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Do Deep Trade Agreements with Intellectual Property Provisions Actually Increase International Trade?

Ridwan Ah Sheikh
Email: ridwan@econdse.org
Department of Economics,
Delhi School of Economic
University of Delhi

Sunil Kanwar
Email: sunil_kanwar@econdse.org
Department of Economics,
Delhi School of Economic
University of Delhi

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Delhi School of Economics
Delhi- 110007

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Ridwan Ah Sheikh* and Sunil Kanwar†

Abstract

This paper examines the impact of preferential trade agreements (PTAs) and deep trade agreements (DTAs) containing intellectual property rights (IPRs) provisions on export flows, for a panel of 87 countries spanning 1990-2017. We estimate a structural gravity model using the Poisson Pseudo-Maximum Likelihood (PPML) framework that simultaneously accounts for heteroskedasticity and a preponderance of zeros in trade flows, and include a rich set of fixed effects to account for multilateral resistance factors and endogeneity in binary trade agreement indicators. We introduce treatment leads and lags to account for anticipatory and phased-in effects of our key trade policy instruments. Our estimation results reveal, first, that there are no significant contemporaneous effects of PTAs or DTAs with IPRs-provisions on export flows. Any discernible effects manifest over time, as businesses gradually adapt to changes in tariff and non-tariff barriers. Second, the heterogeneous impact of deep versus shallow agreements does not appear to matter in our sample. Third, the depth of PTAs though positive significant, is economically small in magnitude. However, the depth of IPRs-related provisions and alternative policy areas within IPRs reveals a significantly negative impact on export flows. This indicates that the inclusion of additional provisions actually diminishes trade volumes, one conceivable explanation for which might be that the increased complexity of IPRs-related provisions in the DTAs renders compliance with the agreements more challenging. Fourth, our results indicate a lagged response of both PTAs and IPRs on high-IP and low-IP export flows. The patent-related, copyright-related and trademark-related provisions have a lagged impact on trade flows in the patent-intensive, copyright-intensive and trademark-intensive industries, respectively. Our findings suggest that IPRs promote trade contemporaneously in specific industrial clusters, demonstrating increased sensitivity to intellectual property. Our results are robust to various checks.

JEL Classification: F100, F130, F140, O340

Key words: Preferential trade agreements, Deep trade agreements, Intellectual property rights, International trade

*Corresponding author: Department of Economics, Delhi School of Economics, University of Delhi-110007. E-mail address: ridwan@econdse.org

†Department of Economics, Delhi School of Economics, University of Delhi-110007. E-mail address: sunil_kanwar@econdse.org

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1 Introduction

The content and design of preferential trade agreements (PTAs) has considerably expanded in recent decades. While traditionally these focused on tariff reduction or services liberalization, more recent PTAs address critical policy areas such as investments provisions, intellectual property protection, and environment laws, amongst others. Evidently, these recent agreements go beyond trade, and aim to achieve deep(er) integration, earning the moniker of 'deep trade agreements' (DTAs).

Recent decades have witnessed a proliferation of preferential trade agreements that include a variety of provisions related to intellectual property rights (IPRs). In the period since the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement, enacted under the aegis of the World Trade Organization (WTO) in 1994, (some) technologically advanced countries have pushed for 'TRIPS-plus' provisions via preferential trade agreements with developing countries. While only about 25% of the preferential trade agreements included IP-related provisions between 1990-1995, this rose to almost 62% during 2011-2015 (Wu 2020). Multiple reasons underlie this phenomenon, such as the apparent dis-satisfaction of the developed countries with the TRIPs agreement, increasing participation of developing countries in global value chains, and the increasing advent of digital technologies which are difficult to protect given national exhaustion of intellectual property rights.

Rather few studies have investigated the trade impact of deep trade agreements. Maskus and Ridley (2016) found that preferential trade agreements with IP-related provisions where one partner is the United States or the European Union or the European Free Trade Association, have significant impact on members' aggregate trade. On the contrary, Campi and Dueñas (2019) find that the trade impact of preferential trade agreements without IP-related provisions is in fact stronger than those with IP provisions. Their results, however, may be biased on account of the absence of controls for multilateral resistance.

A large literature obtains, however, on the trade impact of agreements that do not incorporate the impact of IP-related provisions per se. Baier et al. (2014) and Baier et al. (2018) find that economic integration agreements significantly increase trade flows, both in volume and products. Baier et al. (2019) find that countries with prior trade agreements tend to have a weaker partial impact on trade flows from subsequent agreements, and the same holds for countries that are geographically distant, as they find it difficult to comply with deeper provisions. On the other hand, Dhingra et al. (2018) examine the relative importance of individual provisions of these agreements, and find that provisions related to services, investment and competition have a positive significant impact on the exports of both goods and services, with the latter being larger. Lefebvre et al. (2023) analyze the effects of provisions related to regulating state-owned enterprises in regional trade agreements, and find that agreements between countries that trade with China lead to greater participation of Chinese state-owned enterprises as well as exports to these markets, relative to the performance of Chinese private firms. Breinlich et al. (2022) find that provisions related to technical barriers to trade, antidumping, trade facilitation, subsidies, and competition policy have significant positive impact on trade flows. Larch and Yotov (2022) did not find any significant impact of PTAs on trade. The impact of deep trade agreements (DTAs) in their sample, however, led to a significant increase of some 16% in bilateral trade, and more than 34% in foreign direct investment. Martínez-Zarzoso and Chelala (2021) find that regional trade agreements (RTAs) that contain technology provisions generate a signifcantly higher volume of trade than RTAs that do not.

To perform the empirical analysis, we construct a panel dataset spanning 87 countries for the period 1990-2017. Our dataset incorporates information on export flows, trade agreements and joint membership of the WTO, GATT and EU. An important aspect of our dataset is that we leverage the extensive content information from the World Bank's database on deep trade agreements as detailed in Wu (2020) and Mattoo et al. (2020). This dataset allows us to differentiate between various indicators and continuous variables related to PTAs, by including a standard dummy variable for PTAs, an indicator for DTAs, an indicator for DTAs that include intellectual property related provisions, and two continuous variables for the overall depth of DTAs and for depth of DTAs with IPR-related provisions.

Our study contributes to the existing literature in several ways. First, in estimating the overall impact of deep trade agreements, we focus on the relative importance of intellectual property-related provisions, which is an improvement over Maskus and Ridley (2016) and Campi and Dueñas (2019). Second, we analyze the potential impact of deep trade agreements with intellectual property provisions, both at the *extensive margin* (i.e., number of IP-related provisions) as well as the *intensive margin* (i.e., specific provisions such as those related to copyrights, patents, enforcement, etc.). Third, we attempt to estimate both 'anticipatory' and 'phased-in' effects of deep trade agreements, by using a specification that allows for appropriate leads and lagged terms. Fourth, our study provides the first comprehensive analysis of PTAs and deep trade agreements with IPR-related provisions both at the aggregate and detailed sectoral levels. The impact is further broken down by examining the effect of specific provisions within IPRs on trade in industries exhibiting varying degrees of IPR-intensity, an aspect that has been inadequately explored in previous studies.

Further, our study improves upon earlier analyses in a number of estimation aspects. Thus, we capitalize on recent developments in trade modelling to simultaneously account for heteroskedasticity and the information contained in zero trade flows (Head and Mayer 2014, Yotov et al. 2016, Silva and Tenreyro 2006). We employ a rich set of exporter-time and importer-time fixed effects to control for time-varying multilateral resistance factors (Anderson and Van Wincoop 2003), and country-pair fixed effects that address the endogeneity concerns with respect to our key policy variables, namely the indicators for preferential trade agreements and IP-provisions (Baier and Bergstrand 2007). Finally, as we are dealing with a three-way fixed effects gravity model, we adjust for asymptotic bias in coefficient estimates as well as their standard errors (Weidner and Zylkin 2021), and show that the uncorrected estimates, as in the received studies, would lead to erroneous conclusions about the magnitude of the treatment effects of PTAs or IPR-related provisions.

The empirical analysis in our paper reveals six important findings. First, we did not find any significant impact of preferential trade agreements on export flows. Second, distinguishing between the heterogenous impact of deep versus shallow agreements does not appear to matter, insofar as the trade impact is insignificantly different. Third, using a continuous measure of IP-related depth of trade agreements, reveals that trade flows decline with agreement depth, possibly because it becomes difficult to honour the agreement provisions. Fourth, provisions related to *trademarks* and *biodiversity and traditional knowledge* have a significant negative impact on aggregate export flows. Fifth, we find a dynamic response of PTAs and IPR-related provisions on aggregate export flows. Specifically, the estimates of the PTA anticipation effects for 1 year prior to their inception are negative and significant, and their full trade-facilitation effects phase in 2 years after the agreement. Similarly, deep agreements that include complex chapters covering intellectual property do not have any instantaneous effect on export flows, and the positive effects are realized after 5 years of the agreement. We also find some positive estimates of the IPR indicator up to 2 and 4 years before its entry into force. These effects can be attributed to firm adjustment in anticipation of the agreement. Sixth, there is evidence of phasing-in, and of a sustained impact of both PTAs and IPRs on high-IP and low-IP export flows over time. Likewise, among the high-IP intensive group, provisions related to patents, trademarks, and copyrights exhibit significant delayed effects on export flows in industry type(s) where the respective provision holds the most significance. Moreover, in specific industrial clusters showing heightened sensitivity to IPRs, our findings indicate that IPRs facilitate trade (relatively) immediately among members.

The remainder of the paper is organized as follows: Section 2 takes us from the underlying theory to the empirical specification. Section 3 briefly discusses the dataset employed. Section 4 presents a detailed discussion of the estimation results. The robustness of the baseline model is discussed in Section 5. Finally, Section 6 provides the conclusions emanating therefrom.

2 From Theory to Empirics

In the standard structural gravity framework of international trade (Anderson and Van Wincoop 2003), nominal export flows[1] from country i to country j in year t (X_{ijt}) are expressed as a function

[1] Baldwin and Taglioni (2006) argue that inappropriate deflation of nominal trade values by the U.S. aggregate price index may introduce systematic biases in the parameter estimates, which they call 'Bronze-medal mistake', and caution against using real trade flows in empirical gravity estimation. In addition, deflation may be redundant, because the price-bias is effectively accounted for by the two multilateral resistance terms, which are essentially unobserved price indices. In our preferred specification, the time-varying country-specific directional fixed effects (FEs) also eliminate any problems arising from incorrect deflation of trade flows. Besides, the FEs would absorb any deflator indexes, exchange rates, etc. Thus, real (and nominal) trade estimates should be identical (Anderson and Yotov 2016)

of their incomes (Y_{it} and Y_{jt}) relative to world income (Y_t^w), the vector of bilateral trade costs associated with exports from i to j ($\mathbb{T}_{ijt}$), and outward and inward multilateral resistance terms (Π_{it} and P_{jt}, respectively)[2], as follows:

$$X_{ijt} = \frac{Y_{it}\, Y_{jt}}{Y_t^w} \left[\frac{\mathbb{T}_{ijt}}{\Pi_{it}\, P_{jt}} \right]^{1-\sigma} \quad \forall \quad i, j \tag{1}$$

$$\Pi_{it} = \sum_{j=1}^{N} \left[\left(\frac{\theta_{jt}}{\mathbb{T}_{ijt}^{\sigma-1}} \right) P_{jt}^{\sigma-1} \right]^{\frac{1}{1-\sigma}} \quad \forall \quad i \tag{2}$$

$$P_{jt} = \sum_{i=1}^{N} \left[\left(\frac{\theta_{it}}{\mathbb{T}_{ijt}^{\sigma-1}} \right) \Pi_{it}^{\sigma-1} \right]^{\frac{1}{1-\sigma}} \quad \forall \quad j \tag{3}$$

where σ is the elasticity of substitution between goods, $\theta_{it} = \frac{Y_{it}}{Y_t^w}$ and $\theta_{jt} = \frac{Y_{jt}}{Y_t^w}$ are the income shares of i and j, respectively. The multilateral resistance terms (MRTs) consistently aggregate the bilateral trade costs of each country across their trading partners. Thus, controlling for size, equation (1) states that bilateral trade between i and j depends upon bilateral trade barriers ($\mathbb{T}_{ijt}$) relative to the product of their multilateral resistance factors ($\Pi_{it}\, P_{jt}$). Our estimation approach closely follows Anderson and Yotov (2016), and treats DTAs as a part of unobservable trade costs $\mathbb{T}_{ijt}$, so that the power transformation of trade costs as a function of observables in structural gravity is modeled as:

$$\begin{aligned} \mathbb{T}_{ijt}^{1-\sigma} = exp[DTAS_{ijt}\beta + GRAVITY_{ijt}\alpha + \rho_1 ln(Dist_{ij}) + \rho_2 Cont_{ij} \\ + \rho_3 Comlang_{ij} + \rho_4 Col_{ij} + \rho_5 Comcol_{ij}] \end{aligned} \tag{4}$$

where $DTAS_{ijt}$ is a vector that includes an indicator $PTA_{ijt} = 1$ if i and j are members of preferential trade agreements (PTAs) in year t, and $= 0$ otherwise; and an indicator $DTA_{ijt} = 1$ if i and j are members of deep trade agreements (DTAs), and $= 0$ otherwise. By construction, the observations that take value 1 in DTA_{ijt} are a subset of the observations that equal 1 for the PTA_{ijt} indicator. In other words, there must first be a trade agreement between country pairs at time t, and only then can that agreement be deep or shallow. To capture IPR-related provisions

[2]The structural interpretation of multilateral resistance terms is that they consistently aggregate bilateral trade costs ($\mathbb{T}_{ijt}$) faced by each country across all their trading partners.

(Wu 2020), $DTAS_{ijt}$ also includes an indicator $IPR_{ijt} = 1$ if the agreement includes at least one IPR provision, and $= 0$ otherwise. By construction, the observations for which $IPR_{ijt} = 1$ are a subset of the observations for which $DTA_{ijt} = 1$. Finally, vector $DTAS_{ijt}$ includes two continuous measures of trade agreement depth, namely, variable $DEPTH_{ijt}$ which is a count measure of the total number of provisions in PTA_{ijt}, and $DEPTH^{IPR}_{ijt}$ which is a count measure of the total number of IPR-related provisions in an agreement.

The vector $GRAVITY_{ijt} = [GATT_{ijt},\ WTO_{ijt},\ EU_{ijt}]$ includes a set of time-varying bilateral control variables, where $GATT_{ijt} = 1$ if the trading countries i and j are members of GATT in year t and equals 0 otherwise, $WTO_{ijt} = 1$ if i and j are members of the WTO and equals 0 otherwise, and $EU_{ijt} = 1$ if i and j are members of the EU and equals 0 otherwise. We allow for the differential impact of GATT and WTO to identify those (few) cases in which countries are part of GATT but not WTO (Conte et al. 2022). $Ln(Dist_{ij})$ is the logarithm of bilateral distance between i and j, $Cont_{ij}$, $Comlang_{ij}$, Col_{ij}, and $Comcol_{ij}$ capture the presence of contiguous borders, common language and historical colonial ties, respectively.

The econometric specification of gravity is completed by substituting equation (4) for the power transformation of $\mathbb{T}_{ijt}$ into equation (1) and then expanding the gravity equation with an error term to identify the impact of DTAs on export flows. Therefore, our final estimation equation becomes:

$$X_{ijt} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + GRAVITY_{ijt}\alpha + DTAS_{ijt}\beta] \times \epsilon_{ijt} \quad \forall \quad i, j \tag{5}$$

We include *exporter-time* fixed effects ψ_{it} and *importer-time* fixed effects ϕ_{jt} to proxy the unobservable multilateral resistance terms[3]. In addition to controlling for network dependencies, these fixed effects control for the observable (GDP, human capital, trade openness, etc.) and unobservable country-specific time-varying determinants of bilateral trade. Finally, country-pair fixed effects μ_{ij} mitigate the endogeneity concerns with respect to our key policy variables PTA_{ijt} and IPR_{ijt} in panel data (Baier and Bergstrand 2007). The pair-FE's (additionally) control for time-invariant bilateral determinants of trade, such as: $ln(Dist_{ij})$, $Cont_{ij}$, $Comlang_{ij}$, Col_{ij} and $Comcol_{ij}$. We es-

[3]On log-linearization of equation (1), the structural interpretation of these multilateral resistance terms (MRTs) is obtained as, $\psi_{it} = -(1-\sigma)\ ln\ (\Pi_{it})$ and $\phi_{jt} = -(1-\sigma)\ ln\ (P_{jt})$.

timate equation (5) using Poisson Pseudo-Maximum Likelihood (PPML), which provides unbiased estimates in the presence of heteroskedasticity and takes advantage of the information contained in zero trade flows (Silva and Tenreyro 2006). Further, to correct for asymptotic bias on account of the incidental parameter problem, we use the Weidner and Zylkin (2021) adjustment of the coefficient estimates and their standard errors that is available in Stata.

3 Dataset

We estimate equation (5) using annual data relating to 87 countries, for the period 1990-2017. Estimation with annual data is sometimes criticized on grounds that variables cannot fully adjust annually (Cheng and Wall 2005). To address this criticism, researchers sometimes employ data at 5, 4 or 3-year intervals (Anderson and Yotov 2016, Olivero and Yotov 2012, Baier and Bergstrand 2007, Cheng and Wall 2005). However, it is well-known that an unnecessary discarding of data causes parameters and standard errors to be less precisely estimated. Further, Egger et al. (2022) caution that interval-date may lead to systematic biases in both short-run and long-run treatment effects due to unequal spacing of PTAs and other trade policy indicators. Moreover, interval-date may cause average-out anticipation (pre-window) and delayed (post-window) effects, resulting in attenuation bias in both short-run and long-run responses. An alternative approach is to employ time-averaged data. While this may smoothen out yearly fluctuations, it is subject to the same caveats as noted above for interval data. Keeping all these pros and cons in mind, we prefer to work with annual data.

The dataset on export flows across different sectors by mode of their IP-intensiveness is obtained from UNCOMTRADE (2023). We use the classification of Delgado et al. (2013), which divided product categories from Standard International Trade Classification (SITC), Revision 3 into three types: high-IP group, high-IP clusters and low-IP intensive products. Within the broad category of high-IP group, the classification further divides product categories into high-patent, high-copyright, and high-trademark intensive sub-groups. Further, they use cluster mapping approach by including a particular sub-category of products from high-IP group into the high-IP clusters[4]. The detailed sectoral classification and associated SITC Revision 3 codes and their descriptions are provided in Table A1 in appendix A. While keeping data at the detailed sector level, we first aggregate export flows across all the product categories to obtain total (nominal) value of exports from country i to country j in year t.

The dataset on preferential trade agreements is based on World Bank's database on deep trade agreements (Mattoo et al. 2020). The rich dataset provides information on preferential trade agreements and alternative provisions contained in PTAs, as well as depth measures such as the number of provisions contained in each agreement. Data on the intellectual property-related provisions of deep trade agreements are taken from Wu (2020). The dataset on deep trade agreements contains information on 120 IP-related provisions, which we classify into 13 IP-related policy areas by defining an indicator variable and the corresponding depth for each of the 13 types of alternative trade policy instruments related to IPRs. This enables us to estimate which provisions within IPRs matter more for trade flows and how. For example, ***patent*** is an indicator that highlights the presence (or absence) of provisions related to patents and ***depth*** gives the number of provisions related to patents. Similarly, for other trade policy instruments within IPRs. To control for confounders, we include information on membership of GATT, WTO and EU from CEPII's *Gravity* database (Conte et al. 2022).

4 Estimation Results

4.1 The Base Model Results

Our main findings on the effects of deep trade agreements based on equation (5) are presented in Table 1. The estimates in column (1) of Table 1 includes an overall indicator PTA_{ijt}, that reflects the presence (or absence) of preferential trade agreements (deep or shallow) between i and j in year t. The average treatment effect (ATE) of PTAs on export flows though positive is economically

[4]The objects in the same cluster are more similar to each other than to those in other groups. The industry clusters are groups of industries related by knowledge, skills, inputs, demand and other linkages in a region. For example, the computer hardware and software industries are in the Information and Communications Technology cluster because employment in each industry is strongly co-located (Delgado et al. 2013).

small and statistically insignificant. A possible explanation for this result is that we impose a common effect to all trade agreements, irrespective of their specific type and depth.

We find that without the asymptotic bias correction of Weidner and Zylkin (2021), the estimated coefficient of PTA_{ijt} though insignificant is downward biased. The bias-corrected PPML estimate of PTA_{ijt} is about 29% larger than the uncorrected estimate, and the bias-corrected standard error is almost 17% larger than uncorrected one. Thus, without such adjustment, the prior literature may either have underestimated the magnitude of the treatment effect of PTAs or may have identified significant treatment effects when there were none.

In column (2) we differentiate between deep vs shallow agreements. Even though the estimated impact of deep trade agreements (DTA_{ijt}) is positive, it is not statistically significant, which suggests that the heterogenous impact of deep versus shallow agreements does not appear to matter. We demonstrate that, this is indeed the case in column (3). In column (3), we additionally includes the continuous measure on the number of provisions contained in the agreement ($DEPTH_{ijt}$). The estimates reveal a significant impact of depth on exports, though the magnitude of estimated treatment effects is economically small. In column (4), we isolate the impact of deep agreements that include the complex chapters on intellectual property. The estimated treatment effect of IPR_{ijt} is insignificant, which suggests that the PTAs with IP-related provisions do not have any significant impact on members' export flows. The probable reason could be that the impact may not be contemporaneous, a case that we consider later. Finally, the column (5) results of the number of IP-related provisions ($DEPTH_{ijt}^{IPR}$) reveal a significantly negative effect on the export flows. These results suggest that the impact of additional provisions actually reduces trade flows. One plausible reason could be that more complex IPR-related chapters in the corresponding DTA make the agreements more difficult to comply (Larch and Yotov 2022).

Of the time-varying dyadic controls, we find that membership to EU has a significant positive impact on export flows. However, we do not find any significant effect of GATT and WTO membership in promoting export flows, as in Rose (2004) and Esteve-Pérez et al. (2020) (also see Subramanian and Wei 2007). The impact of a country's membership of the WTO crucially depends on that country's negotiating partners, the composition of products that the negotiation covers, etc., and the de facto compliance of such negotiations.

4.2 Impact of alternative IPR-related provisions on export flows

While studying the overall impact of preferential trade agreements is useful, the impact of the provisions that they contain might be more helpful in gauging their worth. To do so vis-à-vis the intellectual property rights related provisions IPR_{ijt}, we sequentially replace the indicator for IPR_{ijt} and $DEPTH_{ijt}^{IPR}$ in columns (4) and (5) of Table 1 by the corresponding IP indicator and depth for each of the twelve types of intellectual property related provisions. The estimation equation may then be written as:

$$X_{ijt} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + GRAVITY_{ijt}\alpha + DTAS_{ijt}\beta + IPRP_{ijt}^{s}\gamma] \times \epsilon_{ijt} \quad \forall \quad i, j \qquad (6)$$

The variable $IPRP_{ijt}^{s}$ is a $1{\times}2$ vector that contains an indicator for each IPR-related provision of type s and its corresponding depth (number of provisions in indicator type s). For example, indicator *patent* $=$ *1* if the trade agreement with IPR-related provisions contains at least one provision related to patents, and $= 0$ otherwise (which is the subset of observations for which $IPR_{ijt} = 1$). The measure $DEPTH_{ijt}^{s}$ is computed as the total number of chapters in the provision s (in this case *patents*). Similarly, for all the remaining provisions of type s.

Table 2 shows the distribution of policy areas within the broad category of provisions related to IPRs. The enforcement mechanism has the highest number of provisions (23) followed by ratification of international IP agreements (18), whereas national treatment, exhaustion, biodiversity, and traditional knowledge have the lowest number of provisions (02 in each).

Table 3 reports the estimates from equation (6) using the PPML estimator. Panel (A) reports the estimates of each indicator s by sequentially replacing the IPR-related indicator IPR_{ijt} by the corresponding indicator variable for each of twelve policy areas (similar to column (4) of Table 1). Panel (B) reports ATEs by additionally including the measure of depth of each indicator s (akin to column (5) in Table 1).

Our estimates in panel (A) suggest that IP-provisions related to *trademarks* cause aggregate export flows to fall by 8% $[(e^{-0.079} - 1) \times 100]$ in the treatment group (i.e., country-pairs where IPR_{ijt} includes provisions related to trademarks) relative to the control group (country-pairs where it doesn't). Similarly, provisions related to *biodiversity and traditional knowledge* reduce export flows by 10.5%. The estimates on other provisions within the broad category of IPR_{ijt} are insignificant.

The Panel (B) estimates reveal that the continuous measure of depth is significantly negative across all the alternative policy areas of IPRs. These results suggest that in terms of their extensive margin and compositional requirements, these individual agreements are inherently complex and difficult to comply with, which reduces the aggregate export flows. Note that all the specifications in Table 3 contain the vector of variables in $GRAVITY_{ijt}$ and $DTAS_{ijt}$, but their results are omitted for brevity. It is important to mention that due to collinearity with the DTAs dummy, the effect of agreements and their depth covering the *exhaustion* provision could not be identified.

4.3 The anticipatory and phased-in effects of trade policy instruments

In this section we introduce the treatment leads and lags for our key policy variables PTA_{ijt} and IPR_{ijt} to estimate their treatment effects at different lengths of event horizon. The motivation for including lagged terms of PTA_{ijt} or IPR_{ijt} is that the treatment effects may kick in with delay, so that the response cannot be captured in the contemporaneous year itself (Baier and Bergstrand 2007). Similarly, it is reasonable to conjecture that firms may adjust their trade flows in anticipation of an impending agreement, so that the trade response to an agreement may become visible even before the agreement is finalized.

In order to estimate such effects, we include several leads for both PTA_{ijt} and IPR_{ijt}. Apart from capturing the anticipatory effects, the inclusion of treatment leads enables us to test for the 'strict exogeneity' of our trade policy instruments. In the panel data context, if PTA or IPR changes are strictly exogeneous to export flow changes, the future levels of PTAs or IPRs should be uncorrelated with concurrent export flows (Baier and Bergstrand 2007, Wooldridge 2010). After controlling for possible endogeneity in PTAs or IPRs indicators using pair-fixed effects (Baier and

Bergstrand 2007), our empirical analysis in this section reveals that some of the IPR indicator leads are positive and statistically significant[5].

4.3.1 Anticipatory and lagged response of the PTA-indicator

We will first estimate the anticipatory and lagged response of the PTAs indicator on aggregate export flows. Our estimation equation takes the form:

$$X_{ijt} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + \alpha PTA_{ijt} + \sum_{s} \beta_s PTA_{ij(t+s)} + \sum_{k} \delta_k PTA_{ij(t-k)}] \times \epsilon_{ijt} \quad \forall \quad i,j \quad (7)$$

As before, equation (7) is the standard representation of a three-way gravity model with exporter-time (ψ_{it}) and importer-time (ϕ_{jt}) fixed effects to control for unobserved time-variant multilateral resistance. Symmetric country-pair fixed effects (μ_{ij}) are included to mitigate the endogeneity concerns with respect to our policy variable PTA_{ijt}, where $PTA_{ijt} = 1$ if i and j are members of the preferential trade agreement in year t and equals 0 otherwise. Parameter α gives the direct contemporaneous effect on export flows. We include $s = 5$ treatment leads (*future* levels of PTA) in our model to estimate the anticipatory response on country-pairs' aggregate export flows to the inception of the PTA. Therefore, the parameter β_s gives the average treatment effect s-periods before the agreement is signed. The inclusion of treatment leads also enables us to test for the strict exogeneity assumption of PTA_{ijt}. However, since the treatment effect may phase-in with delay, we also include $k = 10$ lagged levels of PTA_{ijt}. Parameter δ_k measures the post-treatment dynamic effects [6]. The gravity structure in equation (7) includes the three sets of fixed effects employed in the previous estimations, and we correct for asymptotic bias à la Weidner and Zylkin (2021).

The PPML estimation results of equation (7) are presented in Table 4. We note that the estimates of PTA anticipation effects for 1 year prior to the inception of an agreement ($PTA_{ij(t+1)}$) are significantly negative. This can be attributed to firms' response to delay exports temporarily in

[5]The contention that trade leads to PTA (IPR), need not even imply trade "causes" PTA (IPR). Trade may increase in anticipation of the PTA (IPR). Alternatively, trade may decrease (or be delayed) in anticipation of benefits of PTA (IPR) (McLaren 1997, Baier and Bergstrand 2007). Therefore, in our context, the significant positive estimates in IPR leads does not imply violation of the strict exogeneity assumption (in lieu of pair fixed effects); rather, it suggests firms' responses in anticipation of impending agreements.

[6]For example., if $k = 2$, then δ_2 is the average treatment effect two periods after the PTA was signed between i and j.

anticipation of future benefits of the PTA. Second, we find that these effects persist in the concurrent year. In particular, the PTAs cause export flows to fall by 2.4% in the immediate year of agreement inception. Third, two years after entering into force, PTAs actually increase aggregated export flows by 3% in treatment relative to control group. The small initial response of trade flows to the establishment of PTAs could stem from the gradual elimination of trade barriers and frictions as well as delayed adaptation of firms to new trade rules and conditions. Fourth, the estimates of ($PTA_{ij(t-10)}$) are negative significant, meaning that 10 years after their entry into force, the PTAs reduce trade flows by 7.5% in agreement signatories relative to non-signatories. This last finding can be attributed to the fact that the PTAs have reached the *'maturity phase'* beginning 8 years after the PTA's entry into force and the corresponding agreement can be said to have reached its full potential (Egger et al. 2022). Therefore, nine years after its inception, firms may bargain to renew the current agreement by including additional provisions and their de facto enforcement. In the meantime, they may reduce their exports with respect to the ongoing agreement. Fifth, the cumulative ATE of PTAs that appear in the bottom of Table 4 (obtained as the sum of all PTA leads and lags) are negative but insignificant implying - if anything - all else equal, the average treatment effect of PTAs that enter into force during the period of investigation have led to an average reduction of export flows by 12%.

4.3.2 Anticipatory and lagged response of the IPR-indicator

To estimate the anticipatory and delayed (lagged) response of trade agreements with IPR-related provisions, we employ the specification:

$$X_{ijt} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + \beta IPR_{ijt} + \sum_{s} \gamma_s IPR_{ij(t+s)} + \sum_{k} \tau_k IPR_{ij(t-k)}] \times \epsilon_{ijt} \quad \forall \quad i, j \qquad (8)$$

As before, $IPR_{ijt} = 1$ when i and j are members of the same PTA (that includes IP provisions) in year t, and equals 0 otherwise. Parameter β gives the contemporaneous average treatment effect of the agreement on the country-pairs' bilateral export flows (X_{ijt}). Likewise, parameters γ_s and τ_k measure the leading (anticipation) and phased-in (delayed) responses of corresponding agreement with IPR-related provisions, respectively. As above, we estimate equation (8) including three sets of fixed effects and adjust for asymptotic bias in estimated coefficients and their standard errors (Weidner and Zylkin 2021).

Table 5 provides the PPML estimates from equation (8). The estimates on $IPR_{ij(t+4)}$ and $IPR_{ij(t+2)}$ are positive significant, implying that on average deep trade agreements with IPR-related provisions enhance export flows by 4.7% and 5% even before 4-years and 2-years of agreement inception, respectively. We offer two explanations for this result. One is that firms start to adjust in anticipation of an impending agreement. An additional factor may be that signatories to an agreement begin to undertake measures which reduce trade costs even before the formal enforcement of the agreement. Second, the estimated effect on IPR_{ijt} is statistically insignificant, suggesting that trade agreements with IP-related provisions do not have any contemporaneous effects on exports. Third, the positive significant estimate on $IPR_{ij(t-5)}$ captures the phasing-in effects of DTAs with IP provisions, suggesting that these agreements need time to expand their full potential on trade flows. Fourth, the negative significant estimate on $IPR_{ij(t-7)}$ suggests that DTAs with IP-related provisions actually reduce trade flows by 4.3% 7-years after the agreement's entry into force. This particular finding can be attributed to the fact that IPR provisions in trade agreements have reached their full potential, and after some time the trade response of corresponding agreement is actually negative.

The results in sections 4.3.1 and 4.3.2 reveal a significant dynamic non-linear response of our key trade policy instruments. We also experimented with data averaged over 4-year intervals[7], but did not find any significant dynamic responses, because the trade response of PTAs or IPRs is highly non-linear and the adjustment process may take altogether 10 years on average, which is consistent with Egger et al. (2022). Therefore, it is difficult to identify three distinctive phases that characterizes the direct impact of PTA on trade either with interval or time-averaged data – namely, the *anticipation phase* (spanning 4-years prior to the implementation), the *growth phase* (spanning the years following the PTA's inception) and the *maturity phase* (starting about 8 years after the PTA's inception).

[7]The results from this alternative data structure are available on request.

5 Robustness checks

5.1 Aggregate impact on high-IP intensive and low-IP intensive products

The analysis in the previous section was based on aggregate export flows. However, it is likely that the trade response to preferential trade agreements could be quite heterogenous at the sectoral level. Furthermore, since intellectual property protection matters more for technologically advanced sectors for rent appropriation, the IPRs-related provisions are likely to have a differential impact on trade in high-IP intensive versus low-IP intensive products. To allow for a varying impact of DTAs on the composition of trade across industries of different IPR-intensity, we use the PPML technique to estimate:

$$X^s_{ijt} = exp[\psi_{it}+\phi_{jt}+\mu_{ij}+GRAVITY_{ijt}\alpha+DTAS_{ijt}\beta+\sum_k \delta_k PTA_{ij(t-k)}+\sum_k \tau_k IPR_{ij(t-k)}]\times\epsilon_{ijt}\ \forall\ i,j \tag{9}$$

The dependent variable is nominal export flows in sector s, high-IP intensive or low-IP intensive products, all other variables are as defined above, and estimation proceeds as before.

In Table 6, models (1) to (7) pertain to high-IP intensive products, and models (8) to (14) pertain to low-IP intensive products. In model (1), we find that PTA leads to a 6.5% increase in high-IP intensive exports, whereas we do not find any significant effects of PTA in low-IP intensive products (model 8). Our results for models (2) and (9) reveal that deep trade agreements significantly promote exports in low-IP intensive products. Notably, the distinction between deep versus shallow agreements itself does not appear to have a significant impact on trade in the high-IP category. One potential explanation for this outcome is that adhering to deep agreements is more challenging, and de facto compliance with the agreement matters more in high-IP intensive sectors compared to low-IP intensive sectors. Depending upon the number of provisions included in the corresponding agreement, the estimates from model (3) do not reveal a significant impact of increase in depth on export flows in high-IP sectors. As argued in the analysis in the previous section, this could be because more provisions make an agreement difficult to comply with. However, the estimated impact though significant is economically small in case of low-IP products (model 10). The IPR-related provisions in the corresponding DTA (models 4 and 11) do not have a statistically significant impact on export flows either in high-IP or in low-IP intensive products. Consistent with previous analysis, model (5) reveals that an increase in the number of IP-related provisions has a significantly negative impact on the export flows in high-IP intensive sectors, while model (12) shows that the impact is insignificant for low-IP intensive products. As argued in section 4.3, the changes in two members' terms of trade from the formation of PTA may have a lagged impact on their bilateral trade (Baier and Bergstrand 2007). The phasing-in effects of PTAs on high-IP and low-IP export flows is allowed for in results reported in models (6) and (13), respectively. The estimate in model (6) indicates that PTAs promote trade between their members in high-IP sectors (relatively) immediately, and these effects persist even two years after the agreement's entry into force. While PTAs do not exhibit concurrent effects on low-IP exports (model 13), the estimated impact emerges gradually after two and three years from the inception of the agreement. Next, in models (7) and (14) we introduce lagged effects of IPR-related provisions on trade. Model (7) indicates that three years after the agreement, the IPR provisions enhance high-IP export flows by 3.3%, and these effects persist even five years after their entry into force. It is important to note that in case of low-IP products (model 14), there is evidence of phasing-in and persistence of IPR provisions over time. Moreover, the estimated lagged effects are relatively stronger in low-IP products than in high-IP products. Finally, we observed no substantial influence of GATT or WTO membership on trade in either of the two sectors. However, membership in the EU has a significant positive impact on export flows in low-IP intensive products.

5.2 Impact of deep trade agreements by type of IPRs-intensiveness

In this section, we narrow our focus to examine the heterogeneous sectoral impacts within the high-IP intensive group, based on the degree of intellectual property rights intensity. In particular, we analyse the impact of provisions relating to patents, copyrights and trademarks on export flows within patent-intensive, copyright-intensive, and trademark-intensive industries. To identify such effects, we augment equation (6) to estimate:

$$X^s_{ijt} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + GRAVITY_{ijt}\alpha + DTAS_{ijt}\beta + IPRP^s_{ijt}\gamma + \sum_k \zeta_k IPRP^s_{ij(t-k)}] \times \epsilon_{ijt} \quad \forall \quad i,j \tag{10}$$

The dependent variable is nominal export flows in industry type s (patent-intensive or trademark-intensive or copyright-intensive), $GRAVITY$ and $DTAS$ denote the vector of variables used in previous analysis, $IPRP^s$ is a vector of IPR-related provisions of type s (patent-related or trademark-related or copyright-related), and the lagged provisions of type s allow for dynamic adjustment.

Table 7 presents the estimation results. We do not observe any significant impact of indicators for PTA, DTA and IPR on export flows in the patent-intensive sectors (model 1), whereas deep agreements enhance export flows by about 22.3% in trademark-intensive industries (model 5) and 41.6% in copyright-intensive industries (model 9). The intellectual property-related preferential trade agreements do not have any significant impact on export flows in patent-intensive and copyright-intensive industries (models 1 and 9, respectively), whereas such agreements lead to a decrease in trademark-intensive export flows by 8.4%. This may be because the significance of the overall IPR indicator might not be relevant for particular types of IPR-intensive industries; instead, the specific provisions within the broader category of IPRs could be more crucial. In models (2), (6) and (10), we include the count measures of overall depth of PTA and depth of IPR-related provisions. As before, the PTA depth is positive significant, but economically small across all the three industry types, although the IPR-depth variable has a negative significant impact on export flows. Further, in models (3), (7) and (11), we include an indicator for an alternative IPR-related provision indexed by s in each industry where it matters the most. We find that provisions related to patents, trademarks, and copyrights do not exhibit an immediate impact on export flows in patent-intensive, copyright-intensive and trademark-intensive industries, respectively. Therefore, in the next specification we include treatment lags to allow for phasing-in effects of these alternative IPR-related trade policy instruments. Our results in model (4) suggest that patent provisions reduce patent-intensive export flows by 5.4% one year after their entry into force. These results may be attributed to the fact that this is a period of adjustment to new trade rules where, initially, the compliance with agreement provisions may be weak. Alternatively, some firms may have underestimated the competition of firms in markets with which they are integrating (Egger et al. 2022). However, three years later, patent provisions cause a 5.4% increase in export flows for patent-intensive industries as the reduction in policy barriers gains bite, then tapers off after four years of the agreement's inception. In model (8), we find that three and four years after the agreement, trademark provisions lead to an average increase of 11% and 3.6% in trademark-intensive export flows respectively. Finally in model (12), we find similar evidence of phasing-in and persistence of copyright-related provisions over time. EU membership has a significant positive impact on copyright-intensive export flows, although we do not find any significant impact of GATT and WTO membership on either of three industry types.

5.3 IPR-related provisions and aggregate export flows in high-IP industry clusters

Section 5.1 focused on assessing the effects of deep trade agreements on aggregate export flows in high IP-intensive industries versus low IP-intensive industries. However, the high-IP intensive category is quite broad. To further refine our analysis, this section delves into a more detailed assessment of the specific impact of IPR-related provisions and their depth within distinct industrial clusters that exhibit heightened sensitivity to IPRs. These industry clusters, as defined by Delgado et al. (2013), are Analytical Instruments, Bio-pharmaceuticals, Chemicals, Information and Communication Technology (ICT), Medical Devices, and Production Technology. As, before, we include lagged levels of the IPR indicator to allow for dynamic firm adjustment following the agreement's inception. Using the PPML estimator, we estimate:

$$X_{ijt}^{c} = exp[\psi_{it} + \phi_{jt} + \mu_{ij} + GRAVITY_{ijt}\alpha + \beta IPR_{ijt} + \gamma Depth_{ijt}^{ipr} + \sum_{k} \tau_k IPR_{ij(t-k)}] \times \epsilon_{ijt} \quad \forall \quad i, j \tag{11}$$

The dependent variable is nominal export flows in industry cluster c.

Table 8 reports the estimation results, where the contemporaneous effects of IPR provisions are presented in panel (A), the measure of depth is included in panel (B), and panel (C) introduces the lagged effects. From panel (A) we find that IPR provisions have an insignificant effect on export flows within each industry cluster. However, panel (B) shows that IPRs promote trade between members (relatively) immediately in 4 out of 7 industry clusters, when including the variable $DEPTH_{ijt}^{IPR}$. The impact of depth though negative is significant only in case of medical devices. Second, two years after the agreement's entry into force, IPRs reduce trade flows by about 56% for the category of analytical instruments. Similarly, the estimated coefficients in first lag are negative significant in chemicals, and production technology, and positive significant for medical devices. These results suggest that IPR provisions enhance trade flows in the concurrent year, while the treatment effects become negative immediately after the agreement's inception. As far as control variables are concerned, membership in WTO and EU significantly enhances trade flows in medical devices and biopharmaceuticals, respectively.

6 Conclusion

This paper studies the links between deep trade agreements (DTAs) and export flows both at the aggregate and detailed product levels, using data for a panel of 87 countries over the period 1990 to 2017. The rich dataset enables us to identify the impact of preferential trade agreements as well as depth measures (relating to the number of IP-provisions in each agreement) on export flows. We categorize these provisions into 13 policy areas associated with IPRs, with each area defined by an indicator variable and its corresponding depth. Through this categorization, we can access the significance of individual IPR provisions in influencing trade flows. Since the response of trade policy instruments, such as an indicator for PTAs or IP-related provisions, typically phases-in with delay, the entire treatment effect cannot be fully captured in the concurrent year. Therefore, by using a specification with leads and lagged terms of our key trade policy instruments, we are able to estimate their treatment effects at different lengths of event horizon.

To perform the empirical analysis, we capitalize on recent advances in structural gravity estimation. The use of panel estimation techniques with rich set of *exporter-time* and *importer-time* fixed effects enables us to effectively control for multilateral resistance or any general equilibrium effects. Additionally, we include *country-pair* fixed effects to address the potential endogeneity concerns with respect to key trade policy instruments - indicators for PTAs and IPR-related provisions. As we deal with a three-way gravity model, we adjust for the asymptotic bias in estimated coefficient and their standard errors, and show that uncorrected estimates may lead to erroneous conclusions about treatment effects. Finally, we use the Poisson Pseudo-Maximum Likelihood estimation framework to simultaneously account for heteroskedasticity and information contained in zero trade flows.

Our estimation results reveal five broad conclusions. First, we do not find any contemporaneous effects of PTAs or DTAs with IP-provisions on export flows. Any discernible effects manifest over time, as businesses gradually adapt to changes in tariff and non-tariff barriers. Second, the heterogeneous impact of deep versus shallow agreements does not appear to matter in our sample. Third, the depth of PTAs though positive significant, is economically small in magnitude. However, the depth of IPR-related provisions and alternative policy areas within IPRs reveal a significantly negative impact on the export flows. These findings indicate that the inclusion of additional provisions actually diminishes trade volumes, one conceivable explanation being that the increased complexity of IPR-related provisions in the DTAs renders compliance with the agreements more challenging. Fourth, the dynamic response of our key trade policy instruments is non-linear over time, and we find that such responses are identified when we use sufficiently granular data such as annual data. Fifth, our results indicate a lagged response of both PTAs and IPRs on high-IP and low-IP export flows. The patent-related, copyright-related and trademark-related provisions have a lagged impact on trade flows in the patent-intensive, copyright-intensive and trademark-intensive industries, respectively. Our findings suggest that IPRs promote trade contemporaneously among their members in particular industrial clusters, demonstrating increased sensitivity to intellectual property.

Employing different estimation strategies and several robustness checks enables us to assert that overall indicator for PTAs and DTAs with IPR-related provisions do not have significant contemporaneous effect on export flows both at aggregate level and across most sectors, and any such effects occur with a lag. More specifically, the dynamic non-linear response of trade policy instruments within the broad category of IPRs appear to be more consequential in industry type(s) where the respective provision holds utmost significance. The results of this paper help us to capture the dynamic adjustment of trade policy changes during an event window. In particular, we provide empirical evidence of IPR-related provisions both at extensive and intensive margins and disentangle their impact across different industries with varying degree of IPR sensitivity. Further, our findings that trade agreements have differential impacts across industries, could be useful to inform theoretical models purporting to study these issues. Such theorizing might be basis of richer quantitative dynamic models that take both trade agreements and industry heterogeneity into consideration.

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Table 1 Estimates of the effects of deep trade agreements on exports

	(1)	(2)	(3)	(4)	(5)
$PTA_{ij,t}$	0.053	-0.005	-0.020	-0.022	-0.017
	(0.034)	(0.046)	(0.048)	(0.047)	(0.047)
$DTA_{ij,t}$		0.061	0.001	0.0003	-0.046
		(0.038)	(0.048)	(0.048)	(0.052)
$DEPTH_{ij,t}$			0.0002	0.0003	0.0005
			(0.0001)**	(0.0001)**	(0.0001)***
$IPR_{ij,t}$				-0.015	0.013
				(0.036)	(0.038)
$DEPTH^{IPR}_{ij,t}$					-0.002
					(0.001)*
$GATT_{ij,t}$	-0.024	-0.021	-0.024	-0.024	-0.022
	(0.020)	(0.020)	(0.021)	(0.021)	(0.020)
$WTO_{ij,t}$	-0.001	-0.0004	0.004	0.004	0.001
	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)
$EU_{ij,t}$	0.035	0.029	0.028	0.028	0.028
	(0.012)***	(0.012)**	(0.011)**	(0.011)**	(0.011)**
$FE(\psi_{it},\ \phi_{jt},\ \mu_{ij})$	Yes	Yes	Yes	Yes	Yes
N	71,592	71,592	71,592	71,592	71,592

Notes: Dependent variable: Nominal export flows. Estimates obtained from equation (4) using PPML estimator with a local de-biasing adjustment to account for estimation noise in the estimated coefficients and their standard errors (Weidner and Zylkin 2021). Estimates obtained using a three-way gravity specification with *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. Standard errors clustered by country-pair reported in parentheses. Column (1) reports the estimates of overall PTA effect across all agreements; column (2) adds the effects of DTAs; column (3) introduces a continuous variable for the depth of DTA; column (4) isolates the impact of DTAs with IPR-related provisions and finally column (5) adds the continuous measure of depth for IPR-related provisions. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$,

Table 2 Distribution of policy areas of type s within the broad category of IPR-related provision

Policy areas within IPR − related provision	*Number of provisions*
Ratification of International IP Agreements	18
National Treatment	02
Exhaustion	02
Transparency	08
Trademarks	15
Geographic Indicators	07
Patents	15
Data Protection/Undisclosed Information	05
Industrial Design	04
Copyrights and Related Rights	14
Biodiversity and Traditional Knowledge	02
Enforcement	23
Others	04
Total	119

Notes: Classification of provisions in respective policy areas is based on Wu (2020). The one provision related to domain name/country name is excluded in this distribution.

Table 3 Estimates of the effects of alternative IPR-related provisions on exports

	(A)	(B)	
Provision	$IPRP^s_{ijt}$	$IPRP^s_{ijt}$	$DEPTH^s_{ijt}$
Ratification of IP agreements	-0.028	0.053	-0.019
	(0.044)	(0.055)	(0.010)*
National treatment	-0.070	0.127	-0.122
	(0.051)	(0.122)	(0.076)
Exhaustion	0.021	-	-
	(0.062)		
Transparency	-0.050	-0.037	-0.004
	(0.055)	(0.065)	(0.012)
Trademark	-0.079	0.008	-0.024
	(0.047)*	(0.044)	(0.008)***
Geographic indicators	0.037	0.051	-0.006
	(0.037)	(0.044)	(0.016)
Patents	-0.053	-0.019	-0.012
	(0.052)	(0.055)	(0.008)
Data protection	0.006	0.074	-0.020
	(0.061)	(0.125)	(0.038)
Industrial design	-0.005	0.119	-0.070
	(0.049)	(0.078)	(0.037)*
Copyrights	-0.068	0.010	-0.014
	(0.058)	(0.072)	(0.008)*
Biodiversity	-0.111	0.107	-0.123
	(0.059)*	(0.168)	(0.094)
Enforcement	-0.002	0.072	-0.008
	(0.046)	(0.072)	(0.006)
Others	-0.020	-0.095	0.048
	(0.043)	(0.077)	(0.046)
$FE(\psi_{it},\ \phi_{jt},\ \mu_{ij})$	Yes		Yes
N	71,592		71,592

Notes: Dependent variable: Nominal export flows. Estimates obtained from equation (5), using PPML estimator, with a local de-biasing adjustment to account for estimation noise in the estimated coefficients and their standard errors (Weidner and Zylkin 2021). Panel (A) reports the estimates of average treatment effect (ATE) of each indicator of type s. Panel (B) reports ATEs by additionally including a continuous measure of depth for each indicator s. Estimates obtained using a three-way gravity specification with *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. Standard errors clustered by country-pair reported in parentheses. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$, respectively.

Table 4 The anticipatory and phased-in effects of PTAs on export flows

$PTA_{ij,t+5}$	0.044
	(0.028)
$PTA_{ij,t+4}$	0.017
	(0.018)
$PTA_{ij,t+3}$	-0.011
	(0.018)
$PTA_{ij,t+2}$	0.015
	(0.016)
$PTA_{ij,t+1}$	-0.027
	(0.015)*
$PTA_{ij,t}$	-0.025
	(0.015)*
$PTA_{ij,t-1}$	0.009
	(0.020)
$PTA_{ij,t-2}$	0.029
	(0.016)*
$PTA_{ij,t-3}$	0.003
	(0.018)
$PTA_{ij,t-4}$	0.002
	(0.018)
$PTA_{ij,t-5}$	-0.005
	(0.018)
$PTA_{ij,t-6}$	-0.017
	(0.017)
$PTA_{ij,t-7}$	-0.028
	(0.024)
$PTA_{ij,t-8}$	-0.020
	(0.025)
$PTA_{ij,t-9}$	-0.035
	(0.023)
$PTA_{ij,t-10}$	-0.078
	(0.022)***
ATE^a	-0.127
	(0.102)
$FE(\psi_{it},\ \phi_{jt},\ \mu_{ij})$	Yes
N	28,896

Notes: Dependent variable: Nominal export flows. Estimates obtained from equation (6), using PPML estimator, with a local de-biasing adjustment to account for estimation noise in the estimated coefficient and their standard errors (Weidner and Zylkin 2021). Estimates obtained using a three-way gravity specification *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. Standard errors clustered by country-pair reported in parentheses. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$, respectively.

[a] The average treatment effect (ATE) is obtained as the sum of all treatment leads and lags parameters.

Table 5 The anticipatory and phased-in effects of IPR-related provisions on export flows

$IPR_{ij,t+5}$	-0.046
	(0.029)
$IPR_{ij,t+4}$	0.046
	(0.019)**
$IPR_{ij,t+3}$	-0.025
	(0.015)
$IPR_{ij,t+2}$	0.048
	(0.023)**
$IPR_{ij,t+1}$	-0.029
	(0.018)
$IPR_{ij,t}$	0.003
	(0.020)
$IPR_{ij,t-1}$	0.026
	(0.019)
$IPR_{ij,t-2}$	0.018
	(0.018)
$IPR_{ij,t-3}$	0.043
	(0.029)
$IPR_{ij,t-4}$	-0.021
	(0.016)
$IPR_{ij,t-5}$	0.051
	(0.019)**
$IPR_{ij,t-6}$	-0.011
	(0.023)
$IPR_{ij,t-7}$	-0.044
	(0.024)*
$IPR_{ij,t-8}$	0.005
	(0.019)
$IPR_{ij,t-9}$	-0.010
	(0.016)
$IPR_{ij,t-10}$	-0.025
	(0.027)
ATE	0.029
	(0.092)
$FE(\psi_{it},\ \phi_{jt},\ \mu_{ij})$	Yes
N	28,896

Notes: Dependent variable: Nominal export flows. Estimates obtained from equation (7), using PPML estimator, with a local de-biasing adjustment to account for estimation noise in the estimated coefficient and their standard errors (Weidner and Zylkin 2021). Estimates obtained using a three-way gravity specification *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. Standard errors clustered by country-pair are reported in parentheses. *, **, *** denotes p¡0.10, p¡0.05, p¡0.01, respectively.. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$, respectively.

Table 6 Estimates of deep trade agreements on export flows in high-IP and low-IP intensive products.

	A. High-IP intensive products							B. Low-IP intensive products						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PTA_{ijt}	0.063	0.027	0.017	0.016	0.023	0.142	0.188	0.042	-0.058	-0.081	-0.080	-0.077	0.040	0.133
	(0.033)*	(0.050)	(0.051)	(0.051)	(0.050)	(0.065)**	(0.065)***	(0.061)	(0.068)	(0.069)	(0.068)	(0.070)	(0.065)	(0.076)*
DTA_{ijt}		0.037	-0.004	-0.005	-0.089	-0.237	-0.243		0.107	0.016	0.016	-0.007	-0.126	-0.162
		(0.043)	(0.055)	(0.054)	(0.064)	(0.076)***	(0.078)***		(0.044)**	(0.060)	(0.060)	(0.073)	(0.072)*	(0.078)**
$DEPTH_{ijt}$			0.0002	0.0002	0.0006	0.0005	0.0005			0.0004	0.0004	0.0005	0.0003	0.0003
			(0.0001)	(0.0001)	(0.0002)***	(0.0002)**	(0.0002)**			(0.0001)**	(0.0002)**	(0.0003)*	(0.0003)	(0.0003)
IPR_{ijt}				-0.005	0.047	0.055	0.030				0.006	0.021	0.039	-0.074
				(0.030)	(0.036)	(0.038)	(0.035)				(0.061)	(0.066)	(0.065)	(0.057)
$DEPTH^{IPR}_{ijt}$					-0.003	-0.003	-0.003					-0.001	-0.001	-0.0005
					(0.001)***	(0.001)**	(0.001)**					(0.002)	(0.002)	(0.002)
PTA_{ijt-1}						0.019							0.050	
						(0.011)							(0.025)**	
PTA_{ijt-2}						0.041							0.044	
						(0.011)***							(0.019)**	
PTA_{ijt-3}						-0.005							-0.016	
						(0.010)							(0.024)	
PTA_{ijt-4}						0.002							0.032	
						(0.012)							(0.022)	
PTA_{ijt-5}						0.014							-0.026	
						(0.017)							(0.043)	
IPR_{ijt-1}							0.005							0.063
							(0.015)							(0.028)**
IPR_{ijt-2}							-0.001							0.030
							(0.013)							(0.020)
IPR_{ijt-3}							0.032							0.064
							(0.018)*							(0.034)*
IPR_{ijt-4}							-0.006							-0.007
							(0.010)							(0.021)
IPR_{ijt-5}							0.030							0.068
							(0.017)*							(0.037)*
$GATT_{ijt}$	-0.017	-0.016	-0.019	-0.019	-0.016	-0.019	-0.016	-0.017	-0.012	-0.015	-0.015	-0.014	-0.016	-0.018
	(0.021)	(0.021)	(0.021)	(0.021)	(0.019)	(0.030)	(0.029)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.044)	(0.043)
WTO_{ijt}	0.011	0.011	0.015	0.015	0.010	0.008	0.005	-0.018	-0.016	-0.011	-0.011	-0.013	-0.012	-0.015
	(0.021)	(0.020)	(0.021)	(0.021)	(0.018)	(0.029)	(0.028)	(0.031)	(0.031)	(0.031)	(0.030)	(0.030)	(0.040)	(0.040)
EU_{ijt}	0.013	0.010	0.010	0.009	0.011	0.016	0.017	0.050	0.039	0.038	0.038	0.038	0.038	0.043
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.017)***	(0.018)**	(0.018)**	(0.017)**	(0.017)**	(0.017)**	(0.017)**
$FE(\psi_{it}, \phi_{jt}, \mu_{ij})$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	69,564	69,564	69,564	69,564	69,564	55,281	55,281	70,045	70,045	70,045	70,045	70,045	55,751	55,751

Notes: Dependent variable: Nominal export flows in high-IP intensive products (models 1-7) and low-IP intensive products (models 8-14). Estimates obtained using PPML estimator with *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of fixed effects omitted for brevity. We use local de-biasing adjustment to account for estimation noise in the estimated coefficients and their standard errors (Weidner and Zylkin 2021). Standard errors clustered by country-pair are reported in parentheses. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$,respectively.

Table 7 Estimates of deep trade agreements on export flows by type of IP-intensiveness.

	A. Patent intensive				B. Trademark intensive				C. Copyright intensive			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PTA_{ijt}	0.023	0.023	0.025	0.213	0.048	0.020	0.027	0.117	-0.261	-0.309	-0.340	-0.460
	(0.054)	(0.054)	(0.054)	(0.070)***	(0.062)	(0.062)	(0.064)	(0.078)	(0.094)***	(0.095)***	(0.098)***	(0.135)***
DTA_{ijt}	-0.003	-0.106	-0.100	-0.270	0.201	-0.025	-0.022	-0.084	0.348	0.171	0.173	0.374
	(0.051)	(0.072)	(0.072)	(0.083)***	(0.058)***	(0.078)	(0.078)	(0.089)	(0.090)***	(0.130)	(0.131)	(0.152)**
IPR_{ijt}	0.030	0.069	0.073	0.071	-0.088	-0.103	-0.095	-0.048	-0.096	-0.193	-0.196	-0.112
	(0.031)	(0.039)*	(0.040)*	(0.043)*	(0.039)**	(0.049)**	(0.054)*	(0.057)	(0.069)	(0.079)**	(0.080)**	(0.095)
$DEPTH_{ijt}$		0.0005	0.0004	0.0003		0.001	0.001	0.001		0.001	0.001	0.0005
		(0.0002)**	(0.0002)*	(0.0002)		(0.0003)***	(0.0003)***	(0.0003)***		(0.0004)**	(0.0004)**	(0.0005)
$DEPTH_{ijt}^{IPR}$		-0.003	-0.003	-0.002		-0.004	-0.004	-0.003		0.001	-0.002	0.002
		(0.001)**	(0.001)*	(0.001)		(0.001)***	(0.001)***	(0.001)**		(0.003)	(0.0037)	(0.004)
$Patent_{ijt}$			-0.043	-0.001								
			(0.059)	(0.067)								
$Trademark_{ijt}$							-0.041	-0.117				
							(0.063)	(0.070)*				
$Copyright_{ijt}$											0.198	-0.088
											(0.142)	(0.129)
$Patent_{ijt-1}$				-0.056								
				(0.027)**								
$Patent_{ijt-2}$				-0.021								
				(0.023)								
$Patent_{ijt-3}$				0.053								
				(0.030)*								
$Patent_{ijt-4}$				-0.044								
				(0.020)**								
$Patent_{ijt-5}$				0.004								
				(0.030)								
$Trademark_{ijt-1}$								-0.006				
								(0.024)				
$Trademark_{ijt-2}$								-0.034				
								(0.027)				
$Trademark_{ijt-3}$								0.104				
								(0.036)***				
$Trademark_{ijt-4}$								0.035				
								(0.016)**				
$Trademark_{ijt-5}$								0.006				
								(0.024)				
$Copyright_{ijt-1}$												0.183
												(0.099)*
$Copyright_{ijt-2}$												0.0008
												(0.071)
$Copyright_{ijt-3}$												-0.001
												(0.130)
$Copyright_{ijt-4}$												0.090
												(0.110)
$Copyright_{ijt-5}$												-0.350
												(0.206)*
$GATT_{ijt}$	-0.023	-0.021	-0.023	-0.022	0.017	0.014	0.014	0.022	-0.072	-0.071	-0.072	-0.045
	(0.024)	(0.022)	(0.022)	(0.034)	(0.028)	(0.027)	(0.027)	(0.035)	(0.049)	(0.049)	(0.049)	(0.060)
WTO_{ijt}	0.014	0.010	0.012	0.010	0.003	0.007	0.008	-0.014	0.028	0.034	0.034	0.007
	(0.024)	(0.021)	(0.021)	(0.034)	(0.025)	(0.024)	(0.024)	(0.033)	(0.040)	(0.040)	(0.040)	(0.054)
EU_{ijt}	0.016	0.017	0.017	0.017	-0.022	-0.023	-0.025	-0.005	0.078	0.070	0.072	0.076
	(0.012)	(0.012)	(0.012)	(0.011)	(0.018)	(0.018)	(0.018)	(0.015)	(0.043)*	(0.043)	(0.043)*	(0.035)**
$FE(\psi_{it}, \phi_{jt}, \mu_{ij})$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	68,711	68,711	68,711	54,494	64,154	64,154	64,154	50,342	55,866	55,866	55,866	43,072

Notes: Dependent variable: Nominal export flows in patent-intensive products (models 1-4), trademark-intensive products (models 5-8) and copyright-intensive products (models 9-12). Estimates obtained using PPML estimator with *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. We use local de-biasing adjustment to account for estimation noise in the coefficients and their standard errors (Weidner and Zylkin 2021). Standard errors clustered by country-pair are reported in parentheses. *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$,respectively.

Table 8 Estimates of deep trade agreements on export flows by type of IP-intensiveness.

	Analytical Instruments	Biopharmaceuticals	Chemicals	ICT	Medical devices	Production technology
A. Contemporaneous effects						
$IPR_{ij,t}$	0.052	-0.043	0.063	0.013	0.038	0.074
	(0.051)	(0.092)	(0.044)	(0.069)	(0.051)	(0.032)**
$GATT_{ij,t}$	0.006	-0.039	0.039	-0.023	-0.071	-0.025
	(0.058)	(0.049)	(0.031)	(0.047)	(0.046)	(0.030)
$WTO_{ij,t}$	0.008	-0.046	-0.032	-0.007	0.082	0.025
	(0.061)	(0.043)	(0.027)	(0.047)	(0.047)*	(0.031)
$EU_{ij,t}$	-0.005	0.100	-0.010	0.029	0.001	0.016
	(0.020)	(0.050)**	(0.023)	(0.027)	(0.021)	(0.015)
N	49,829	50,665	52,882	57,028	50,511	58,503
B. Depth						
$IPR_{ij,t}$	0.130	-0.025	0.102	0.092	0.114	0.108
	(0.068)*	(0.124)	(0.060)*	(0.095)	(0.055)**	(0.052)**
$DEPTH^{IPR}_{ij,t}$	-0.003	-0.001	-0.001	-0.002	-0.002	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)*	(0.001)
$GATT_{ij,t}$	0.018	-0.038	0.041	-0.018	-0.062	-0.023
	(0.053)	(0.049)	(0.031)	(0.045)	(0.043)	(0.029)
$WTO_{ij,t}$	-0.004	-0.047	-0.036	-0.014	0.072	0.022
	(0.054)	(0.042)	(0.027)	(0.046)	(0.043)*	(0.029)
$EU_{ij,t}$	-0.005	0.100	-0.009	0.031	0.002	0.017
	(0.020)	(0.050)**	(0.023)	(0.027)	(0.021)	(0.015)
N	49,829	50,665	52,882	57,028	50,511	58,503
C. Phasing-in estimates						
$IPR_{ij,t}$	0.124	-0.015	0.108	0.091	0.108	0.110
	(0.068)*	(0.124)	(0.060)*	(0.095)	(0.055)*	(0.052)**
$DEPTH^{IPR}_{ij,t}$	-0.002	-0.001	-0.001	-0.002	-0.002	-0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)*	(0.001)
$IPR_{ij,t-1}$	0.009	-0.048	-0.030	-0.0008	0.045	-0.023
	(0.016)	(0.064)	(0.015)**	(0.024)	(0.020)**	(0.010)**
$IPR_{ij,t-2}$	-0.828	0.111	-0.618	0.240	0.085	0.355
	(0.460)*	(0.213)	(0.472)	(0.447)	(0.276)	(0.699)
$IPR_{ij,t-3}$	-0.602	0.243	0.033	-0.242	-0.665	-0.607
	(1.222)	(0.205)	(0.171)	(0.175)	(0.509)	(0.614)
$GATT_{ij,t}$	0.011	-0.030	0.048	-0.024	-0.065	-0.026
	(0.056)	(0.047)	(0.031)	(0.047)	(0.045)	(0.031)
$WTO_{ij,t}$	0.001	-0.053	-0.040	-0.008	0.077	0.026
	(0.057)	(0.040)	(0.027)	(0.046)	(0.046)*	(0.031)
$EU_{ij,t}$	-0.005	0.098	-0.016	0.030	-0.0001	0.015
	(0.020)	(0.050)*	(0.023)	(0.027)	(0.021)	(0.015)
N	48,929	49,329	51,494	55,349	49,389	56,535
$FE(\psi_{it}, \phi_{jt}, \mu_{ij})$	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results in panel (A) report contemporaneous effects. Panel (B) also includes the count measure of the depth of IPR-related provisions. Panel (C) reports phasing-in IPR estimates.

Dependent variable: Nominal export flows in each industry cluster. Estimates obtained using PPML estimator with *exporter-time*, *importer-time* and *country-pair* fixed effects. Estimates of these fixed effects omitted for brevity. We use local de-biasing adjustment to account for estimation noise in the estimated coefficients and their standard errors (Weidner and Zylkin 2021). Standard errors clustered by country-pair are reported in parentheses . *, **, *** denotes $p < 0.10$, $p < 0.05$, $p < 0.01$,respectively.

A Appendix

Table A1 Definition of product categories according to IPR-intensity

A. Definition of High-IP Group	
High-patent products (most of which are also high-trademark)	
Crude fertilizer Organic & inorganic chemicals Dyeing material Medicinal & pharmaceutical products Essential oils & perfume materials Chemical materials & products Rubber manufactures Power-generating machinery Machinery for industries	Metalworking machinery General machinery Office machines Telecommunications Electrical machinery Professional apparatus Photographic apparatus Miscellaneous manufacturing
High-trademark products (with low-patent/copyrights)	
Dairy products & beverages Crude rubber Pulp & waste paper Plastics Paper & related articles	Manufactures of metals Road vehicles Furniture Footwear
High-copyright products (most of which are also high-trademark)	
Cinematographic films & beverages	Printed matter & recoded media
B. Definition of High-IP Clusters	
Biopharmaceuticals Medicinal & pharmaceutical products	**Medical Devices** Diagnostic substances Medical equipment & supplies
Analytical Instruments Optical instruments Laboratory instruments Process instruments	**Chemicals** Organic chemicals Chemically based ingridients Dyeing & packaged chemicals
ICT Office machines Computer & peripherals Communication equipments Electric & electronic components	**Production Technology** Materials & tools Process & metalworking machinery General industrial machinery
C. Definition of Low-IP Group	
Food & live animals Crude materials, inedible, except fuel Mineral fuels, lubricants & related material Animal & vegetable oils, fats & waxes	Manufactures of leather, cork, wood, minerals & metals Prefabricated buildings, travel goods, and apparel & accessories

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