however, Figure 4 plots average total offshoring intensity among sample countries across years relative to each country's PTA reform together with linear trend lines in the pre and post-PTA periods. Given the substantial heterogeneity in the scale of offshoring among sample countries, each county's offshoring intensity in Low-IP and High-IP categories is normalized to one in the year its PTA enters into force. This normalization mirrors our actual estimation methodology that includes country, industry pair fixed effects and ensures that sample countries are weighted equally in the calculated average.[10]

In the years leading up to a PTA, the High-IP and Low-IP industry groups exhibit similar rates

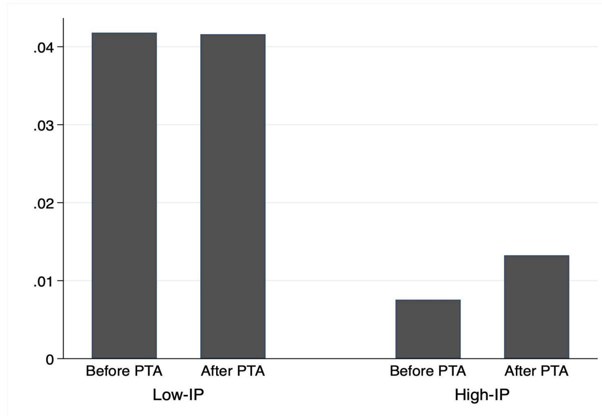
[10]This normalization does imply that Figure 4 illustrates relative trends only; it does not reflect differences in offshoring levels between Low-IP and High-IP industries. For reference, average offshoring in the year of PTA reform (year zero) is 43.6% higher in Low-IP industries.

Figure 3: Composition of Offshoring

(a) Related Party



(b) Non-related Party



(c) Composition: Share of Non-related Party

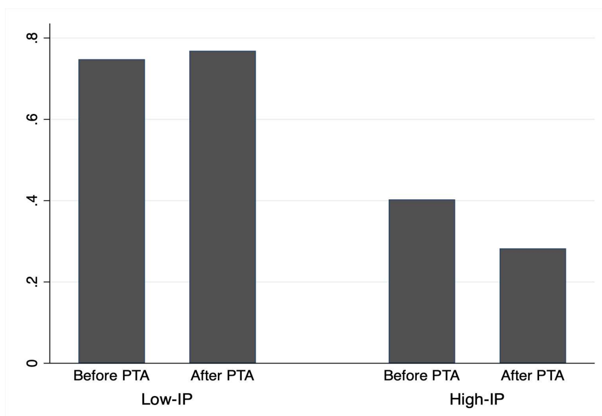


Figure 3 reports related party offshoring, non-related party offshoring, and the share of total offshoring conducted through non-related parties. As in Figure 2, offshoring is combined among all industries included in the associated industry category and averaged across country-year observations in the before and after PTA periods. Averages in panel (a) and (b) are reported in cents per dollar of output.

of increase in total offshoring intensity to their respective reform date average. As shown in panel (b), the ratio of average offshoring in High-IP industries to Low-IP industries is essentially flat in the pre-PTA period. However, in the years following an IP-related PTA, average total offshoring in High-IP industries continues to exhibit substantial growth while offshoring in Low-IP stagnates. This corresponds to a clear increase in the growth rate of offshoring in High-IP industries relative to their Low-IP counterparts in the post-PTA period. Note that our measure of offshoring intensity ensures that this relative growth in offshoring in High-IP industries is not driven by increased US consumption in these industries in the post-PTA period. This is because any change to the overall volume of offshoring in a particular industry due to corresponding changes in the volume of US consumption in that industry will not affect the associated value of offshoring per dollar of output that we capture.[11]

Figure 4: Trends in Total Offshoring

(a) Average Total Offshoring (b) Ratio of High-IP to Low-IP

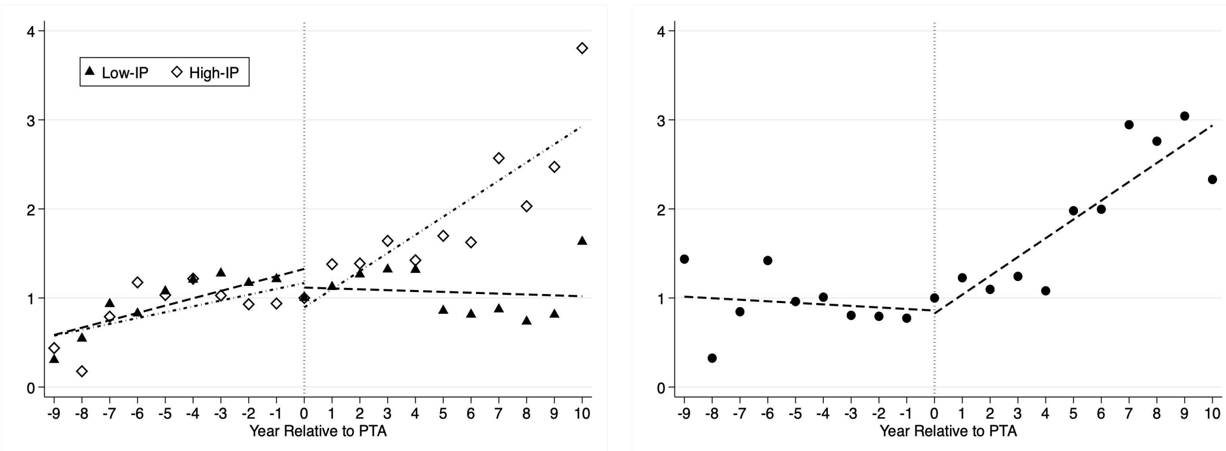


Figure 4 panel (a) plots normalized total offshoring intensity combined among all industries in Low-IP and High-IP categories and averaged across countries in each year relative to the year of PTA reform. Each country's total offshoring intensity in Low-IP and High-IP categories is normalized to its value in the year of PTA reform. Panel (b) plots the ratio of average normalized total offshoring in High-IP industries to Low-IP industries.

3 Estimation Methodology

To assess the impact of PTA-induced IPR reform on US offshoring, we utilize a difference-in-difference approach following Branstetter et al. (2006, 2011), Delgado et al. (2013), and Canals and Şener (2014). Our primary specification at the industry-country level is

$$O^k_{ict} = \alpha_{ic} + \alpha_t + \beta_c t + \beta_1 H_{ct} + \beta_2 \mathrm{PTA}_{ct} + \beta_3 \mathrm{PTA}_{ct} \cdot \text{High-IP}_i + \epsilon_{ict}, \tag{3.1}$$

where i indexes industry, c indexes country, and t indexes year (2002-2012). As discussed in the previous section, the dependent variable O^k_{ict} represents the value of US offshoring of category k in industry i from country c per dollar of output in year t. We separately examine three categories of US offshoring intensity: related party (R), non-related party (NR), and the combined total (T). The key variables of interest are the post reform dummy variable PTA_{ct} and the interaction term $\mathrm{PTA}_{ct} \cdot \text{High-IP}_i$ that estimates the differential effect of the reform in IP-intensive industries. PTA_{ct} takes a value of one beginning in the year that the country's first IP related PTA enters into force

[11] Since our sample includes the 2007-2009 recession, the lack of growth in offshoring intensity in Low-IP industries in the post-PTA period should be viewed in the context of the sustained decline in overall US trade relative to GDP following the recession. Although the years affected by the recession differ relative to reform year among sample countries, they will still be concentrated in the post-PTA period. We account for the impact of the recession in our empirical specification both by estimating the treatment effect of an IP-related PTA as the differential effect on offshoring in High-IP and Low-IP industry groups and by including year fixed effects.

and thereafter (see Table 1). High-IP$_i$ takes a value of one if the industry is classified as IP intensive (Table 2).

As controls, we include country-industry pair fixed effects, year fixed effects, country-specific time trends, and several time varying country characteristics H_{ct}. Following Canals and Şener (2014), H_{ct} includes GDP, GDP per capita, the real exchange rate with the US dollar, and a measure of trade openness defined as total international trade over GDP. In addition, we include the Fraser Institute's index of the strength of each country's legal system. As emphasized by Hu and Png (2013), this helps to control for potential differences in sample countries' ability to enforce legal rights, possibly including IPRs. Finally, as a check against the primary empirical results, we estimate a version of equation (3.1) that includes both country-industry and country-year pair fixed effects. That is, we estimate

$$O^k_{ict} = \alpha_{ic} + \alpha_{ct} + \beta_3 \text{PTA}_{ct} \cdot \text{High-IP}_i + \epsilon_{ict}. \tag{3.2}$$

As argued in Bilir (2014) and Maskus and Yang (2018), country-year pair fixed effects help alleviate endogeneity concerns associated with the effect of any omitted policy changes that are implemented concurrently with the IPR reforms required by a PTA. This is because including country-year fixed effects ensures that identification of the coefficient of interest, β_3, is driven by industry level variation in the effect of a PTA across Low and High-IP industries within each country-year observation.

Of course, the potential endogeneity of PTA related IPR reform remains an important concern. Specifically, it may be that developing countries select into an IP-related PTA because of factors related to their existing relationship with US offshoring in IP intensive industries. If this is indeed the case, the treatment of IPR reform is nonrandom with respect to the outcome of interest. However, as argued in Maskus and Ridley (2016), Maskus and Yang (2018) and Campi and Dueñas (2019), this concern is partially alleviated because the IPR requirements of a PTA are often considered a second-order negotiating concession from developing countries, rather than a primary motivating factor for signing an PTA. In other words, at least to a certain extent, PTA-induced IPR reform in developing countries can be reasonably viewed as an exogenous policy change.

However, since endogeneity can not be ruled out completely, we also include estimates from a sample that excludes all countries that sign PTAs with the US at any time during the sample period. All remaining countries sign PTAs only with either EU, the EFTA, or both. Within this restricted sample of only non-US PTAs, we argue that it is unlikely that a country's selection into a PTA is driven by its relationship with US offshoring.[12] Since IPR policy must be applied to all WTO members under TRIPS requirements, the reform still impacts the IPR policy faced by US firms. Moreover, since the US is not party to a PTA with any country included in the restricted sample, there is no direct tariff effect for US MNFs.

[12]This approach is similar to Ridley (2018), which examines the impact of IP-related PTAs on bilateral trade flows among countries that are not directly party to the agreement.

3.1 Data Set

We combine several data sources to construct our final data set that covers offshoring activities of 19 US industries (see Table 2) to 25 developing economies over the period 2002-2012 (see Table 1). Each of those countries has implemented at least one PTA with IPR requirements with the US, the EU or EFTA. As detailed in Section 2.3, we combine US IO tables from the BEA with US bilateral imports that distinguish between related and non-related party from the US Census Bureau to construct our measures offshoring intensity. Data on IP-related PTAs is from Kohl et al. (2016) and Maskus and Ridley (2016). The High-IP industry classification is based on the "Research and Development Funding Expenditures" survey conducted by the National Science Foundation. GDP, GDP per capita, and trade openness are obtained from the World Development Indicators (WDI 2009), while RER is constructed by using nominal exchange rates from Penn World Tables 6.3 and inflation rates from WDI (2009) for most countries. Finally, we utilize the Fraser Institute's index of the strength of legal systems and property rights.

Table 3: Summary Statistics

	All PTAs (25 countries)				Exclude US PTAs (15 countries)			
	Mean	St. Dev.	Min.	Max.	Mean	St. Dev.	Min.	Max.
Total offshoring (cents per US$)	0.091	0.129	4.38E-04	0.505	0.060	0.113	4.38E-04	0.418
Non-related party offshoring	0.053	0.074	3.98E-04	0.306	0.044	0.083	3.98E-04	0.306
Related party offshoring	0.038	0.079	4.04E-05	0.385	0.016	0.031	4.04E-05	0.112
GDP per capita (US$)	6795	8438	1023	37038	6960	6856	1023	24876
GDP (billons US$)	54.95	71.84	1.628	272.9	56.88	83.57	1.628	272.9
Trade openness $(X + M)/GDP$	106.7	71.39	36.23	391.9	101.7	46.00	36.22	198.3
Real exchange rate	147.1	409.8	0.392	1969	217.8	517.4	0.392	1969
Legal system index	5.049	1.344	2.538	8.394	5.078	1.367	2.538	7.368

Summary statistics are computed from country level averages across the 2002-2012 sample period. As in Section 2.3, offshoring intensities are combined across all industries to obtain overall offshoring within a sample country and reported in cents per US dollar of output. Legal system index refers to the Fraser Institute's index of the strength of legal systems and property rights. The index ranges from zero to ten.

Country level descriptive statistics are displayed in Table 3. Note that countries included in the estimation sample exhibit substantial heterogeneity across economic size, development, and openness to trade. For example, average GDP ranges from a minimum of 1.628 billion US dollars in Guyana to a maximum of 272.9 billion in South Africa. The sample includes a number of extremely poor countries such as Cameroon, Cote d'Ivoire, and Nicaragua, and substantially wealthier countries such as Cyprus and Singapore. The minimum average GDP per capita in the sample is $1,023 in Cameroon and the maximum is $37,038 in Singapore. Similarly, sample countries display large differences in openness to international trade. Average trade openness ranges from 36.23% of GDP in Colombia to a whopping 391.9% in Singapore.

Note that overall country averages in GDP, GDP per capita, and trade openness are quite similar among the two estimation samples. On the other hand, the restricted sample excluding US PTAs exhibits substantially smaller mean offshoring intensity. This difference is most pronounced in related party offshoring, where the restricted sample mean is just 42% of the overall sample average. This implies that sample countries that enter into an IP-related PTA with the United States tend to have a stronger offshoring relationship with the US compared to countries that sign PTAs with the EU or EFTA. While only suggestive, this is consistent with the possibility that countries may select into US PTAs because of their relationship with US offshoring, and underscores the importance of including estimation results using the restricted sample.

4 Results

We now present our empirical estimates of equations (3.1) and (3.2) for the time period 2002-2012 using both the sample including all IP-related PTAs and the restricted sample excluding PTAs signed with the US. We begin by separately examining the relationship between IP-related PTAs and each of the three categories of US offshoring: total, non-related party, and related party. In each case, we take the log of the associated offshoring dependent variable so that estimated reform coefficients carry a semi-elasticity interpretation. In all regressions, we report robust standard errors clustered at the country level to allow for correlation in the error term among industries and across time within the same country.

Table 4 reports our results with the log of total offshoring intensity as the dependent variable. First note that the estimates in column (1) imply that IP-related PTA reforms are associated with a statistically insignificant 4.1% increase in total offshoring ($e^{0.04} - 1$) when we do not distinguish between High and Low-IP industries. This suggests that the overall increase in US offshoring across all industries following a PTA is not statistically different from the value predicted by the other control variables, including country-specific time trends. On the other hand, the positive and statistically significant coefficient on the PTA, High-IP interaction term in column (2) implies that an IP-related PTA is associated with a substantial increase in offshoring within IP intensive industries, relative to the Low-IP control group. More specifically, the estimated coefficients imply that total offshoring in High-IP industries increases by 43.5% ($e^{0.361} - 1$) relative to the statistically insignificant 11.3% decrease ($e^{-0.120} - 1$) in Low-IP industries. To examine the absolute, rather than relative, effect of the reform in High-IP industries, we test the null hypothesis that the sum of estimated coefficients on the reform dummy and the reform, High-IP interaction term is equal to zero ($\beta_2 + \beta_3 = 0$ in equation (3.1)). As reported in column (2), we reject this null hypothesis at the 5% level, suggesting that PTAs are associated with a 27.5% ($e^{(0.361-.120)} - 1$) absolute increase in total offshoring in High-IP industries, in addition to its relative effect. Finally in column (3), we include country-year pair FE, which absorb all country level variation in the sample to ensure identification is driven by differences in the impact of PTAs at the industry level. The interaction term coefficient remains positive, statistically significant, and translates to a 45.2% ($e^{0.373} - 1$) differential increase High-IP industries, consistent with the results in column (2).[13]

[13]Henceforth, we omit the calculations that convert coefficient estimates to their implied semi-elasticity interpretation.

Table 4: Total Offshoring

	All PTAs			Exclude US PTAs		
	(1)	(2)	(3)	(4)	(5)	(6)
Log GDP per capita	-7.277	-7.331	–	-24.27***	-24.52***	–
	(4.773)	(4.810)		(7.558)	(7.587)	
Log GDP	7.731	7.786	–	24.88***	25.13***	–
	(4.822)	(4.859)		(7.632)	(7.661)	
Log Real Exchange	0.666	0.660	–	0.495	0.483	–
	(0.549)	(0.551)		(0.549)	(0.549)	
Log Trade Openness	0.151	0.152	–	0.133	0.142	–
	(0.292)	(0.293)		(0.330)	(0.331)	
Legal System Index	-0.034	-0.034	–	0.025	0.024	–
	(0.066)	(0.066)		(0.073)	(0.073)	
PTA dummy	0.040	-0.120	–	-0.029	-0.178	–
	(0.100)	(0.100)		(0.115)	(0.105)	
PTA x High-IP	–	0.361***	0.373***	–	0.333**	0.352***
		(0.074)	(0.072)		(0.104)	(0.101)
P-Values for H_0:						
PTA + PTAxHigh = 0	–	0.039	–	–	0.304	–
Country-ind. pair FE	Y	Y	Y	Y	Y	Y
Country-year pair FE	N	N	Y	N	N	Y
Country time trends	Y	Y	–	Y	Y	–
Year FE	Y	Y	–	Y	Y	–
Countries	25	25	25	15	15	15
Observations	4,465	4,465	4,465	2,499	2,499	2,499
R-squared	0.917	0.918	0.922	0.904	0.904	0.909

PTA dummy is equal to one in the year that an IP-related PTA enters into force and thereafter. See Table 1 for the timing of PTAs and Table 2 for the list of High-IP industries. Robust standard errors clustered at the country level in parentheses. P-values for PTA + PTAxHigh-IP = 0 are computed using the delta method. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

In columns (4)-(6), we repeat the same regressions using the restricted sample that excludes all sample countries that sign a PTA with the US during the sample period. First, note that the estimated coefficients on the interaction term in columns (5) and (6) imply a relative increase in total US offshoring in High-IP industries of 39.5% and 42.2% respectively. On the other hand, we cannot reject the null hypothesis of $\beta_2 + \beta_3 = 0$ in column (5), and thus do not find evidence of an absolute increase in US offshoring in High-IP industries in the restricted sample. These findings suggest the IPR reform induced by a PTA are associated with a similar relative increase in US offshoring in High-IP industries even when the US is not party to the agreement. However, other aspects of the PTAs that are specific to signatories, namely tariff reductions, may partially drive increases in the overall scale of US offshoring. Indeed, note from column (4) that the negative coefficient estimate on the PTA dummy implies a 2.9% decrease in total offshoring following a non-US PTA. Although this finding is not statistically significant, this estimated decrease compared to the corresponding estimate of a 4.1% increase when using the entire sample in column (1) is consistent with a positive absolute effect on US offshoring when all regulatory changes in the PTA apply to the US.

Table 5: Related Party Offshoring

	All PTAs			Exclude US PTAs		
	(1)	(2)	(3)	(4)	(5)	(6)
PTA dummy	0.018	-0.132	–	-0.002	-0.360	–
	(0.103)	(0.142)		(0.139)	(0.214)	
PTA x High-IP	–	0.308	0.309	–	0.680**	0.684***
		(0.193)	(0.184)		(0.245)	(0.227)
P-Values for H_0:						
PTA + PTAxHigh = 0	–	0.201	–	–	0.044	–
Country-ind. pair FE	Y	Y	Y	Y	Y	Y
Country-year pair FE	N	N	Y	N	N	Y
Country controls	Y	Y	–	Y	Y	–
Country time trends	Y	Y	–	Y	Y	–
Year FE	Y	Y	–	Y	Y	–
Countries	25	25	25	15	15	15
Observations	3,683	3,683	3,681	1,897	1,897	1,895
R-squared	0.862	0.862	0.869	0.847	0.849	0.857

PTA dummy is equal to one in the year that an IP-related PTA enters into force and thereafter. Country controls refer to log GDP per capita, log GDP, log real exchange rate, log trade openness, and legal system index. Robust standard errors clustered at the country level in parentheses. P-values for PTA + PTAxHigh-IP = 0 are computed using the delta method. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

Next, we repeat the same regression exercise with the log of related party offshoring as the dependent variable. We report results in Table 5 and omit estimates of control variable coefficients for brevity. Although, we do not find significant evidence that IP-related PTAs increase related party offshoring (either absolute or relative to Low-IP industries) when the entire sample is considered, we think that this result should be interpreted cautiously. The interaction term coefficient point estimates do indicate a substantial relative increase in High-IP related party offshoring and their associated p-values of 0.118 and 0.106 are close to marginal levels of statistical significance. In addition, we show in Section 4.1 that we do find significant evidence of a positive increase when we consider a narrower set of IP-intensive industries. Finally, when PTAs signed with the US are excluded, the coefficient estimates of column (5) translate to a 97.4% relative increase in related party offshoring. We find statistically significant evidence of a 37.7% absolute increase in related party offshoring in the restricted sample. The estimated relative increase is essentially unchanged when we include country-year pair fixed effects in column (6). When interpreting the magnitude of these results, keep in mind that countries included in the restricted sample tend to have low levels of related party offshoring in the pre-reform period. While these estimates suggest impressive increases in related party offshoring compared to this baseline, they imply a more modest absolute increase in offshoring in terms of cents per dollar of output.

Table 6: Non-Related Party Offshoring

	All PTAs			Exclude US PTAs		
	(1)	(2)	(3)	(4)	(5)	(6)
PTA dummy	0.056	-0.089	–	0.011	-0.114	–
	(0.105)	(0.108)		(0.098)	(0.108)	
PTA x High-IP	–	0.324***	0.330***	–	0.297**	0.303**
		(0.075)	(0.074)		(0.120)	(0.119)
P-Values for H_0:						
PTA + PTAxHigh = 0	–	0.042	–	–	0.164	–
Country-ind. pair FE	Y	Y	Y	Y	Y	Y
Country-year pair FE	N	N	Y	N	N	Y
Country controls	Y	Y	–	Y	Y	–
Country time trends	Y	Y	–	Y	Y	–
Year FE	Y	Y	–	Y	Y	–
Countries	25	25	25	15	15	15
Observations	4,429	4,429	4,429	2,471	2,471	2,471
R-squared	0.904	0.904	0.909	0.896	0.897	0.902

PTA dummy is equal to one in the year that an IP-related PTA enters into force and thereafter. Country controls refer to log GDP per capita, log GDP, log real exchange rate, log trade openness, and legal system index. Robust standard errors clustered at the country level in parentheses. P-values for PTA + PTAxHigh-IP = 0 are computed using the delta method. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

We report empirical results with the log of non-related party offshoring as the dependent variable in Table 6. The corresponding empirical estimates largely mirror our total offshoring findings. In both samples, the estimates in columns (1) and (4) suggest no significant increase in non-related party offshoring without distinguishing between High-IP and Low-IP industries. The estimates in columns (2), (3), (5), and (6) all suggest a substantial positive differential effect of reform in High-IP industries. When the whole sample is considered in column (2), we find that an IP-related PTA is associated with a 38.3% relative increase in non-related party offshoring. Using the restricted sample, estimates reported in column (5) suggest a comparable relative increase of 34.6%. In both cases, the corresponding estimates when we include country-year fixed effects in columns (3) and (6) imply very similar relative increases. Once again, we find evidence of an absolute increase in non-related party offshoring when we include US PTAs, but not in the restricted sample.

Finally, we repeat our regression estimation using the percentage of total offshoring that is conducted through non-related parties as the dependent variable, $\%NR = O_{ict}^{NR}/O_{ict}^{T}$ x 100. This allows us to examine if IP-related PTAs are associated with significant changes to the composition of US offshoring. As reported in Table 7, we do not find evidence for a compositional effect in either sample. Although the sign of the estimated interaction term coefficient suggests a relative movement towards related party offshoring in High-IP industries (about 2.7% and 4.0% of total offshoring using the entire and restricted sample respectively), this effect is not statistically significant in any of our regression specifications. The direction of our results do mirror our preliminary findings using unconditional sample averages in Section 2.3. As illustrated in Figure 3, the unconditional average share of offshoring in High-IP industries conducted through non-related parties using the entire sample decreased by 12% in the post reform period. Although not statistically significant, the corresponding point estimate in column (2) suggests a PTA can account for a 2.77% decrease (about 23% of the observed change in unconditional averages).

Table 7: Composition of Offshoring: Percentage Non-Related (%NR)

	All PTAs			Exclude US PTAs		
	(1)	(2)	(3)	(4)	(5)	(6)
PTA dummy	-1.090	0.137	–	-0.917	0.910	–
	(1.378)	(1.433)		(1.698)	(1.905)	
PTA x High-IP	–	-2.766	-2.693	–	-4.066	-3.966
		(2.158)	(2.137)		(2.535)	(2.506)
P-Values for H_0:						
PTA + PTAxHigh = 0	–	0.204	–	–	0.178	–
Country-ind. pair FE	Y	Y	Y	Y	Y	Y
Country-year pair FE	N	N	Y	N	N	Y
Country controls	Y	Y	–	Y	Y	–
Country time trends	Y	Y	–	Y	Y	–
Year FE	Y	Y	–	Y	Y	–
Countries	25	25	25	15	15	15
Observations	4,465	4,465	4,465	2,499	2,499	2,499
R-squared	0.631	0.631	0.646	0.556	0.557	0.571

PTA dummy is equal to one in the year that an IP-related PTA enters into force and thereafter. Country controls refer to log GDP per capita, log GDP, log real exchange rate, log trade openness, and legal system index. Robust standard errors clustered at the country level in parentheses. P-values for PTA + PTAxHigh-IP = 0 are computed using the delta method. *** p < 0.01, ** p < 0.05, * p<0.1

4.1 Alternate Specifications

In this section, we examine the robustness of our findings to alternate regression specifications. First, we examine the sensitivity of our primary results to an alternate classification of Low-IP and High-IP industries based on the standard classification used in existing literature, rather than NSF survey responses. As mentioned in Section 2.2, a substantial empirical literature has identified the impact of IPR reforms by estimating the differential effect in IP intensive industries relative to non-intensive industries. Although there is some variation in the approach to these classifications in the literature, there is also broad agreement that a certain set of industries qualify as IP intensive.[14] Following this precedent, we consider an alternate High-IP group of 5 industries: computer and electronic products, chemicals, electrical equipment, machinery, and transportation equipment. All other industries are included in the Low-IP group. Note that all of the industries comprising this alternate High-IP group are included in our primary High-IP classification. However, the alternate High-IP group is narrower; excluding petroleum and coal products, plastics and rubber products, and miscellaneous manufacturing.

Table 8: Alternate High-IP Intensity Classification

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	% NR	Total	Related	Non-Related	%NR
PTA	-0.055	-0.119	-0.019	-0.027	-0.113	-0.183	-0.076	0.133
	(0.094)	(0.130)	(0.104)	(1.538)	(0.095)	(0.189)	(0.087)	(1.733)
PTA x Alt. High-IP	0.335***	0.431***	0.262**	-3.751*	0.292*	0.528**	0.297*	-3.634*
	(0.096)	(0.152)	(0.113)	(1.943)	(0.150)	(0.233)	(0.152)	(2.063)
P-Values for H_0:								
PTA + PTAxHigh = 0	0.048	0.007	0.088	0.042	0.370	0.028	0.210	0.137
Observations	4,465	3,683	4,429	4,465	2,499	1,897	2,471	2,499
R-squared	0.917	0.862	0.904	0.631	0.904	0.848	0.897	0.556

Industries considered High-IP in the alternate classification are: computer and electronic products, chemicals, electrical equipment, machinery, and transportation equipment. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, year FE, and country time trends. Robust standard errors clustered at the country level in parentheses. *** p $<$ 0.01, ** p $<$ 0.05, * p$<$0.1

In Table 8, we report results for each of the three offshoring categories and the percentage of offshoring conducted through non-related parties for both estimation samples using the alternate High-IP classification. In all cases, these regressions include country-industry pair fixed effects, country-specific time trends, year fixed effects, and the same country level control variables as the previous section. Thus, they correspond directly to the estimates of equation (3.1) reported in columns (2) and (5) in the tables of the previous section. We omit the estimation results of the control variables for brevity.[15] We find strong evidence for relative and absolute increases in each type of offshoring when the entire sample is included. Unlike our primary results, this includes related party offshoring; the estimated coefficients in Table 8 imply a substantial 53.9% relative and 36.6% absolute increase in related party offshoring among these industries following a PTA. This supports the hypothesis that some US enterprises do increase offshoring within the boundaries of the firm following implementation of a PTA with the US, but that positive effect is confined to a narrower set of industries. When the restricted sample is considered, our empirical estimates echo our primary findings. We find evidence that all types of offshoring experience a relative increase

[14] Analyses using this empirical methodology include Javorcik (2004), Branstetter et al. (2011), Delgado et al. (2013), Hu and Png (2013), and Canals and Şener (2014). Common approaches to proxying industry IP intensity include measuring patents awarded or R&D expenditure relative to industry sales.

[15] We also examined specifications with country-year pair fixed effects and found results to be similar.

in the industries included in the alternate High-IP classification, and find some evidence for a compositional shift towards related party offshoring. However, we only find evidence that these industries experience an absolute increase in related party offshoring.

Next, we depart from the binary Low and High-IP industry categorization and examine how the effect of IP-related PTAs differs across industries based on the relative importance of IPRs to firms within the industry. As before, we rely on NSF survey results of the percentage of firms within each industry that report patents to be "somewhat important" or "very important" to proxy the importance of IPRs. We estimate an alternate version of equation (3.1) where the High-IP dummy variable measure is replaced by this continuous, industry specific proxy (Pat. imp. %).[16] Results are reported in Table 9.

Table 9: Continuous Patent Importance

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	% NR	Total	Related	Non-Related	%NR
PTA	-0.135	-0.164	-0.064	1.297	-0.208**	-0.369	-0.146	1.447
	(0.096)	(0.189)	(0.105)	(1.880)	(0.095)	(0.283)	(0.102)	(1.959)
PTA x Pat. imp. %	0.011***	0.011	0.008**	-0.153*	0.011*	0.021*	0.010*	-0.150*
	(0.004)	(0.008)	(0.003)	(0.082)	(0.005)	(0.011)	(0.005)	(0.074)
Abs. Effect Threshold	12.27%	14.91%	8.00%	8.48%	18.91%	17.57%	14.60%	9.65%
Observations	4,465	3,683	4,429	4,465	2,499	1,897	2,471	2,499
R-squared	0.917	0.862	0.904	0.631	0.904	0.848	0.897	0.556

Industry specific values of the percentage of firms that consider patents to be either somewhat or very important are reported in Table 2. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, year FE, and country time trends. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1

Focusing first on the results from the entire sample, the estimated interaction term coefficients imply that an IP-related PTA is associated with a significant relative increase in both total and non-related party offshoring in industries where patents are viewed as more important. The results suggest that a one standard deviation increase in patent importance (10.23% of industry firms) is associated with a relative increase of 11.9% ($e^{0.011*10.23} - 1$) and 8.5% ($e^{0.008*10.23} - 1$) in total and non-related party offshoring respectively. Once again, we do not find evidence for a relative increase in related party offshoring. Interestingly however, we do find marginally significant evidence that a greater proportion of offshoring is conducted through related parties after reform among industries where patents are more important.

Turning to the absolute effect of a PTA, the industry specific predicted marginal effect is $e^{(\hat{\beta}_2+\hat{\beta}_3 \cdot \text{Pat. imp.\%})} - 1$. Referencing the values reported in Table 2, the average patent importance among industries included in the original Low and High-IP industry groupings are 8.08% and 25.25% respectively. The results in column (1) indicate that an industry with a Pat. imp. % equal to that

[16] We explored specifications that allow for a non-linear relationship between offshoring and patent importance, but did not find significant results.

of the Low-IP group average experiences a 4.5% absolute decrease in total offshoring, while an industry with the High-IP group average experiences a 15.3% absolute increase in total offshoring. In accordance with our findings in Table 7, the results in column (4) imply that an industry with the High-IP group average experiences a 2.57% decrease in the share of offshoring conducted through non-related parties. For each set of regression estimates reported in Table 9, we calculate the implied patent importance threshold where $\hat{\beta}_2+\hat{\beta}_3\cdot\text{Pat. imp.}\% = 0$, so that all industries with greater patent importance than the threshold level are associated with an absolute increase in offshoring. The estimated threshold for total offshoring reported in column (1) implies that all industries included in the original High-IP classification (see Table 1) experience an absolute increase in offshoring, while Low-IP industries experience a decrease. The lower estimated threshold for non-related offshoring implies an absolute increase across a substantially broader range of industries. Once again, these findings suggest that substantial increases in related party offshoring may be present only among a narrower set of industries.

Before proceeding, note that similar to the main results, the estimates using the restricted sample excluding US PTAs suggest a positive relative effect for all three types of reform. Although statistical significance is weaker, we again find the largest relative effect for related party offshoring and we do find some evidence for a compositional shift in offshoring towards related parties. The estimated coefficient implies a one standard deviation increase in patent importance is associated with a 24% relative increase in related party offshoring and an additional 1.5% of total offshoring conducted through related parties. Across the board, we estimate a larger patent importance threshold needed to imply a positive absolute increase in each type of offshoring compared to the estimates with the entire sample. This implies a narrower set of industries that experience an absolute increase in offshoring, consistent with our finding of a weaker absolute effect on US offshoring from non-US PTAs from the primary specification.

Finally, we consider an empirical specification where we replace the PTA reform indicator variable with a country-specific index of the strength of patent protection. This allows us to check that our primary empirical results are effectively capturing the result of strengthened IPRs induced by PTAs, rather than other policy changes included in the agreement. We utilize the widely used Ginarte and Park (GP) index, which scores the strength of patent protection for each of our sample countries from zero to five.[17] Although the index covers a time period well beyond our 2002-2012 sample period, it is only updated every five years. For the purposes of this empirical exercise, we linearly interpolate between five-year updates to maintain our annual panel structure and lag the index five years to ensure that the index captures changes to patent strength from the implementation of a PTA.[18] All regressions use the primary High-IP classification as displayed in Table 2.

Empirical results using the GP index are reported in Table 10 and largely echo our primary results. Using the entire sample, we find strong evidence for both a relative and absolute increase

[17]The GP index is based on five individual components: patent coverage, duration of protection, enforcement mechanisms, restrictions on patent rights, and membership in international treaties. See Park (2008).

[18]We examined different lag structures and found results to be similar.

Table 10: Patent Index (GP)

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	%NR	Total	Related	Non-Related	%NR
Lagged GP	0.108	-0.085	0.151	2.221	0.038	-0.565	0.147	1.279
	(0.171)	(0.301)	(0.213)	(4.002)	(0.328)	(0.796)	(0.480)	(8.130)
Lagged GP x High-IP	0.288**	0.344	0.335**	-0.280	0.491**	1.064**	0.511*	-5.175
	(0.107)	(0.260)	(0.128)	(3.034)	(0.182)	(0.452)	(0.252)	(5.698)
P-Values for H_0:								
GP + GPxHigh = 0	0.023	0.258	0.024	0.606	0.167	0.309	0.159	0.543
Observations	4,465	3,683	4,429	4,465	2,499	1,897	2,471	2,499
R-squared	0.917	0.862	0.904	0.631	0.904	0.849	0.897	0.556

Lagged PI denotes a five year lag of the interpolated Ginarte and Park (1997) index of patent strength as discussed in the main text. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, year FE, and country time trends. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1

in total and non-related party offshoring. We do not find significance evidence of an increase in related party offshoring nor a compositional shift in offshoring. To get a sense of magnitudes, we compare the relative increases in offshoring implied by these coefficient estimates to the corresponding primary estimates using the PTA-induced reform indicator. This comparison suggests that the estimated relative increase in offshoring from a PTA is equivalent to an impact that would be generated by a 1.25 and 0.97 increase in the GP index for total and non-related party offshoring respectively. Given that the standard deviation in the GP index among countries in our sample is 0.68, this corresponds to a substantial IPR reform. To take one example, prior to the PTA between Peru and the United States in 2009, the GP index for Peru was 2.9 and for the US was 4.9. Our results suggest that the effect of an IP-related PTA is equivalent to an IPR reform that moves Peru substantially closer to US standards. Finally, note that we continue to find evidence for a relative increase in all three types of offshoring in the restricted sample, with the largest relative effect for related party offshoring. We do not find significant evidence of an absolute increase in offshoring in the restricted sample.

4.2 Timing of Changes to Offshoring

In this section, we examine the timing of changes to offshoring using an event study framework. We normalize the date that each PTA enters into force to zero and regress each of our three measures of offshoring on a set of dummies indicating the year relative to reform. We define the dummy variable Post7+ to equal 1 beginning seven years after the PTA takes effect and in all subsequent years. The variable Pre7- is defined analogously to equal one for all years at least seven years prior to reform. All other dummy variables equal one only in the indicated year relative to reform. For brevity, we only report results using the entire sample of PTAs in the main text. Our results using the restricted sample excluding US PTAs are similar, and can be found in Appendix A.2.

Table 11: Event Study Framework (All PTAs)

	Pre1 Reference Year			Pre2 Reference Year		
	Total	Related	Non-Related	Total	Related	Non-Related
Pre7-	0.475	-0.117	0.117	0.283	-0.153	-0.007
Pre6	0.315	-0.039	0.040	0.122	-0.075	-0.084
Pre5	0.231	0.103	0.081	0.039	0.067	-0.044
Pre4	0.241	0.041	0.068	0.049	0.004	-0.057
Pre3	0.221	0.033	0.084	0.029	-0.003	-0.040
Pre2	0.192**	0.037	0.124	–	–	–
Pre1	–	–	–	-0.192**	-0.037	-0.124
Post0	0.005	0.130	0.107	-0.187	0.093	-0.017
Post1	-0.011	0.198	0.102	-0.203	0.162	-0.022
Post2	-0.130	0.240	0.056	-0.322	0.203	-0.069
Post3	-0.088	0.124	0.149	-0.281	0.088	0.024
Post4	-0.143	0.165	0.170	-0.335	0.128	0.045
Post5	-0.053	0.195	0.368	-0.245	0.158	0.244
Post6	-0.224	0.224	0.257	-0.416	0.188	0.133
Post7+	-0.200	0.467	0.308	-0.392	0.430	0.183
Pre7- x High-IP	-0.284	-0.449	-0.314	0.021	-0.211	-0.085
Pre6 x High-IP	-0.274***	-0.571**	-0.191	0.031	-0.333	0.039
Pre5 x High-IP	-0.374**	-0.629***	-0.398**	-0.068	-0.391**	-0.168
Pre4 x High-IP	-0.310**	-0.483**	-0.305**	-0.005	-0.245	-0.076
Pre3 x High-IP	-0.287**	-0.353**	-0.216	0.018	-0.115	0.013
Pre2 x High-IP	-0.305***	-0.238	-0.230**	–	–	–
Pre1 x High-IP	–	–	–	0.305***	0.238	0.230**
Post0 x High-IP	0.001	-0.220	-0.017	0.306**	0.018	0.213*
Post1 x High-IP	0.005	-0.154	0.062	0.310**	0.085	0.290**
Post2 x High-IP	0.247**	-0.068	0.201	0.552***	0.171	0.431***
Post3 x High-IP	0.133	0.228	0.150	0.438***	0.466**	0.380**
Post4 x High-IP	0.218*	0.162	0.152	0.523***	0.400	0.381**
Post5 x High-IP	0.156	0.228	0.090	0.461***	0.466	0.318*
Post6 x High-IP	0.393***	0.225	0.362**	0.698***	0.464	0.592***
Post7+ x High-IP	0.439***	0.286	0.371***	0.744***	0.524	0.601***
Observations	4,465	3,683	4,429	4,465	3,683	4,429
R-squared	0.916	0.858	0.901	0.916	0.858	0.901

Pre7- equals one for 7 years prior to reform and all proceeding years. Post7+ equals one for 7 years after reform and all subsequent years. Pre1 and Pre1xHigh-IP are omitted to serve as the reference point in columns 1-3, Pre2 and Pre2xHigh-IP are omitted in columns 4-6. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, and year FE. Robust standard errors clustered at the country level are omitted. *** p < 0.01, ** p < 0.05, * p<0.1

The first three columns of Table 11 display estimates for event study regressions with a dependent variable of the log of total, related, and non-related party respectively using the year prior to reform (Pre1) as the omitted reference group. This aligns with our primary specification, where the year of reform is included in the post reform period. Similar to our main results, the estimated coefficients on the period dummies imply that we do not detect any significant effect of PTAs on any of the three types of offshoring in Low-IP industries.[19] To understand what our results imply for the effect on offshoring in High-IP industries, consider the estimated coefficients on our interaction terms in column one where the dependent variable is the log of total offshoring intensity. Note that the estimated coefficients in the pre-reform period are negative and statistically significant two to six years prior to reform. This implies significantly lower total offshoring in High-IP industries, relative to Low-IP industries, compared to the omitted reference point of one year prior to reform.

Importantly however, the point estimates in the pre-reform period exhibit no clear trend and remain in a tight range of $[-0.374, -0.274]$. In other words, our results are consistent with a stable pre-reform trend in relative total offshoring between Low-IP and High-IP industries, and a significant departure from that trend beginning one year prior to reform. This finding provides strong evidence that the increases in offshoring that we estimate in our main results are driven by PTA related reforms, rather than reflecting a continuation of a pre-existing trend in offshoring at the industry level. This is most easily seen visually in Panel (a) of Figure 5, which plots the interaction term estimated coefficients of column one together with 95% confidence intervals. Note the clear departure from pre-reform trend to the level of the omitted reference point of one year prior to reform, the increasing trend following reform, and the eventual statistically significant increase above the reference point beginning six years post reform. Thus, we find evidence for a significant, one-year anticipatory effect of IP-related PTAs on total offshoring in High-IP industries when the entire sample is considered. We view this as a reasonable finding given that PTAs typically involve lengthy negations before they are finalized and often allow for a grace period before regulatory standards, including IPRs, officially enter into force. Our findings also mirror the significant anticipatory effects of regional free trade agreements found in Magee (2008) and Mölders and Volz (2011).

To better incorporate the anticipatory effect of PTAs in our analysis, we also report estimates of our event study regressions in columns 4-6 of Table 11 using a reference point of two years prior to reform (Pre2), the last year consistent with the estimated pre-reform trend. The relative increase total offshoring in High-IP industries estimated in column 4 is illustrated in Figure 5, Panel (b). Note that the point estimates of the interaction term coefficients are simply translated up by the estimated anticipatory effect of the PTA. That is, the estimated coefficients of the Pre1xHigh-IP interaction term indicate a 35.7% and 25.9% relative increase in total and non-related party offshoring in High-IP industries one year prior to the PTA entering into force, compared to the omitted two years prior to reform (Pre2) reference. Our results imply the magnitude of these increases continues to grow over time. Two years after the PTA enters into force, our estimates suggest an overall (including anticipatory effect) relative increase of 73.7% and 53.9% total and non-related party offshoring. In the period at least seven years after reform, we estimate an overall relative increase of 110% and 82.4% respectively. On the other hand, we are unable to detect a significant absolute increase for any particular year or type of offshoring. Although point estimates

[19] In the Appendix, we also show that we observe no significant effect of reform when we estimate regressions that do not include interaction terms and thus do not distinguish between Low-IP and High-IP industries.

Figure 5: Event Study: Total Offshoring (All PTAs)

(a) Pre1 Reference Year

(b) Pre2 Reference Year

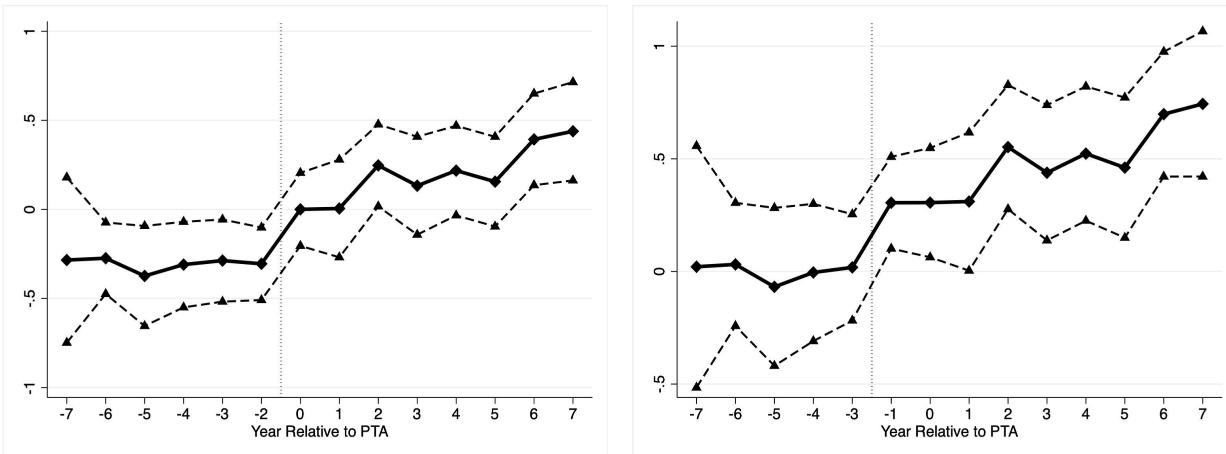


Figure 5 plots the estimated coefficients of the interaction terms on columns 1 and 4 of Table 11, where the dependent variable is log total offshoring. Dashed lines represent 95% confidence intervals.

for the sum of coefficients on Post-Year and Post-YearxHigh-IP are uniformly positive, the large standard errors associated with the Post-Year estimated coefficients prevent us from concluding that this sum is significantly different from zero. Consistent with our primary results, we do not find evidence for any significant effect of PTAs on related party offshoring when the entire sample is considered.[20]

5 Conclusion

The TRIPS agreement created an intense debate among scholars and policy makers on the costs and benefits of IPR reforms in developing countries. The debate continued in the post-TRIPS era with the implementation of TRIPS-plus provisions in the context of bilateral and multilateral PTAs. The expansion of negotiations from the multilateral WTO platform to the multilateral/bilateral PTA platform signifies the ongoing complexity and importance of IPRs protection policies for cross-border transactions.

In this paper, we contribute to this debate by conducting an empirical analysis that investigates the effects of IP-Related PTAs on US offshoring behavior. We focus on three measures of US offshoring at the intra-industry level: total offshoring intensity, related party and non-related party offshoring intensities. We find that IP-Related PTAs exert a positive and substantial impact on all three measures of offshoring in High-IP industries relative to Low-IP industries. In our sample of 25 IP-Related PTAs, our estimates imply that PTA-induced IPR reform in developing countries

[20] We also examined event study regressions using the percentage of offshoring conducted through non-related parties as the dependent variable. Again consistent with our main results, we did not find significant evidence for a compositional effect of PTA-induced reform.

is associated with a relative increase in total offshoring intensity between 39.8 and 45.2 percent, related party offshoring intensity between 36.1 and 53.9 percent, and non-related party offshoring between 30.0 and 39.1 percent. This differential impact of PTAs for High-IP industries is consistent with the hypothesis that industries that make heavy use of patents respond relatively strongly to PTA-induced IPR reform.

Our analysis makes several contributions to the existing literature. First, we study the impact of PTA-induced IPR reform on the offshoring activity of US multinational firms. By decomposing the intra-industry offshoring measures into related and non-related party components, we are able to examine how these reforms affect both the scale and composition of US offshoring. We thus differ from existing literature that exclusively focuses on the effects of IP-Related PTAs on trade flows [see: Maskus and Ridley (2016), Ridley (2018) and Campi and Dueñas (2019)]. Second, we address the challenges of identifying the offshoring effects of PTA-induced IPR reform by implementing a variety of recent econometric methods from the literature. In particular, we incorporate the identification strategy of Ridley (2018), event-study techniques similar to Branstetter et al. (2006) and Ivus and Park (2019), and country-year fixed effects regressions in the spirit of Bilir (2014) and Maskus and Yang (2018). Third, we use a novel indicator, the continuous patent-importance measure based on NSF surveys, in order to classify industries as High-IP and Low-IP. The use of this continuous measure also allows us to depart from the standard binary industry classification in alternate regressions. Finally, we compare the magnitude of our primary results to estimates obtained using the standard Ginarte and Park index of patent protection. This exercise suggests that PTA-induced IPR reform is equivalent to a major domestic IPR reform in terms of its impact on in US offshoring.

From a policy perspective, our paper sheds light on the question of whether increased IPRs protection in developing countries leads to more cross-border activity and whether that increased activity takes place within the boundaries of the MNF or extends to unrelated domestic parties. Our paper sides with the literature that finds that increased IPRs protection leads to the increased cross-border activity, in this case higher levels of offshoring intensity (Branstetter et al., 2006, 2011; Delgado et al., 2013; Canals and Şener, 2014; Naghavi et al., 2015; Klein, 2018; Ivus et al., 2017) However, similar to the bulk of this literature, we find that the increase in offshoring associated with PTA-induced IPR reform is confined to High-IP industries, and does not apply across the board. We find that both related party and non-related party offshoring intensities increase substantially in response to PTA-induced IPR reform. Moreover, both intensities increase roughly in the same proportion. Although we find some evidence for a modest shift towards related party offshoring following reform, we do not observe a major change in the share of either type of offshoring in total offshoring. Policy makers might be concerned that increased international transactions driven by PTAs may exclusively materialize within the boundaries of the MNF and not through arm's length subcontracting to domestic firms. Such an outcome could indeed imply limited technology spillovers to the domestic economy. Our results alleviate such concerns.

Our empirical work can be extended in several directions to provide a more comprehensive assessment of the effects of IP-related PTAs. First, our analysis considers a particular subset of IP-related PTAs that include a developing country and either the US, EU or EFTA as a signatory. We have argued that this somewhat narrow focus allows us to isolate the impact of meaningful PTA-induced reform on a key potential benefit from this reform in developing countries, namely US offshoring. Future work can examine how these results generalize to a broader sample of IP-related PTAs and investigate the responsiveness of offshoring from countries other than the US. Second, one can use firm-level data to study the impact of PTA-induced IPR reform on firm-specific measures such as licensing fees, royalty payments, R&D investment etc. (see Bilir (2014), Ivus and Park (2019), and Branstetter et al. (2006)). Third, one can analyze additional effects of these reforms on the domestic economy including their consequences for consumers, wages, employment, domestic innovation, and institutional implementation costs. In our view, understanding each of these potential effects is essential to a full analysis of whether developing countries ultimately benefit from IP-related PTAs

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Appendix A

A.1 Constructing the Offshoring Measure

To construct our measure of offshoring between related and non-related parties, we match two different datasets. First, we use IO tables from the Bureau of Economic Analysis from 2002 to 2012 (use of commodities by industries, after redefinitions) and related trade data collected by the US Census Bureau from the U. S. customs declarations for the same time period.

Manufacturing industries for IO tables are classified according to Table A1.1 (total of 20 industries), and for the US Census Bureau are classified according to Table A1.2 (total of 22 industries). We match both datasets and end up with a total of 19 industries. Details regarding the final matching are given in Table A1.3. As discussed in Section 2, we construct the following three distinct offshoring measures for each industry, country, year triplet (offshoring intensity between related parties, between non-related parties and total):

$$O_{ict}^{R} = a_{iit} \cdot \frac{M_{ict}^{R}}{C_{it}}$$

$$O_{ict}^{NR} = a_{iit} \cdot \frac{M_{ict}^{NR}}{C_{it}}$$

$$O_{ict}^{T} = a_{iit} \cdot \frac{M_{ict}^{NR} + M_{ict}^{NR}}{C_{it}}$$

We obtain the a_{iit} coefficient from IO tables that indicate the dollar value of inputs that industry i gets from this same industry to produce one dollar worth of i output at time t. For the transportation equipment industry (which combines two industries from IO data) we simply add up columns and rows to obtain the final a_{iit} coefficient. We also obtain the total consumption of industry i at time t in the U.S economy (C_{it}) from IO tables, again summing up the rows of the two industries that form the final equipment industry. We use the US Census Bureau data to obtain M_{ict}^{R}, which is the total imports of industry i from country c at time t that takes place within the boundaries of the firm, and M_{ict}^{NR}, which is the total imports that take place outside the boundaries of the firm. As we did with the IO data, for final industries that are composed of more than one industry in the original US Census data, we sum the imports to obtain imports in the final industry.

Table A1.1: BEA Input Output Tables 2002-2012

IO Code	Commodities/Industries
321	Wood products
327	Nonmetallic mineral products
331	Primary metals
332	Fabricated metal products
333	Machinery
334	Computer and electronic products
3361MV	Motor vehicles, bodies and trailers, and parts
3364OT	Other transportation equipment
337	Furniture and related products
339	Miscellaneous manufacturing
311FT	Food and beverage and tobacco products
313TT	Textile mills and textile product mills
315AL	Apparel and leather and allied products
322	Paper products
323	Printing and related support activities
324	Petroleum and coal products
325	Chemical products
326	Plastics and rubber products
511	Publishing industries, except internet (includes software)

Source: Bureau of Economic Analysis (BEA).

Table A1.2: US Census Bureau bilateral related and non-related party imports data

NAICS Code	Industries
311	Food and kindred products
312	Beverages and tobacco products
313	Textiles and fabrics
314	Textile mill products
315	Apparel and accessories
316	Leather and allied products
321	Wood products
322	Paper
323	Printed matter and related products, nesoi
324	Petroleum and coal products
325	Chemicals
326	Plastics and rubber products
327	Nonmetallic mineral products
331	Primary metal mfg
332	Fabricated metal products, nesoi
333	Machinery, except electrical
334	Computer and electronic products
335	Electrical equipment, appliances and components
336	Transportation equipment
337	Furniture and fixtures
339	Miscellaneous manufactured commodities
511	Newspapers, books, and other published matter, nesoi

Source: US Census Bureau.

Table A1.3: Final matched industries

New code	IO Code	NAICS Code	Name
1	311FT	311, 312	Food and kindred products
2	313TT	313, 314	Textile products
3	315AL	315, 316	Apparel and accessories
4	321	321	Wood products
5	322	322	Paper products
6	323	323	Printing and related activities
7	324	324	Petroleum and coal products
8	325	325	Chemicals
9	326	326	Plastics and rubber products
10	327	327	Nonmetallic mineral products
11	331	331	Primary metals
12	332	332	Fabricated metal products
13	333	333	Machinery
14	334	334	Computer and electronic products
15	335	335	Electrical equipment
16	3361MV, 336OT	336	Transportation equipment
17	337	337	Furniture and related products
18	339	339	Miscellaneous manufacturing
19	511	511	Publishing

A.2 Additional Event Study Regressions

In this subsection, we report the results of several event study regressions that were omitted from the main text. Table A2.1 displays results from event study regressions using the restricted sample of non-US PTAs using both one and two year prior to reform as the reference year. As before, we plot the coefficient estimates corresponding to the relative effect of the PTA on total offshoring in High-IP industries in Figure A2.1. Note that our estimates remain consistent with a stable pre-reform trend in total offshoring in the restricted sample. While we continue to find some evidence for an anticipatory effect of PTA reform on total and non-related party offshoring, the associated point estimates are only statistically significant at the 10% level and smaller than the corresponding estimates using the entire sample. We view this as an intuitive result given that US enterprises are likely better able to anticipate the implementation of a PTA that includes the US as a signatory. Including the anticipatory effect in panel (b), we begin to a detect an overall significant relative increase in High-IP industries of 77.7% two years after reform that grows to a peak of 185% six years after reform. Mirroring our primary results, we also find a significant relative increases in related party and non-related party offshoring beginning three and five years post reform respectively. Once again, we find the largest relative increase in related party offshoring in the restricted sample. As in our results using the entire sample of PTAs, we are unable to detect a significant absolute effect on any type of offshoring in the event study framework.

Figure A2.1: Event Study: Total Offshoring (Exclude US PTAs)

(a) Pre1 Reference Year

(b) Pre2 Reference Year

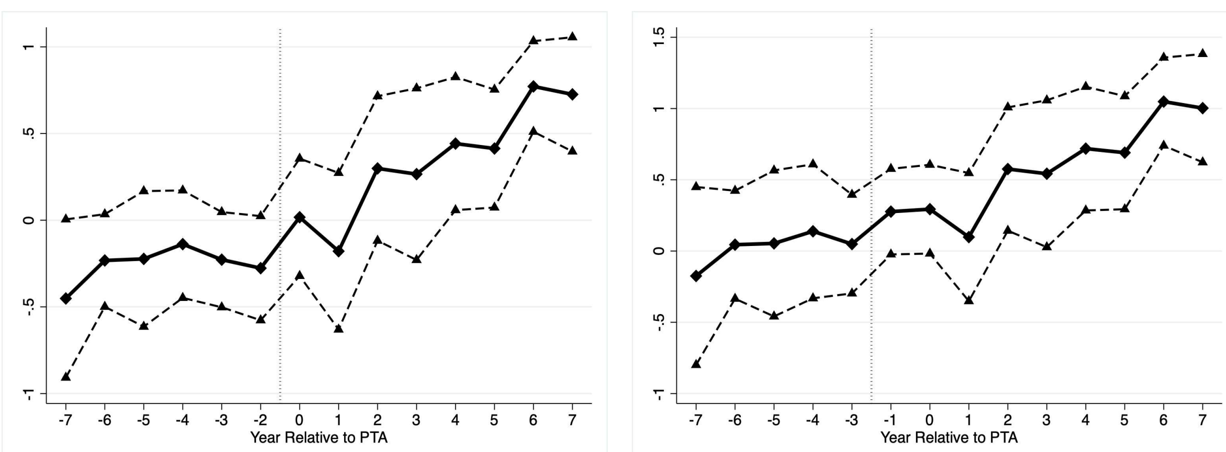

Figure A2.1 plots the estimated coefficients of the interaction terms on columns 1 and 4 of Table A2.1, where the dependent variable is log total offshoring. Dashed lines represent 95% confidence intervals.

Table A2.1: Event Study Framework (Exclude US PTAs)

	Pre1 Reference Year			Pre2 Reference Year		
	Total	Related	Non-Related	Total	Related	Non-Related
Pre7-	1.071	1.743	0.895	0.740	1.640	0.620
Pre6	0.605	1.079	0.530	0.274	0.976	0.255
Pre5	0.394	0.999	0.386	0.063	0.896	0.112
Pre4	0.426	0.915	0.324	0.095	0.811*	0.049
Pre3	0.338	0.482	0.221	0.008	0.379	-0.053
Pre1	–	–	–	-0.331**	-0.104	-0.274**
Pre2	0.331**	0.104	0.274**	–	–	–
Post0	-0.116	-0.219	-0.003	-0.447	-0.323	-0.277
Post1	-0.082	-0.525	-0.057	-0.413	-0.629	-0.332
Post2	-0.426	-0.714	-0.344	-0.757	-0.818	-0.619
Post3	-0.482	-1.089	-0.369	-0.813	-1.193	-0.643
Post4	-0.673	-1.027	-0.516	-1.003	-1.131	-0.791
Post5	-0.505	-1.193	-0.237	-0.836	-1.297	-0.512
Post6	-1.019	-1.879	-0.642	-1.350	-1.982	-0.917
Post7+	-0.830	-1.530	-0.511	-1.161	-1.633	-0.785
Pre7- x High-IP	-0.452*	-0.932***	-0.462**	-0.175	-0.912**	-0.236
Pre6 x High-IP	-0.232*	-0.503	-0.201	0.045	-0.483	0.025
Pre5 x High-IP	-0.223	-0.423*	-0.328	-0.054	-0.403*	-0.101
Pre4 x High-IP	-0.138	-0.337	-0.188	-0.139	-0.317	0.038
Pre3 x High-IP	-0.228*	-0.269	-0.162	0.049	-0.249	0.064
Pre2 x High-IP	-0.277*	-0.020	-0.227*	–	–	–
Pre1 x High-IP	–	–	–	0.277*	0.020	0.227*
Post0 x High-IP	0.017	-0.013	0.001	0.294*	0.007	0.228
Post1 x High-IP	-0.179	0.182	-0.109	0.098	0.202	0.117
Post2 x High-IP	0.299	0.344	0.169	0.575**	0.364	0.396
Post3 x High-IP	0.266	0.804**	0.175	0.543**	0.824**	0.401
Post4 x High-IP	0.442**	0.726*	0.378	0.719***	0.746*	0.604**
Post5 x High-IP	0.413**	1.262***	0.185	0.690***	1.282***	0.412
Post6 x High-IP	0.772***	1.536***	0.623***	1.049***	1.556***	0.849***
Post7+ x High-IP	0.726***	1.471*	0.629***	1.003***	1.491*	0.856***
Observations	2,499	1,897	2,471	2,499	1,897	2,471
R-squared	0.902	0.847	0.894	0.902	0.847	0.894

Pre7- equals one for 7 years prior to reform and all proceeding years. Post7+ equals one for 7 years after reform and all subsequent years. Pre1 and Pre1xHigh-IP are omitted to serve as the reference point in columns 1-3, Pre2 and Pre2xHigh-IP are omitted in columns 4-6. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, and year FE. Robust standard errors clustered at the country level are omitted. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

Tables A2.2 and A2.3 report results from event study regressions without including the period dummy, High-IP interaction term. As in our primary results, we do not detect a significant effect of PTA-induced IPR reform when we do not distinguish between High-IP and Low-IP industries.

Table A2.2: Event Study Framework - No interaction Terms (All PTAs)

	Pre1 Reference Year			Pre2 Reference Year		
	Total	Related	Non-Related	Total	Related	Non-Related
Pre7-	0.337	-0.304	-0.033	0.281	-0.232	-0.054
Pre6	0.189	-0.289	-0.048	0.134	-0.217	-0.070
Pre5	0.060	-0.168	-0.102	0.004	-0.096	-0.123
Pre4	0.101	-0.163	-0.070	0.045	-0.091	-0.091
Pre3	0.091	-0.123	-0.014	0.035	-0.051	-0.035
Pre2	0.056	-0.072	0.021	–	–	–
Pre1	–	–	–	-0.056	0.072	-0.021
Post0	0.007	0.023	0.102	-0.048	0.095	0.080
Post1	-0.006	0.121	0.130	-0.062	0.193	0.109
Post2	-0.016	0.201	0.148	-0.072	0.273	0.127
Post3	-0.024	0.230	0.219	-0.080	0.301	0.219
Post4	-0.042	0.229	0.240	-0.098	0.301	0.219
Post5	-0.023	0.285	0.413	-0.033	0.357	0.391
Post6	-0.047	0.314	0.418	-0.103	0.385	0.397
Post7+	0.002	0.589	0.478	-0.054	0.660	0.457
Observations	4,465	3,683	4,429	4,465	3,683	4,429
R-squared	0.915	0.857	0.901	0.915	0.857	0.901
Within R-squared	0.013	0.006	0.016	0.013	0.006	0.016

Pre7- equals one for 7 years prior to reform and all proceeding years. Post7+ equals one for 7 years after reform and all subsequent years. Columns (1)-(3) use one year prior to reform as the reference point, columns (4)-(6) use two years prior to reform. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, and year FE. Robust standard errors clustered at the country level are omitted. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

Table A2.3: Event Study Framework - No Interaction Terms (Exclude US PTAs)

	Pre1 Reference Year			Pre2 Reference Year		
	Total	Related	Non-Related	Total	Related	Non-Related
Pre7-	0.824	1.243	0.636	0.624	1.148	0.471
Pre6	0.474	0.801	0.406	0.274	0.705	0.242
Pre5	0.268	0.784	0.208	0.068	0.688	0.044
Pre4	0.342	0.753	0.214	0.142	0.657	0.050
Pre3	0.223	0.347	0.133	0.023	0.252	-0.031
Pre2	0.200*	0.096	0.164	–	–	–
Pre1	–	–	–	-0.200*	-0.096	-0.164
Post0	-0.105	-0.206	0.002	-0.305	-0.302	-0.162
Post1	-0.149	-0.396	-0.090	-0.348	-0.492	-0.255
Post2	-0.271	-0.491	-0.246	-0.471	-0.587	-0.410
Post3	-0.340	-0.600	-0.263	-0.539	-0.695	-0.428
Post4	-0.447	-0.579	-0.313	-0.647	-0.674	-0.477
Post5	-0.283	-0.456	-0.112	-0.483	-0.552	-0.277
Post6	-0.636	-0.982	-0.318	-0.836	-1.078	-0.483
Post7+	-0.453	-0.629	-0.167	-0.653	-0.724	-0.331
Observations	2,499	1,897	2,471	2,499	1,897	2,471
R-squared	0.901	0.842	0.892	0.901	0.842	0.892
Within R-squared	0.018	0.019	0.020	0.018	0.019	0.020

Pre7- equals one for 7 years prior to reform and all proceeding years. Post7+ equals one for 7 years after reform and all subsequent years. Columns (1)-(3) use one year prior to reform as the reference point, columns (4)-(6) use two years prior to reform. All regressions include control variables: log GDP per capita, log GDP, log real exchange rate, log trade openness, legal system index, country-industry pair FE, and year FE. Robust standard errors clustered at the country level are omitted. *** $p < 0.01$, ** $p < 0.05$, * $p<0.1$

A.3 Additional Robustness

In the main estimation sample, we dropped all observations for which some data was missing for any of the controls included in H_{ct} in (3.1). Even though (3.2) includes country-year controls, which absorb all variation at the country level, all estimates were based on the main estimation sample for consistency. In Table A3.1 and A3.2, we report estimates when we exclude the H_{ct} controls. The corresponding estimation sample includes all observations for which the associated offshoring dependent variable is present. This expanded estimation sample incorporates a maximum of about 300 additional observations. Table A3.1 displays estimates of regression specification (3.1) without including the H_{ct} controls. Table A3.2 displays estimates from this same expanded sample when country-year pair fixed effects are included. All estimates remain consistent with our primary results.

Table A3.1: Country Controls (H_{ct}) Excluded

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	%NR	Total	Related	Non-Related	%NR
PTA	-0.128	-0.103	-0.147	-1.056	-0.112	-0.217	-0.124	-1.304
	(0.089)	(0.133)	(0.102)	(1.479)	(0.126)	(0.229)	(0.143)	(2.290)
PTA x High-IP	0.323***	0.378*	0.296***	-2.082	0.275**	0.741***	0.255*	-2.706
	(0.087)	(0.187)	(0.085)	(2.012)	(0.124)	(0.232)	(0.130)	(2.352)
Observations	4,753	3,832	4,711	4,753	2,787	2,046	2,753	2,787
R-squared	0.912	0.856	0.900	0.615	0.894	0.836	0.888	0.529

All regressions include country-specific time trends, industry-country fixed effects and year fixed effects. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1

Table A3.2: Country Controls (H_{ct}) Excluded, Country-Year Fixed Effects Included

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	%NR	Total	Related	Non-Related	%NR
PTA x High-IP	0.331***	0.381**	0.300***	-1.972	0.287**	0.757***	0.258*	-2.545
	(0.086)	(0.184)	(0.086)	(2.006)	(0.124)	(0.225)	(0.131)	(2.354)
Observations	4,753	3,830	4,711	4,753	2,787	2,044	2,753	2,787
R-squared	0.916	0.865	0.905	0.634	0.900	0.847	0.895	0.552

All regressions include industry-country and country-year fixed effects. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1

Next, we examine regression results when we remove publishing from the industries included in the estimation sample. According to the NAICS definition, publishing incorporates all entities responsible for the production of copies of works in print or CD-ROM form, including software. In this way, it occupies a grey area between a traditional manufacturing industry and a traditional service industry. In the main sample, we include publishing in the estimation sample to err on the side of completeness. However, due to a high occurrence of observations with zero recorded offshoring intensity in publishing, publishing accounts for a relatively small proportion of observations in our main estimation sample. This implies that although including publishing increases our total number of observations, it also increases our incidence of missing observations. Here, we briefly demonstrate that our primary results are robust to removing publishing from the estimation sample.

Tables A3.3 and A3.4 display results from regressions using the expanded sample (country controls H_{ct} excluded) without publishing. We note that this sample exhibits our lowest incidence of missing observations. For example, when examining total offshoring intensity and all PTAs, the 4,702 observations in this sample constitutes 95% of the maximum possible 4,950 observations (18 industries x 25 countries x 11 years) if no missing data were present. Excluding US PTAs, the sample of 2,760 observations constitutes 93% of a maximum 2,970 observations (18 industries x 15 countries x 11 years).

Table A3.3: Country Controls (H_{ct}) Excluded, Publishing Removed

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	%NR	Total	Related	Non-Related	%NR
PTA	-0.128	-0.123	-0.134	-1.130	-0.118	-0.236	-0.114	-1.560
	(0.086)	(0.134)	(0.105)	(1.483)	(0.120)	(0.229)	(0.147)	(2.269)
PTA x High-IP	0.321***	0.390***	0.288***	-1.988	0.271*	0.752***	0.244*	-2.502
	(0.089)	(0.188)	(0.086)	(1.992)	(0.127)	(0.232)	(0.133)	(2.307)
Observations	4,702	3,816	4,663	4,702	2,760	2,044	2,727	2,760
R-squared	0.911	0.856	0.899	0.618	0.894	0.836	0.888	0.529

All regressions include country-specific time trends, industry-country fixed effects and year fixed effects. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1

Table A3.4: Country Controls (H_{ct}) Excluded, Publishing Removed, Country-Year Fixed Effects Included

	All PTAs				Exclude US PTAs			
	Total	Related	Non-Related	%NR	Total	Related	Non-Related	%NR
PTA x High-IP	0.328***	0.391**	0.292***	-1.912	0.282**	0.765***	0.248*	-2.385
	(0.088)	(0.186)	(0.087)	(1.996)	(0.127)	(0.226)	(0.133)	(2.320)
Observations	4,702	3,814	4,663	4,702	2,760	2,042	2,727	2,760
R-squared	0.915	0.865	0.904	0.636	0.899	0.847	0.894	0.552

All regressions include industry-country and country-year fixed effects. Robust standard errors clustered at the country level in parentheses. *** p < 0.01, ** p < 0.05, * p<0.1