WP-2025-025

Revisiting the Impact of TRIPS on Trade: Evidence from Staggered Difference-in-Differences

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November 2025

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Keywords: TRIPS, International Trade, Staggered Difference-in-Differences, Treatment Effect Heterogeneity.

JEL Code: C21, C23, F13, F14, O34

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November 25, 2025

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*We gratefully acknowledge the valuable feedback on earlier versions of this paper from conference participants at the Indian Statistical Institute–Delhi and the Delhi School of Economics. I also express my gratitude to the IT staff at IGIDR for their support.

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1 Introduction

The agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), adopted under the auspices of World Trade Organization (WTO) in 1994, led to notable changes in the international framework of legal institutions governing the ownership and flow of knowledge, technology, and other intellectual assets. Many developing and least-developed countries (LDCs) had considerably less stringent intellectual property protection than required by the TRIPS agreement when they joined the WTO. The agreement obligates member countries to legislate and enforce certain *minimum* standards of protection for virtually all major types of intellectual property rights (IPRs) with the stated goal of promoting innovation and dissemination of technology.

The critics, however, voiced several concerns. They feared that the TRIPS requirements would raise imitation costs in developing countries, constraining their opportunities to reverse engineer and adopt foreign technology (Helpman 1993; Lai and Qiu 2003). Further, there was apprehension that the prices of critical life-saving drugs may increase, with adverse consequences on public health and well-being [1]. Furthermore, the dominance of corporate monopolies in controlling intellectual property would exacerbating North-South technology gap, and would perversely encourage capital flows from developing to developed countries (Deere 2009). In partial recognition of these possibilities, the TRIPS agreement incorporated *"transitional arrangements"* whereby member countries could take advantage of *'flexibilities'*, and tailor the timing of their compliance with the agreement stipulations. As a result, one of the most economically significant aspects of the TRIPS reform was its staggered adoption, which led to a natural (cross-country) variation in the timing of legislative reforms related to IPRs.

The theoretical literature on the relationship between IPRs and trade is very rich, highlighting various channels through which IPRs influence the pattern of bilateral trade. The impact of stronger intellectual property protection on trade, nevertheless, remains contentious. On the one hand, heightened protection of IPRs reduced the ability of domestic firms to imitate or reverse engineer foreign technology, making it more appealing for the technology-haves to export to such markets, a phenomenon referred to as the *'market expansion effect'*. On the other hand, stronger host-

[1] Chaudhuri et al. (2006) find that TRIPS-induced pharmaceuticals product-patents led to significant increase in prices of special class of antibiotics (quinolones) and large welfare loss for the Indian economy

country IPRs strengthen the monopoly position of foreign firms, permitting them to exports less at higher prices, a phenomenon dubbed the *'market power effect'* (Maskus and Penubarti 1995). Evidently, the market power and market expansion effects are mutually offsetting, rendering the effect of stronger IPRs on trade an essentially empirical question. Existing empirical studies yielded mixed and, at times, difficult to interpret results. Ivus (2010) finds that stronger patent protection in developing countries increased high-tech exports from developed countries into those markets. While, Maskus and Penubarti (1995), Delgado et al. (2013), and Maskus and Yang (2018) also report similar results, several other studies either report a negative or an insignificant effect of intellectual property (IP) reform on trade (Smith 1999; Co 2004; Braga and Fink 2005; and Campi and Dueñas 2016).

Most of the empirical studies examining the impact of domestic patent reforms on trade have relied exclusively on traditional 'gravity-type' models, estimated using a two-way fixed effects (TWFE) estimator. For example, Ivus (2010) employ a canonical 2×2 difference-in-differences approach to compare the export growth in patent-sensitive relative to patent-insensitive industries before and after the introduction of TRIPS, using former colonies of Britain and France as a treatment group and non-colonies as a comparison group. However, a key limitation of this study is that it does not account for the staggered pattern of TRIPS compliance across colonies and may produce misleading results in a more complicated designs involving variation in treatment timing [2]. One exception is Ivus and Park (2019) who exploit variation in the timing of national patent reforms using a PPML estimator within a standard TWFE gravity specification to examine their impact on export growth. Similarly, Delgado et al. (2013) employ difference-in-differences framework to investigate the impact of compliance with TRIPS agreement on members' international trade. Unlike the PPML estimator typically employed in gravity settings, their approach uses OLS within a standard TWFE framework.

A major limitation of such studies is that they do not account for the staggered pattern of TRIPS compliance across countries, which may yield misleading results. Thus, several econometric studies point out that TWFE estimator capture the common or average effect of domestic patent

[2] See, for example, De Chaisemartin and d'Haultfoeuille (2023) and Roth et al. (2023) who provide comprehensive survey of this literature.

reforms on international trade, which may be biased when treatment effects are heterogeneous (De Chaisemartin and d'Haultfoeuille 2020; Goodman-Bacon 2021; Callaway and Sant'Anna 2021; Sun and Abraham 2021; and Borusyak et al. 2024). For example, this may happen due to the so-called *'forbidden comparisons'* that (mis)use already-TRIPS-compliant units as a comparison for units that comply with the agreement in later periods. This remains an important shortcoming in Ivus (2010); Delgado et al. (2013); Ivus and Park (2019); Maskus and Ridley (2016), and other related studies that rely on TWFE gravity-type models (Nagengast and Yotov 2025).

Our study improves upon the earlier studies by leveraging the variation in the timing of TRIPS compliance across countries within a heterogeneity-robust difference-in-differences (DiD) framework, to estimate the average causal effect of IP reforms on trade. Our estimation procedure relies on Wooldridge (2023), who proposes an *extended two-way fixed effects (ETWFE) estimator* for the estimation of non-linear models in a staggered difference-in-differences design. The ETWFE estimator is particularly relevant for gravity-type models, where the use of non-linear Poisson pseudo-maximum likelihood (PPML) estimator have become a standard approach (Silva and Tenreyro 2006). This estimator allows for treatment effects heterogeneity, insofar as it estimates the family of relevant estimands, referred to as 'cohort-time' average treatment effects, $ATT(g, s)$, i.e., the average treatment effect for units in cohort g in year s, where a 'cohort' is defined by the time period when units (countries) first complied with the TRIPS agreement. It avoids comparisons with already-compliant units, and compares the outcome for units in group g with those not-yet-compliant by period g, or those that never-complied during the sample period. Thus, the main contribution of our paper is to exploit a natural experiment in identifying the IPR policy shock via staggered TRIPS compliance, which yields estimates that are robust to treatment effect heterogeneity, an aspect which existing studies have failed to address (Smith and Anti 2022).

To perform the empirical analysis, we rely on three standard datasets: (i) The trade data used to derive our baseline estimates are obtained from the Structural Gravity Database (SGD) of the WTO that contains information on aggregate manufacturing trade flows (Monteiro 2020); (ii) For sectoral analysis, we utilize industry-specific *International Trade and Production Database for Estimation (ITPD-E, release 2)* which provides consistent data on both international and domestic trade flows pertaining to 118 manufacturing industries over 1988-2017 period (Borchert et al., 2021, 2022); (iii) To control for confounders that may affect the outcome (trade flows) other than the treatment (TRIPS compliance), we use standard gravity variables (e.g., bilateral distance, contiguity, etc.) from CEPIIs *Gravity* database (Conte et al. 2022). Finally, we employ multiple classification criteria to identify when each country became TRIPS compliant, including WTO's original compliance schedule.

The results reveal several interesting patterns in international trade: First, bilateral trade flows are about 58% higher among TRIPS compliant cohorts relative to the non-compliant group. Second, the average response to TRIPS compliance masks significant heterogeneity, with earlier-complying cohorts experiencing stronger impacts compared to those complying later. Third, the event-study results suggest that the trade response to TRIPS compliance is positive and increases in magnitude for up to eleven years, before eventually tapering off. Finally, at industry level, the results indicate that compliance with the TRIPS agreement significantly increased trade flows in both high-IPR- and low-IPR-intensive industries.

To test the sensitivity of our baseline estimates, we conduct a battery of robustness checks. First, we compare the results from ETWFE model with those obtained from canonical TWFE, commonly used in gravity setting. Second, we test the degree of heterogeneity of ETWFE model as well as DiD and ETWFE-specific assumptions using both PPML and OLS estimators. Third, in a specific setting we consider, such as gravity-type models, the parallel trend assumption may hold only after conditioning on covariates (Callaway and Sant'Anna 2021). Therefore, we consider an extension of ETWFE model, in which cohort-time-specific treatment effects are allowed to vary by time-constant covariates, such as bilateral distance between the countries. Fourth, we consider alternative weighting schemes to aggregated cohort-specific treatment to obtain the overall impact of complying with the agreement. Fifth, we impose certain restrictions on ETWFE model by allowing the treatment effect to vary only along specific dimensions, such as, cohort or event-time level. Finally, we test the robustness of our baseline results to alternative clustering of standard errors. Although the magnitude of estimated coefficients varies in some cases, all robustness tests confirm our baseline findings.

The remainder of the paper is organized as follows: Section 2 discusses the variation in the timing of TRIPS implementation. Section 3 introduces the estimation method. Section 4 provides a brief discussion of our data. Section 5 presents our main findings. The robustness of baseline model is discussed in Section 6. Section 7 examines the industry-level effects. Section 8 concludes.

2 Variation in the timing of TRIPS implementation

The TRIPS agreement of 1994 obligates member countries to provide certain minimum standards of protection for various categories of intellectual property. However, the implementation process became an intense political game with developed countries seeking stronger IPR protection and strict de facto compliance to TRIPS, while developing and least-developed countries resisted the universal harmonization of IP laws in order to safeguard their national interests, for reasons outlined in our introductory section.

Consequently, the agreement allowed certain flexibilities, one of which pertained to the implementation period. Advanced countries were given one year, extending until January 1, 1996, to bring their laws and practices in conformity with TRIPS requirements. The member states of WTO that self-designated themselves as 'developing' were granted a transition period of five years, until January 1, 2000 to adhere with the TRIPS mandated guidelines, with further extension to January 1, 2005 for those that did not provide patent protection in pharmaceuticals and agriculture chemical products. The least-developed countries had been given maximum leeway until January 1, 2006 to comply with TRIPS, but this was later extended to January 1, 2016 for product patents in pharmaceuticals and chemicals, and to 2013 for other product categories. Thus, different countries implemented the TRIPS agreement in different years, creating natural variation in the timing of IPR-related legislative reforms across countries.

We identify the TRIPS compliance date of our sample countries, using the Hamdan-Livramento (2009) compliance index. This index captures country-level IPRs compliance with respect to patents, copyrights, trademarks, industrial designs, geographic indicators, layout designs of integrated circuits, and undisclosed information. A binary indicator for each of these IP categories equals 1 if a country has fulfilled its TRIPS obligations vis-à-vis that category, and equals 0 otherwise. Their unweighted sum yields the Hamdan-Livramento index (HLI), which ranges between 0 and 7. For each country, the TRIPS compliance date is taken to be the year in which HLI first exceeds 5. Since HLI is available for only 53 developing countries, we build on Delgado et al. (2013) and Smith and Anti (2022) to expand this sample to 147 countries. To do so, we draw on Park (2008) and Maskus and Ridley (2016) to identify countries that used various exemptions allowed under TRIPS [3]. Since the *de facto* and *de jure* protection of IP in least developed countries remained weaker than that mandated by TRIPS, these countries are classified as non-compliant throughout the sample period. Figure 1 shows the timeline of TRIPS compliance based on the classification criteria described above. Each node lists the group of countries that became compliant in a particular year, referred to as treatment-timing cohorts in our analysis. For instance, China, Moldova, and Mauritius first complied with the TRIPS agreement in year 2002, and therefore belong to $g = 2002$ cohort.

The reluctance of most of developing countries to enact the TRIPS mandated policy changes suggests that compliance with the agreement was not an endogenous response to domestic innovation and other activities. Rather, the broader push to strengthen IPRs in countries with weak protection was exogenously imposed by the TRIPS agreement or driven by coercive pressure from developed countries (Deere 2009; Ivus 2010; Kanwar 2012; and Delgado et al. 2013), which improves the credibility of our identification strategy. Moreover, we include a rich set of *exporter-by-year*, *importer-by-year*, and *exporter-importer* fixed effects to effectively control for unobserved time-varying country-specific factors, as well as time-invariant bilateral characteristics, that could be correlated with either the treatment (TRIPS compliance) or the outcome (trade flows).

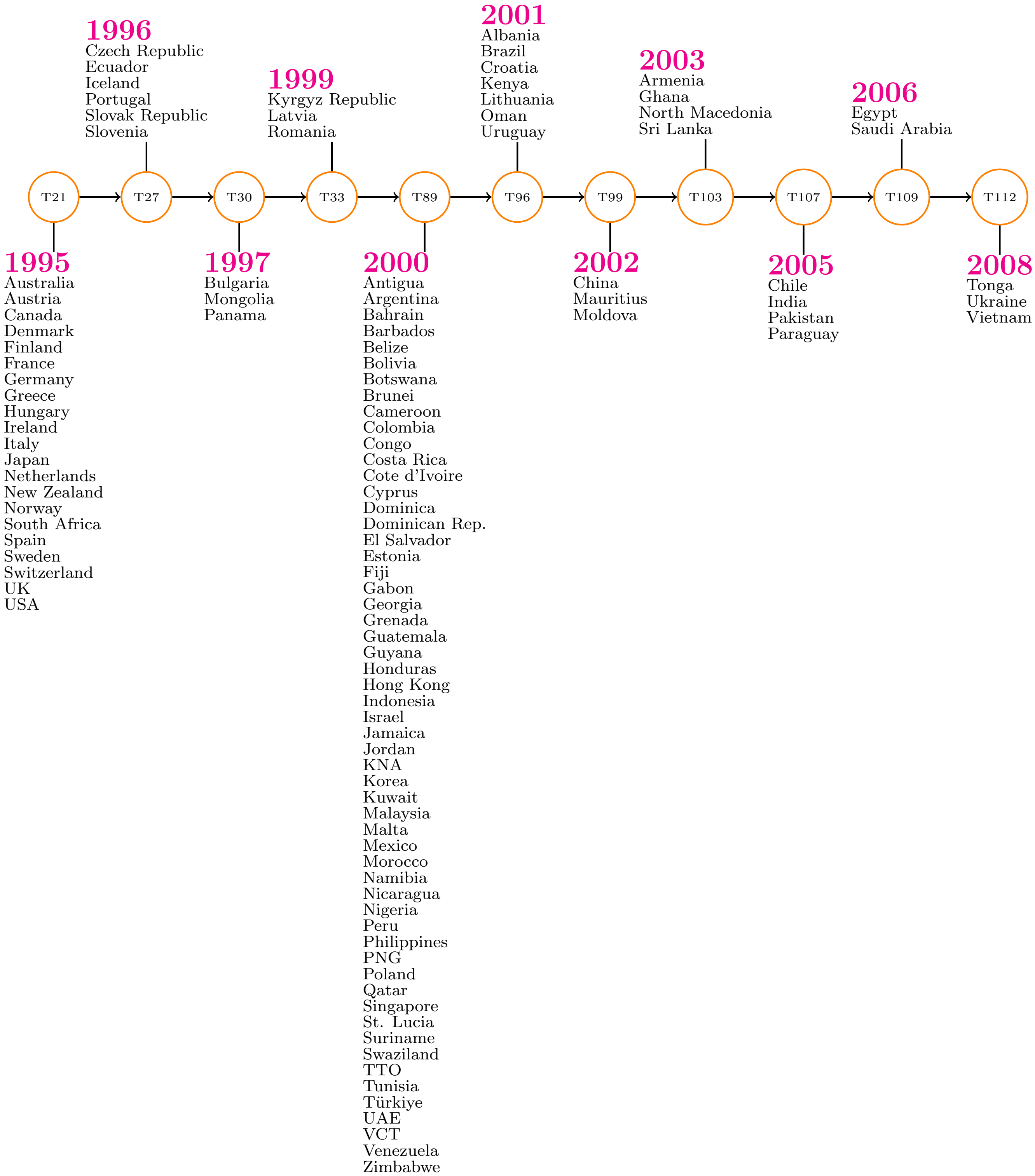
3 Methods

3.1 Structural gravity and pitfalls of TWFE estimator

As a benchmark, we employ the following econometric panel gravity model (Yotov et al. 2016), estimated using the PPML estimator (Silva and Tenreyro 2006) with data on consecutive years

[3] We extend our gratitude to Maskus and Ridley (2016) for sharing their data on TRIPS compliance.

Figure 1 TRIPS Compliance Timeline



Notes: The figure illustrates the timeline of TRIPS compliance. Each node lists the countries that became compliant in a given year, which we refer to as treatment-timing cohorts in our analysis. T# counts the total number of countries compliant by period g.

(Egger et al. 2022):

$$Trade_{ij,t} = exp\left\{\delta^{twfe}TRIPS_{ij,t} + \chi_{i,t} + \psi_{j,t} + \mu_{ij}\right\} \times \epsilon_{ij,t} \tag{1}$$

The dependent variable, $Trade_{ij,t}$, denotes the nominal trade flows from country i to county j at time t, and includes both international and domestic flows (Baldwin and Taglioni 2006; Yotov 2022). $TRIPS_{ij,t}$ equals 1 if both i and j are TRIPS compliant in year t and equals 0 otherwise, $\chi_{i,t}$ are *exporter-year* fixed effects, and $\psi_{j,t}$ are *importer-year* fixed effects which account for unobserved multilateral resistance (Anderson and Van Wincoop 2003). 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. Further, μ_{ij} are directional *exporter-importer* (pair) fixed effects which mitigate the endogeneity in panel data (Baier and Bergstrand 2007), and additionally control for symmetric and asymmetric time-invariant trade costs, such as distance, contiguous border, common language, and colonial history etc. Finally, $\epsilon_{ij,t}$ is a multiplicative error term. In a baseline model of aggregate manufacturing trade flows, we cluster standard errors by exporter-importer level to account for the serial correlation in the error term within pairs over time (Egger and Tarlea 2015). In the robustness check, we consider alternative dimensions of standard error clustering.

However, the TWFE estimate of the impact of TRIPS on trade, δ^{twfe}, in equation (1) captures the common/average effects of TRIPS on bilateral trade flows and may lead to erroneous conclusions in a setting with staggered treatment adoption and treatment effects heterogeneity. Moreover, in a standard TWFE specification (1), the estimated impact of TRIPS is obtained as the weighted average of a series of 2×2 unit-specific difference-in-differences estimates:

$$E[\delta^{twfe}] = E\left[\sum_{ij,t:TRIPS_{ij,t}=1} w_{ij,t}\tau_{ij,t}\right]$$

where $\tau_{ij,t}$ denotes the average treatment effect (ATE) in country pair ij at time t. In other words, for observations with $TRIPS_{ij,t} = 1$, the TWFE specification calculates the ATE for each pair ij at time t, and then takes their weighted averages to obtain the overall effect of complying with the agreement. The weights sum to 1 but may be negative, because the TWFE estimator uses already-compliant units as a comparison for units that complied with the agreement later, referred to as "forbidden comparisons". The negative weights are problematic because δ^{twfe} could be negative even when unit-specific treatment effects ($\tau_{ij,t}$'s) are all positive, i.e., TWFE may not identify a convex combination of treatment effects (see, for example, De Chaisemartin and d'Haultfoeuille 2020; Goodman-Bacon 2021; Callaway and Sant'Anna 2021; Sun and Abraham 2021; De Chaisemartin and d'Haultfoeuille 2023; Borusyak et al. 2024).

Moreover, the average response of trade flows to the implementation of TRIPS may be heterogeneous both across treatment cohorts and over different event-time horizons, rendering the TWFE estimator less favorable. First, the enforcement mechanisms may vary across countries, and in some cases, they may have been slow to develop, so that any discernible effects of TRIPS may only manifest itself over time. Second, the impact of TRIPS-induced IPR reforms depends crucially on complementary investments, such as the availability of electricity in ICT and trained staff in the pharmaceuticals, electronics, and professional goods industries. Given the heterogeneity in the level of such investments across countries, the impact of TRIPS may vary accordingly (Delgado et al. 2013). Third, the impact of TRIPS could be different for the countries that complied with the agreement earlier, versus those that complied later (Egger et al. 2024). Finally, the impact of TRIPS compliance on trade could also be different at different lengths of treatment exposure, i.e., the average treatment effect may increase or decrease with elapsed treatment time.

3.2 Heterogeneity-robust staggered DiD in gravity settings

To avoid the potential pitfalls of TWFE regression that may arise in presence of treatment effect heterogeneity at cohort-year level, we follow Nagengast and Yotov (2025) while preserving all the recommendations from the gravity literature. Specifically, we replace the δ^{twfe} coefficient and a single indicator variable for TRIPS membership between i and j at time t ($TRIPS_{ij,t}$) in equation (1) with the following term:

$$\sum_{g=q}^{T}\sum_{s=g}^{T}\delta_{gs}D_{gs}$$

Therefore, our main estimating equation becomes:

$$Trade_{ij,t} = exp\left\{\sum_{g=q}^{T}\sum_{s=g}^{T}\delta_{gs}D_{gs} + \chi_{i,t} + \psi_{j,t} + \mu_{ij}\right\} \times \epsilon_{ij,t} \tag{2}$$

where country pair ij belongs to the treatment cohort g if the TRIPS onset for this pair was in period g, q is the first year of treatment of cohort g and T is the last year of sample period, D_{gs} is a time-varying treatment indicator equal to 1 for cohort g for $s = t$ in post treatment periods and 0 otherwise [4], and δ_{gs} captures the cohort-year-specific treatment effects.[5] Equation (2) implements the extended two-way fixed effect (ETWFE) estimator of Wooldridge (2023) for non-linear models. This approach allows for treatment effect heterogeneity at cohort-year level by additionally introducing suitable cohort-by-year interactions, while also avoiding the problem of "forbidden comparisons"(Nagengast and Yotov 2025).[6]

The cohort-time treatment effects δ_{gs} in case of non-linear PPML model are obtained as a ratio of means in treatment versus counterfactual state rather than the difference in means as in linear case (Athey and Imbens 2006; Ciani and Fisher 2019), that is., $\forall\, g \in \{q, \ldots, T\}$ and $s \in \{g, \ldots, T\}$:

$$\delta_{gs} = \ln\left(\frac{E[Y_t(g) \mid D_g = 1]}{E[Y_t(\infty) \mid D_g = 1]}\right)$$

where $Y_t(g)$ is the potential outcome (trade flows) of cohort g at time t in a treated state, and $Y_t(\infty)$ is the potential outcome for the same cohort in the never treated (counterfactual) state, D_g is a binary variable indicating membership to cohort g. In a standard DiD settings, however, $Y_t(\infty)$

[4]Suppose country pair ij first complied with the agreement in 1997, then this pair belongs to $g = 1997$ cohort and the post-treatment dummy D_{gs} takes the value of 1 for $t \geq 1997$ and 0 otherwise. The treatment periods $q = 1997, 1998, 1999....T$ denote the immediate, first, second, and subsequent years since the onset of treatment for the corresponding cohort.

[5]For example, $\delta_{1997,1997}$ captures the instantaneous treatment effect of TRIPS on trade for $g = 1997$ cohort, and $\delta_{1997,1998}$ captures the treatment effects for the same cohort one year after the agreement inception, similarly for other cohorts. Naturally, as the number of cohorts and time-periods increase, the number of δ_{gs} terms to be estimated also grows accordingly.

[6]The ETWFE relies on two types of comparisons: not-yet-complied and never-complied units. First, in a setting where never-complied group behaves differently from other eventually-complied groups, or is not available, the ETWFE uses units that have not-yet-complied by period g as a valid comparison group (Callaway and Sant'Anna 2021). For example, to identify the treatment effects for cohort $g = 1997$, it uses all other cohorts that have not yet complied with the agreement by 1997 ($g = 1998, 1999, 2000$, etc.) as a comparison group. Second, to identify the relevant estimands, one can leverage pure never-treated group that did not receive the treatment during the sample period as a valid comparison.

is unobserved for periods after g, i.e., we cannot observe the same cohort in both the treated and untreated states simultaneously, a limitation often referred to as fundamental problem of causal inference. Therefore, to identify δ_{gs}, the ETWFE estimator imposes parallel trend assumption, such that:

$$\frac{E[Y_t(\infty) \mid D_g, \ldots D_T]}{E[Y_1(\infty) \mid D_g, \ldots D_T]} = exp\{\boldsymbol{\pi_t}\}, \quad \forall\, t \in \{1, ...T\} \tag{3}$$

where $\boldsymbol{\pi}_t$ is a vector that captures all the coefficients corresponding to *exporter-year* and *importer-year* fixed effects. The parallel trend assumption states that the growth in the outcome of the treatment and control group would have been same in absence of treatment, i.e., growth may depend on time-varying covariates $\boldsymbol{\pi}_t$ but not on the treatment $\boldsymbol{D}_i = D_{iq}, \ldots, D_{iT}$ (see, for example, Borusyak et al. 2024 for more).

3.2.1 Partial aggregation of cohort-time average treatment effects

The ETWFE estimator estimates the family of cohort-time average treatment effects ($\delta_{g,s}$). However, in DiD settings with multiple cohorts and time periods, interpreting all the cohort-time average treatment effects may be challenging (see footnote 5). The ETWFE estimator consider several partial aggregation schemes to combine $\delta_{g,s}$ into a more manageable set of causal parameters. In particular, we are interested to highlight the treatment effect heterogeneity across three dimensions: (i) What is the overall average impact of TRIPS on trade? which we refer to as simple weighted average (ii) How do the effects of TRIPS compliance evolve with the duration of exposure to the agreement? referred to as event-study-type estimands, and (iii) Does the average treatment effects differ between cohorts that complied with the agreement earlier and those that complied later? which we call cohort-specific estimands.

(i) Simple weighted average

Our main estimation target is to obtain a single (average) impact of TRIPS on international trade, calculated as the weighted average of estimated cohort-time-specific treatment effects as:

$$\delta_{average} = \sum_{g=q}^{T} \sum_{s=g}^{T} \frac{N_{gs}}{N_D}\, \hat{\delta}_{gs} \tag{4}$$

where the weights $\frac{N_{gs}}{N_D}$ correspond to the total number of observations of cohort g in period s, N_{gs}, relative to the total number of treated observations, $N_D = \sum_{g=q}^{T} \sum_{s=g}^{T} N_{gs}$.

(ii) Event-study estimands

In DiD setup with multiple time periods, often the interest lies in comparing the outcome trajectories over different lengths of event horizon. As discussed in Subsection 3.1, trade flows may exhibit a delayed response to the initiation of TRIPS, i.e., the estimated effects may increase/decrease with elapsed treatment time, making the dynamic treatment effects of particular interest to us. Therefore, we compute event-time-specific treatment effects by averaging over cohort-dimensions as follows:

$$\delta_{.s} = \sum_{g=q}^{s} \frac{N_{gs}}{N_{.s}} \hat{\hat{\delta}}_{gs} \tag{5}$$

where $N_{.s} = \sum_{g=q}^{s} N_{gs}$ is the total number of treated observations in period s.

(iii) Cohort-specific estimands

Finally, we consider the average effect of complying with the TRIPS agreement across cohort, which we refer to as cohort-specific estimands by averaging over time dimension as follow:

$$\delta_{g.} = \sum_{s=g}^{T} \frac{N_{gs}}{N_{g.}} \hat{\hat{\delta}}_{gs} \tag{6}$$

where $N_{g.} = \sum_{s=g}^{T} N_{gs}$ is the total number of post-treatment observations of cohort g. Although understanding this sort of heterogeneity is relatively less common in applied work, it may be of particular interest in international trade, to understand the role of sequential trade liberalization and incumbency effects (Egger et al. 2024). Accordingly, countries trade more if they complied with the TRIPS agreement earlier than those that complied later. In other words, trade flows are influenced not only by current trade frictions, as (implicitly) assumed in standard gravity equations, but also depend on the history of trade liberalizations.

4 Data

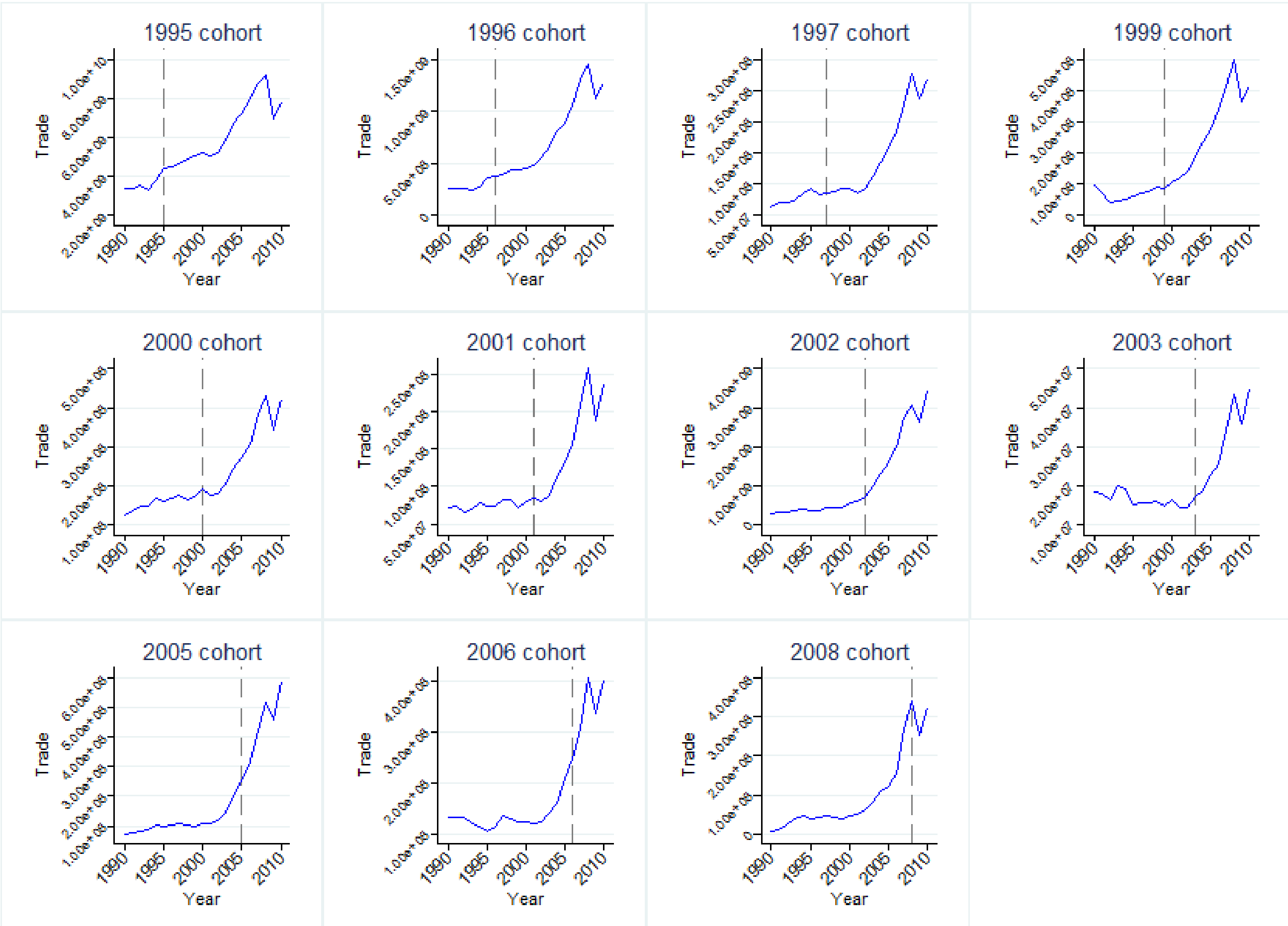
The empirical analysis is conducted using three standard datasets: (i) The data on bilateral trade flows that we use to obtain our main results comes from the 'Structural Gravity Database (SGD)' of the WTO (Monteiro 2020). The SGD provides aggregate manufacturing trade flows for 229 trading partners over the 1980-2016 period. It includes consistent data on both international and domestic trade flows, and we demonstrate that ETWFE results are sensitive to the exclusion of domestic trade flows (Yotov 2022) (ii) Since, the impact of TRIPS may vary across industries depending on their sensitivity to intellectual property. To perform the industry-level analysis, we draw on the 'International Trade and Production Database for Estimation (ITPD-E, release 2)', that contains detailed information on international and domestic trade flows pertaining to 118 manufacturing industries for the period 1988-2017 (Borchert et al., 2021, 2022). (iii) To control for confounders that may affect the outcome variable (trade) other than the treatment (TRIPS), we use standard gravity variables (e.g., bilateral distance) from CEPIIs 'Gravity' database (Conte et al. 2022) (iv) Finally, we employ multiple classification criteria to determine the year in which each country became TRIPS compliant, including the WTO's original compliance schedule.

5 Main findings

This section presents our main results. We begin by examining the growth rate of trade flows across cohorts, as shown in Figure 2. The vertical line in each plots indicates the onset of TRIPS for the respective cohort. We find that the growth in trade was generally modest prior to TRIPS compliance, and increased noticeably thereafter, across nearly all cohorts. We now proceed to the formal estimation results.

In Subsection 5.1 we test the parallel trend assumption underlying the ETWFE estimator. In Subsection 5.2 we discuss our main results. Finally, in Subsection 5.3, we present event-study-type estimates that illustrate how the treatment effects evolve over over time following the inception of the agreement, including the cohort-specific TRIPS estimates.

Figure 2 Trade flow growth across cohorts

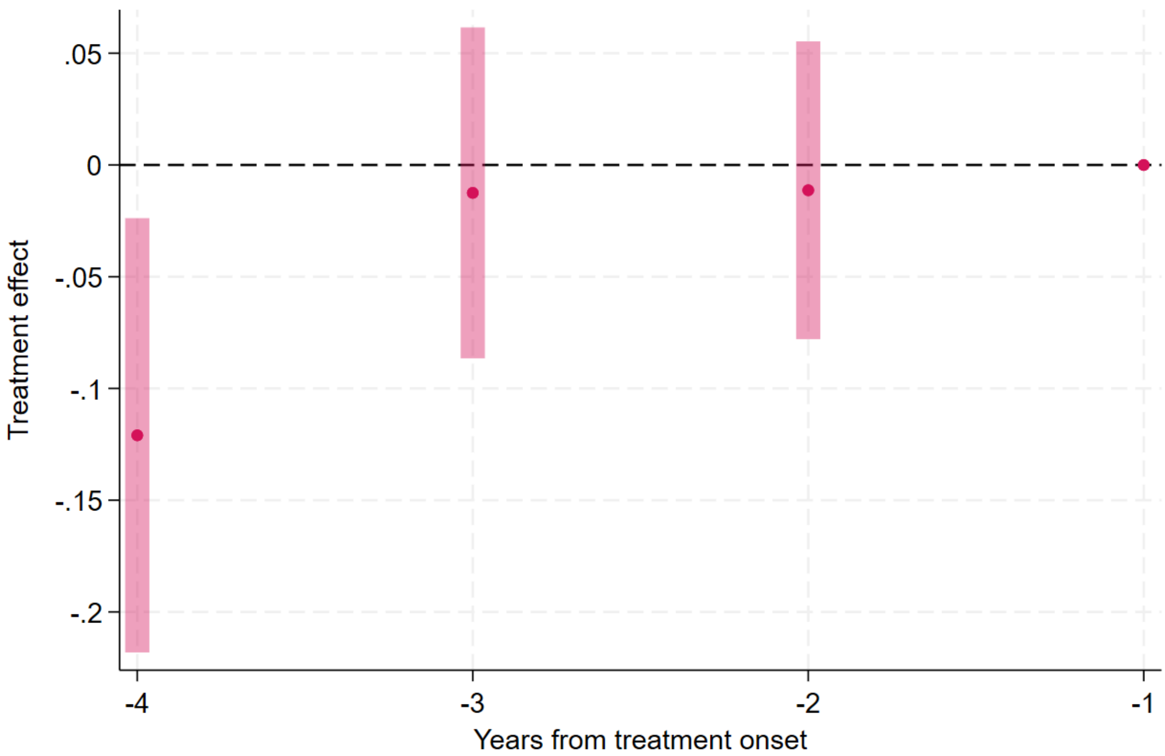


Notes: The figure shows the evolution of nominal trade flows for each cohort during 1990-2010 period. The vertical line in each panel indicates the onset of TRIPS for the respective cohort.

5.1 Test of identifying assumption

A key identifying assumption in DiD analysis requires that, in the absence of treatment, the growth in the average outcomes for treated and comparison cohorts would have been the same, commonly known as parallel (or common) trend assumption (PTA). To test the validity of PTA in the ETWFE model (Wooldridge 2023; Nagengast and Yotov 2025), we replace the treatment effects in equation (2) with cohort-year-specific placebo effects prior to the treatment onset, after conditioning on the covariates (Heckman et al. 1997; Callaway and Sant'Anna 2021; Wooldridge 2023). The conditional parallel trend (CPTA) becomes more plausible when the distribution of observed covariates, such as bilateral distance, differs significantly between treated and never-treated country pairs.[7] The results depicted in Figure 3 for the placebo treatment effects provide no evidence of differential pre-TRIPS trends, as all pre-treatment effects are not significantly different from zero. Therefore, CPTA is tenable, and we proceed to obtain our main results.

Figure 3 Pre-treatment effects



Notes: The figure reports the cohort-time-specific placebo treatment effects prior to the onset of TRIPS, obtained from a PPML estimation of equation (2). The regression is estimated using never-compliant units as a comparison (Borusyak et al. 2024). Pre-trend estimates were obtained by aggregating cohort-time-specific treatment effects using equation (5). To assess the validity of the conditional parallel trend assumption, cohort-time specific treatment effects are allowed to vary by time-constant covariate, bilateral distance. 95% confidence intervals were obtained from standard errors clustered by country pair.

5.2 Main estimation results

Using the data on aggregate manufacturing trade flows from the Structural Gravity Database, Table 1 reports the average impact of TRIPS compliance on international trade. The estimates in column (1) correspond to the standard TWFE regression specified in equation (1), which is

[7]Bilateral distance is most widely used proxy for bilateral trade costs in the gravity literature (Anderson and Van Wincoop 2004; Disdier and Head 2008)

estimated using the data on consecutive years. Employing the PPML estimator with exporter-time, importer-time, and country pair fixed effects, we find that the TRIPS effect is positive and statistically significant, implying that on average TRIPS compliance led to an increase of about 58% $\big((e^{0.455}-1)\times 100 = 57.61\big)$ in trade among member countries, relative to the comparison group.

Table 1 Average TRIPS effects on trade: TWFE vs. ETWFE estimates

	(1) TWFE	(2) ETWFE	(3) TWFE	(4) ETWFE
$TRIPS_{ij,t}$	0.455***	0.455***	-0.016	0.262***
	(0.020)	(0.019)	(0.037)	(0.101)
$Observations$	344,188	344,188	342,278	342,278
$Exporters$	145	145	145	145
$Importers$	145	145	145	145
$Years$	21	21	21	21
$Coefficients$	1	109	1	109
$Domestic\ trade$	Yes	Yes		
$Exporter \times Year\ FE's$	Yes	Yes	Yes	Yes
$Importer \times Year\ FE's$	Yes	Yes	Yes	Yes
$Exporter \times Importer\ FE's$	Yes	Yes	Yes	Yes

Notes: The table presents the PPML estimates using both TWFE regression, which captures the common TRIPS effect (equation 1), and the ETWFE model, which implements the heterogeneity-robust staggered DiD method (equation 3), for which cohort-time specific treatment effects were aggregated using equation (4) to obtain the average impact of compliance with the agreement. The dependent variable is nominal trade flows (exports) in levels, varying over exporter-importer-year dimension. Results in column (1) and column (2) are based on full sample including both international and domestic trade flows, whereas those in column (3) and column (4) are obtained from the sample without domestic trade flows. Standard errors clustered by country pair are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. The row labeled 'Coefficients' reports the number of parameters estimated in a given model apart from fixed effects.

The estimates in column (2) correspond to the ETWFE estimator specified in equation (2), which employ the heterogeneity-robust staggered DiD method. Note that the ETWFE estimator estimates 109 cohort-time-specific treatment effects (δ_{gs}), which are then aggregated using equation (4) to obtain a single estimated effect of TRIPS compliance. The TRIPS compliance estimate is again positive and statistically significant, with a magnitude nearly identical to that obtained from the TWFE estimator. These results indicate that compliance with the TRIPS agreement has led to a significant increase in trade flows between member countries, providing evidence of knowledge diffusion (Eaton et al. 2004; Keller 2004; Delgado et al. 2013).

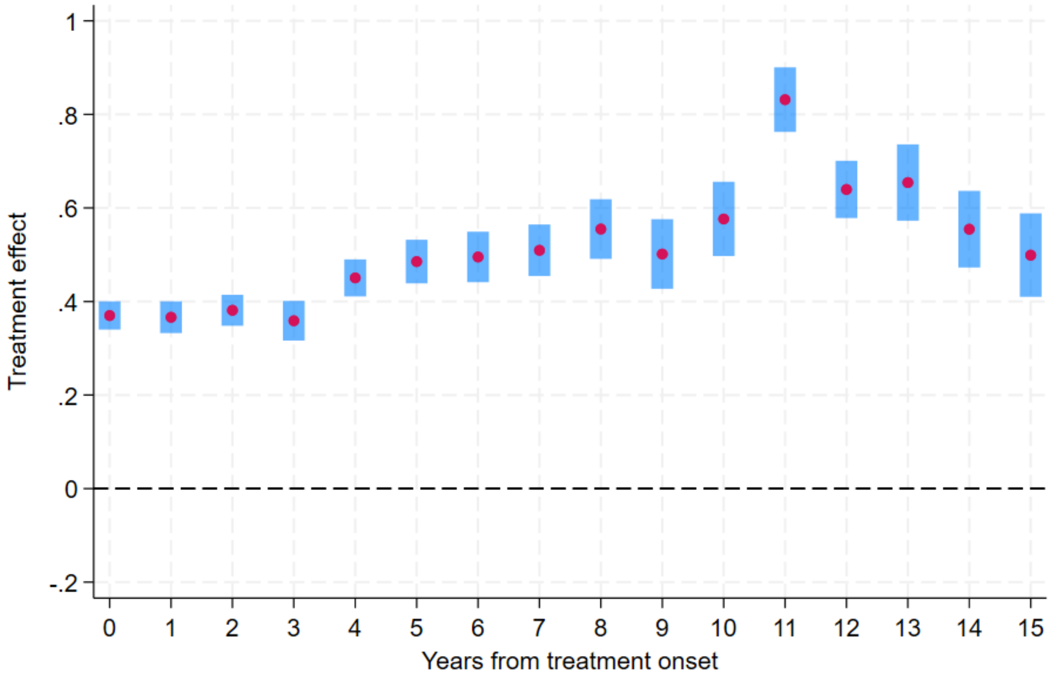
The sensitivity of the baseline results is tested by re-estimating the model without domestic trade flows. The TWFE TRIPS-compliance estimate in column (3) is no longer significant, whereas the ETWFE estimate in column (4) remains positive and statistically significant, albeit smaller than the corresponding estimate in column (2). The difference between the implied trade effects is approximately 27 percentage points (57% from column 2 versus 30% in column 4). Thus, consistent with Nagengast and Yotov (2025), Nagengast et al. (2025), and Yotov (2022), we find that estimates based solely on international trade flows may be biased downward, underlining the role of domestic trade flows in our estimation exercise.

5.3 Event-study and cohort-specific TRIPS effects on trade

We complement the aggregate TRIPS estimates from Table 1 with a series of disaggregated results. As discussed in Subsection 3.1, we expect the causal effect of TRIPS to vary depending on the years relative to the inception of agreement. Figure 4 presents the event-time-specific ETWFE TRIPS estimates, which are computed from the cohort-time-specific treatment effects ($\delta_{g,s}$) by averaging over the cohort dimensions, as specified in equation (5). We find, first, that trade flows exhibit a gradual response during the first few years following the implementation of TRIPS. One plausible explanation for this could be that the enforcement mechanism may have been slow to develop, and thus IPR protection may have become effective only after some time, resulting in delayed trade response to the agreement (Delgado et al. 2013). Second, the phasing-in effects of TRIPS on trade are positive and statistically significant, which is consistent with our aggregate estimates from Table 1. Third, trade flows exhibit a sustained positive response to TRIPS compliance for roughly 11 years after its inception, before eventually declining. This pattern can be attributed to the fact that TRIPS compliance reached its "maturity phase", around 11-12 years from its implementation, after which the trade response to the agreement begins to diminish (Egger et al. 2022; Sheikh and Kanwar 2024).

Next, to examine treatment effect heterogeneity across different treatment-timing cohorts, we aggregate cohort-time-specific treatment effects ($\delta_{g,s}$) over the time dimension, as specified in equation (6). In our setting, understanding this sort of heterogeneity is particularly intriguing, where

Figure 4 Event-time-specific TRIPS effects

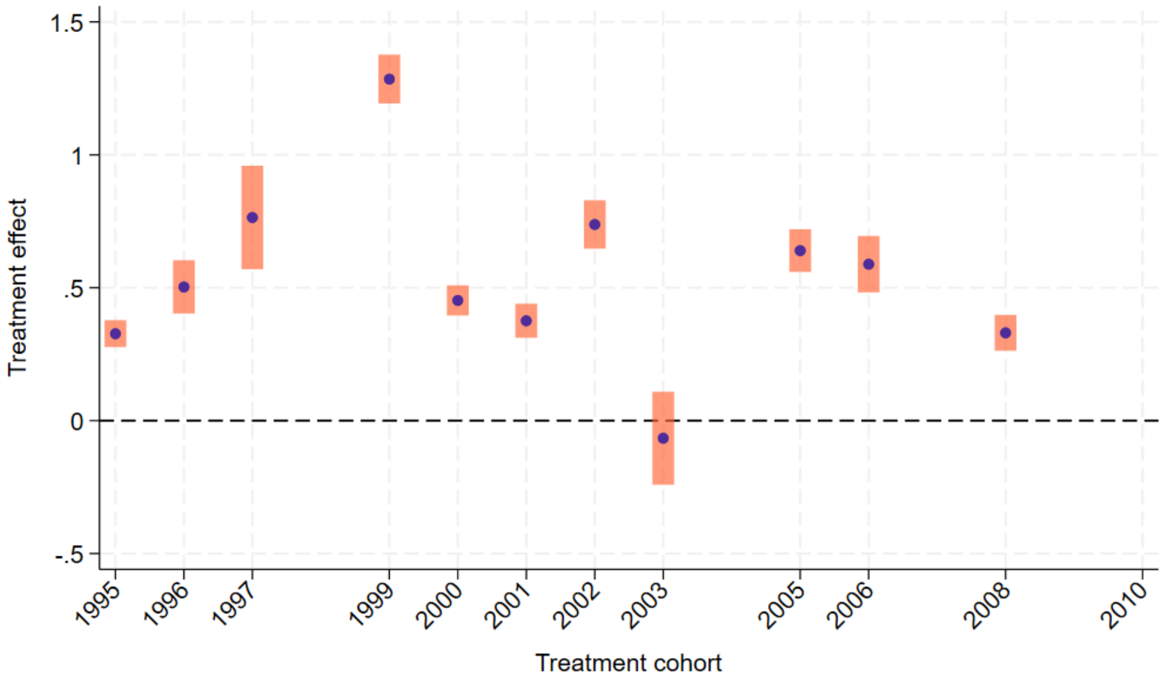


Notes: The figure reports event-year-specific ETWFE estimates of TRIPS, where cohort-year treatment effects were aggregated across cohorts using equation (5) to obtain the dynamic effects relative to the implementation of agreement. Outcome variable is nominal trade flows in levels that varies over exporter-importer-year dimension. 95% confidence intervals were obtained from standard errors clustered by country pair.

compliance timing is as important as compliance itself. Figure 5 presents the cohort-specific treatment effects. Two main results stand out. First, almost all cohort estimates are positive and statistically significant, which is consistent with baseline findings in Table 1, indicating that TRIPS implementation has enhanced bilateral trade flows among members. Second, the TRIPS compliance effects are quite heterogeneous across cohorts. Specifically, early-complying cohorts experience stronger impact compared to later-complying cohorts. These findings are consistent with Egger et al. (2024), who highlight the role of sequential trade liberalization and incumbency effects, i.e., countries tend to trade more if they liberalized their trade relationship earlier, and less if they liberalize later. Therefore, it is not merely compliance, but rather the *timing* of compliance as well, that appears to be important for trade flows, and the latter factor appears to be the relatively important in our setting.

Lastly, we obtain event-time specific ETWFE estimates by cohort, to trace the evolution of the TRIPS effects over time for each cohort in our sample. Our findings depicted in Figure 6, demon-

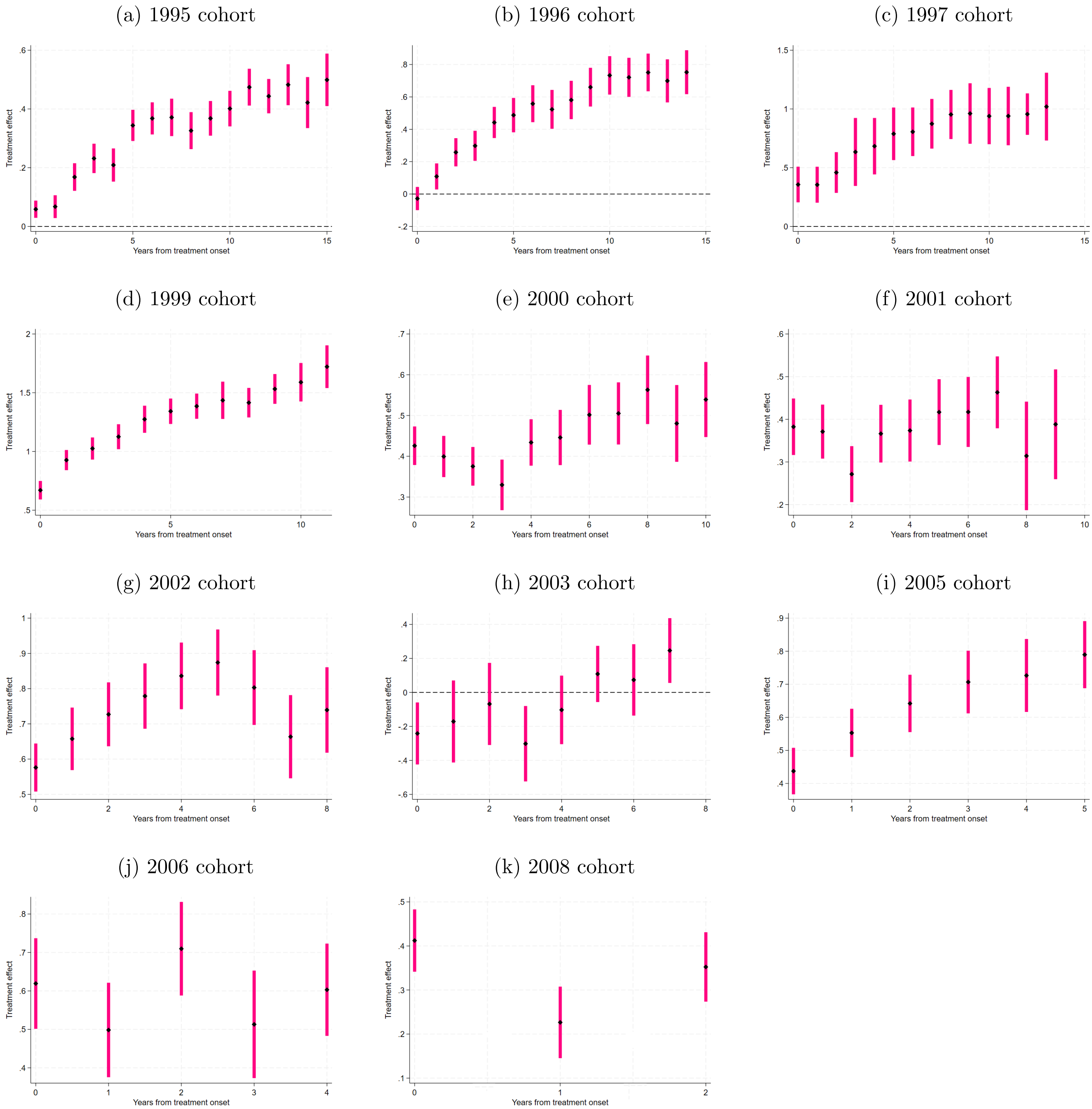
Figure 5 Cohort-specific treatment effects



Notes: The figure reports cohort-specific ETWFE estimates of TRIPS, where cohort-year-specific treatment effects are averaged over time-dimension using equation (6). Outcome variable is nominal trade flows in levels that varies over exporter-importer-year dimension. 95% confidence intervals were obtained from standard errors clustered by country pair.

strate that the aggregate estimates presented in Table 1 mask significant heterogeneity. First, we find stronger positive effects for the 1995 cohort, which persist for up to 15 years following TRIPS compliance. Similar long-lasting effects are also observed for other early compliance cohorts. These results suggest that advanced countries benefit more from TRIPS implementation. One plausible explanation could be that countries in the early compliance cohorts, predominately high-income countries, have substantial technical capacity at the time of TRIPS implementation and were well positioned to translate stronger intellectual property protections into tangible trade gains in terms of higher exports. Second, we observe that cohorts which implemented TRIPS in later years initially exhibit a decline in trade flows. Thus, for instance, although the average treatment effects for the 2000 and 2001 cohorts are positive and statistically significant, they decline during the first 3 years post-compliance and then begin to rise from around the fourth year onwards. The reason is that the stronger IPRs are likely to enhance trade when accompanied by carefully tailored policies and a range of complementary measures. However, most of the developing countries (which constitute

Figure 6 Event-time specific TRIPS effects by cohort



Notes: The figure reports the event-time-specific ETWFE estimates of TRIPS by cohort. Outcome variable is nominal trade flows in levels that varies by exporter-importer-year dimension. 95% confidence intervals were obtained from standard errors clustered by country pair.

the late-compliers group), were ill-equipped to implement TRIPS. They incurred substantial costs to develop the relevant legal expertise, required to administer IPR rules as mandated by TRIPS agreement (Deere 2009). In other words, their domestic enforcement mechanism developed slowly, so that the trade response following TRIPS compliance initially diminished and began to increase only after a lag. Third, interestingly, the effects for the 2002 cohort (China, Moldova, Mauritius) remain significantly positive and relatively stronger for up to five years after the agreement's implementation, before eventually declining. We attribute this pattern primarily to the presence of China as a major trading partner within the cohort. Finally, the effects for the 2005 cohort (Chile, India, Pakistan, Paraguay), countries that leveraged the extended compliance deadline granted under WTO by withholding patent protection in certain technological fields, experienced a sustained positive response of trade in the years after TRIPS compliance.

6 Robustness experiments

6.1 Heterogeneity of ETWFE and alternative estimators

The ETWFE estimates the family of cohort-time-specific treatment effects ($\delta_{g,s}$). In this exercise, we consider variants of the ETWFE estimator that require the estimation of fewer coefficients, by imposing restrictions on treatment effect heterogeneity. The Table 2 column (1) estimates correspond to the case where the treatment effects are allowed to vary only at the event-time level. This is similar to standard dynamic event-study specification, used to highlight the treatment effect heterogeneity across different lengths of exposure to the treatment. The results reveal that TRIPS implementation has led to a 54% $\big((e^{0.433} - 1) \times 100 = 54.18\big)$ increase in bilateral trade among its members. In column (2) we allow for only cohort-level heterogeneity in treatment effects, and find that the TRIPS compliance coefficient remains positive, though slightly larger than the estimate reported in column (1). Therefore, we conclude that cohort heterogeneity is more important than event-time-specific heterogeneity in our setting.

In column (3), we allow treatment effect heterogeneity across both cohort-time and event-time dimensions (akin to our baseline results in column 2 of Table 1) and investigate the robustness of our results to alternative clustering of standard errors. Note that, in the baseline estimates reported in Table 1, standard errors were clustered at the *exporter-importer* (country pair) level. By contrast, the results in column (3) of Table 2 cluster standard errors by *exporter-importer-year*

Table 2 Degree of heterogeneity of the ETWFE and alternative estimators

	(1)	(2)	(3)	(4)	(5)
$TRIPS_{ij,t}$	0.433***	0.450***	0.455***	0.254***	0.070**
	(0.020)	(0.020)	(0.067)	(0.048)	(0.026)
PPML/OLS	*PPML*	*PPML*	*PPML*	*OLS*	*OLS*
Estimator	*ETWFE*	*ETWFE*	*ETWFE*	*ETWFE*	*TWFE*
Unit heterogeneity		*Cohort*	*Cohort*	*Cohort*	*Cohort*
Time heterogeneity	*Event*		*Event*	*Event*	*Event*
Standard error clustering	$Exp \times Imp$	$Exp \times Imp$	$Exp \times Imp \times Year$	$Exp \times Imp$	$Exp \times Imp$
Observations	344,188	344,188	344,188	290,785	290,785
Exporters	145	145	145	145	145
Importers	145	145	145	145	145
Years	21	21	21	21	21
Coefficients	16	11	109	109	1
$Exporter \times Year\ FE's$	Yes	Yes	Yes	Yes	Yes
$Importer \times Year\ FE's$	Yes	Yes	Yes	Yes	Yes
$Exporter \times Importer\ FE's$	Yes	Yes	Yes	Yes	Yes

Notes: The table presents PPML estimates of equation (2) using variants of the ETWFE model, except for column (4) and column (5), which are based on OLS. The ETWFE estimates are obtained by aggregating cohort-time-specific treatment effects using equation (4) to derive the overall impact of compliance with TRIPS agreement. Column (1) imposes complete homogeneity in treatment effects across cohorts while allowing heterogeneity along the event-year dimension. Column (2) allows treatment effects to vary across cohorts but imposes complete homogeneity along the event-year dimension. Column (3) allow treatment effects to vary across both cohort-year and event-year dimensions (as in column (2) of Table 1), with standard errors clustered at exporter-importer-year level. Column (4) and (5) report the ETWFE and TWFE estimates, respectively, obtained using OLS estimator, where the dependent variable in logarithm of trade flows. Standard errors clustered at country pair level are reported in parenthesis (except for column (3)). Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

level. The standard error more than doubles (0.019 vs. 0.067), though the magnitude and the level of significance of estimated coefficient remains unchanged.

Column (4) reports the ETWFE results based on the OLS estimator, in contrast to PPML estimator, which serves as the workhorse model in structural gravity settings (Silva and Tenreyro 2006). The TRIPS compliance coefficient is relatively small, indicating the trade among member states increased by 29%, which is roughly half the magnitude of the corresponding estimate based on PPML estimator (column 2, Table 2).

Column (5) reports TWFE estimates based on OLS estimator, which is still widely used in the empirical literature examining the impact of IPRs on trade (Ivus 2010; Delgado et al. 2013; Ivus and Park 2019 etc.). Again, the results indicate a smaller economic impact of TRIPS compliance on trade, compared to the baseline results reported in Table 1. Therefore, our observation that the TWFE estimates are severely downward biased remains unchanged with both the OLS and PPML estimators (Nagengast and Yotov 2025; Nagengast et al. 2025), and this remain a significant shortcoming of the existing literature.

6.2 DiD and ETWFE related experiments

This section offers additional robustness checks with respect to DiD and ETWFE specific assumptions. First, we consider the sensitivity of our findings by relaxing the parallel trend assumption. Second, we experiment with an alternative weighting scheme for obtaining the aggregate treatment effect estimates. Our findings are reported in Table 3.

Table 3 Additional results using covariate interactions and alternative weighting schemes

	(1)	(2)	(3)	(4)	(5)
$TRIPS_{ij,t}$	0.066**	0.540***	0.372***	0.566***	0.460***
	(0.035)	(0.018)	(0.015)	(0.019)	(0.019)
$Covariate\ interactions:$					
$log(Distance)$	Yes				
$Weights$		Cohort	Year	Cohort × Year	Trade
$Observations$	344,188	344,188	344,188	344,188	344,188
$Exporters$	145	145	145	145	145
$Importers$	145	145	145	145	145
$Years$	21	21	21	21	21
$Coefficients$	247	109	109	109	109
$Exporter \times Year\ FE's$	Yes	Yes	Yes	Yes	Yes
$Importer \times Year\ FE's$	Yes	Yes	Yes	Yes	Yes
$Exporter \times Importer\ FE's$	Yes	Yes	Yes	Yes	Yes

Notes: The table reports the PPML estimates of equation (2) corresponding to DiD-and the ETWFE-specific assumptions. The ETWFE estimates are obtained by aggregating cohort-time-specific treatment effects using equation (4) to derive the overall impact of compliance with the agreement. The dependent variable is nominal trade flows in levels that varies by exporter-importer-year dimension. Column (1) relaxes the unconditional parallel trend assumption by including interactions between $log(distance_{ij})$ and cohort-year-specific treatment effects (Callaway and Sant'Anna 2021; Wooldridge 2023). Column (2) - Column (5) reports results from alternative weighting scheme that differ from the approach in all other specifications that give every post-treatment observation the same weight. Instead, we give every cohort (column 2), every event-time (column 3), and every cohort-year (column 4) the same weight. We also experiment with trade-share weights in column (5). Standard errors clustered at country pair level are reported in parenthesis. ***, **, and * indicate the significance at the 1%, 5%, and 10% levels respectively.

As discussed in sub-section 5.1, the unconditional parallel trend may not be appropriate to identify the sensible causal parameter of interest. In many settings, the PTA may only hold when conditioning on covariates (Heckman et al. 1997; Callaway and Sant'Anna 2021; Wooldridge 2023). Therefore, in column (1), we consider an extension of ETWFE model, in which the cohort-time-specific treatment effects ($\delta_{g,s}$) are allowed to vary by time constant covariate (bilateral distance between countries). The results in column (1) are positive and significant, though economically smaller that the baseline estimates reported in Table 1. A key implication from this finding is that making treatment and control groups more comparable with regard to distance, and thereby relaxing the PTA may lead to a substantially smaller (7 %) impact of TRIPS compliance on trade.

Lastly, we consider alternative weighting schemes for obtaining the aggregate treatment effect estimates. In our baseline specification, we give every post-treatment observation the same weight. In this experiment, we give every cohort (column 2), every event year (column 3), or every cohort-year (column 4) the same weight. We also consider a variant of ETWFE model that uses trade share weights (column 5). The estimates based on event year weights reveal significantly smaller effects. By contrast, all other alternative weighting methods yield aggregate treatment effects that are considerably larger than our baseline estimate, as they either place greater weight on δ_{gs} with large magnitudes or assigns disproportionately higher weights to early-compliant cohorts, which, by design, have more distinct cohort-year pairs and therefore, on average, exhibit larger treatment effects (Nagengast and Yotov 2025).

7 Industry specific effects

The evidence from aggregate trade flows reported in the preceding analysis is rather extensive, and the impact of TRIPS compliance is likely to vary between sectors marked by different knowledge-intensity. Policy changes induced by TRIPS may be more consequential for trade in knowledge-intensive industries, where substantial investments in R&D is undertaken and patents are considered an important mechanism for safeguarding competitive advantage and securing monopoly rents (Cohen et al. 2000). Moreover, many trade policies, such as those related to IPRs, are negotiated at the sectoral level, so that implementation of TRIPS disproportionately impacted patent protection in knowledge-intensive industries.

To identify industry-specific effects of TRIPS compliance on trade, we draw on the detailed industry-level ITPD-E database, which provides consistent data on both international and domestic trade flows pertaining to 118 manufacturing industries for the period 1988-2017 (Borchert et al., 2021, 2022). Our analysis requires classification of product categories that vary in terms of their sensitivity to intellectual property, we follow Sheikh and Kanwar (2024) to classify ITPD-E industries into high-IPR and low-IPR intensive sectors. Within the broad category of high-IPR group, the classification further subdivides product categories into patent-intensive, trademark-intensive, and copyright-intensive sub-groups. We augment the ETWFE specification in equation (2) to estimate:

$$Trade_{ijkt} = exp\left\{\sum_{g=q}^{T}\sum_{s=g}^{T}\delta_{gs}D_{gs} + \chi_{ikt} + \psi_{jkt} + \mu_{ijk}\right\} \times \epsilon_{ij,t} \tag{7}$$

Equation (7) is estimated with the data pooled across sectors. Variable $Trade_{ijkt}$ denotes the nominal trade flows between country i and country j in industry k at time t. The multilateral resistances, however, are sector specific, and we include *exporter-industry-year* (χ_{ikt}) and *importer-industry-year* (ψ_{jkt}) fixed effects to control for time-varying industry-specific outward and inward multilateral resistances, respectively (Anderson and Van Wincoop 2003; Yotov et al. 2016). In addition, we incorporate *exporter-importer-industry* (μ_{ijk}) fixed effects to account for unobservable time-invariant bilateral characteristics specific to a given industry (Brunel and Zylkin 2022).[8] All other variables are as defined above, and estimation proceeds as before.

7.1 Average effects in High- and Low-IPR intensive industries

Table 4 column (1) presents the results for the sensitivity of trade flows in high-IPR-intensive industries, and column (2) presents similar results for low-IPR-intensive industries. We find that, on average, compliance with the TRIPS agreement led to an increase of about 46% in trade flows

[8]The estimation is computationally intensive, requiring approximately fifteen days to execute on a workstation equipped with an Intel Xeon 2.60 GHz processor and 80 GB RAM. The long runtime primarily reflects the inclusion of high-dimensional *exporter–industry–time*, *importer–industry–time*, and *exporter–importer-industry* fixed effects in the ETWFE specification, implemented in Stata using the `jwdid` package.

in high-IPR-intensive industries and 63% in low-IPR-intensive industries. This pattern may be driven by two underlying factors. First, while IPR protection is typically more relevant for high-IPR-intensive industries, it can also affect trade in low-IPR-intensive goods, which are relatively easier to imitate. Therefore, TRIPS-induced policy changes have reduced the risk of imitation, encouraging foreign firms to expand trade in these industries as well. Second, low-IPR-intensive industries include categories of commodities characterized by substantial technological change and process improvements, and therefore also exhibit a positive trade response to the implementation of TRIPS.

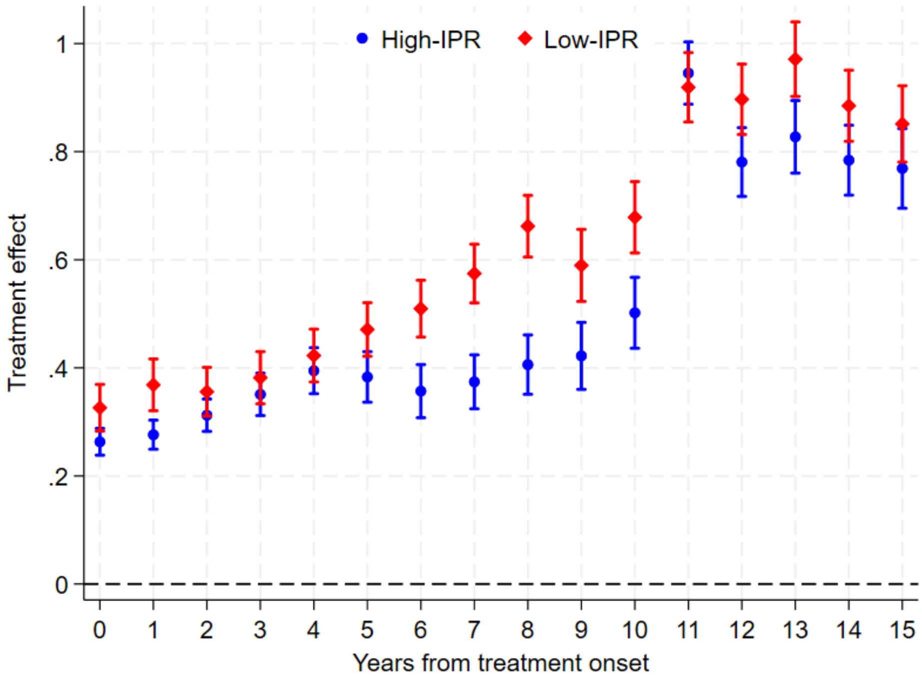
Table 4 Average TRIPS effects on trade in High-IPR and Low-IPR intensive industries

	(1) $High-IPR\,intensive$	(2) $Low-IPR\,intensive$
$TRIPS_{ij,t}$	0.378*** (0.018)	0.489*** (0.021)
$Observations$	15,619,903	8,816,341
$Exporters$	147	147
$Importers$	147	147
$Industries$	64	41
$Years$	21	21
$Coefficients$	109	109
$Exporter \times Industry \times Year\ FE's$	Yes	Yes
$Importer \times Industry \times Year\ FE's$	Yes	Yes
$Exporter \times Importer \times Industry\ FE's$	Yes	Yes

Notes: The table reports the PPML estimates of equation (7) using the ETWFE estimator, which implements a heterogeneity-robust staggered DiD method. Column (1) reports the ETWFE TRIPS estimates for high-IPR-intensive industries, and Column (2) in low-IPR-intensive industries. Standard errors clustered by country pair are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Figure 7 shows the event-time-specific ETWFE estimates of TRIPS across high-IPR and low-IPR intensive industries. The estimates of phasing-in effects of TRIPS are positive and statistically significant for both industry groups, with stronger impact observed in the latter, which is consistent with our finding reported in Table 4. The magnitude of the estimated effects increases over time throughout the period of investigation in both high-IPR and low-IPR-intensive industries, suggesting that the impact of TRIPS is long-lasting.

Figure 7 Event-time specific TRIPS effects in High-IPR and Low-IPR intensive industries



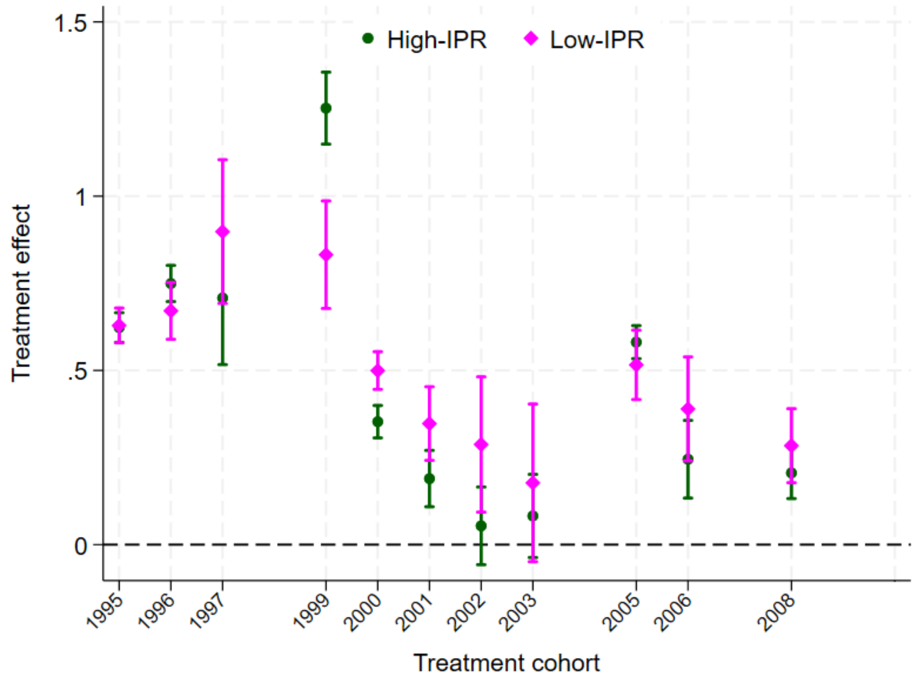
Notes: The figure presents the event-time-specific ETWFE estimates of TRIPS in High-IPR and Low-IPR intensive industries. The 95% confidence intervals were obtained from standard errors clustered by country pair.

Next, we capitalize on the advantages of ETWFE estimator to obtain cohort-specific effects of TRIPS compliance on trade in high-IPR and low-IPR intensive industries, which are visualized in Figure 8. We find that TRIPS has a stronger effect on trade in high-IPR intensive industries among early-complying cohorts, which are predominantly high-income countries, whereas for later-complying cohorts, largely comprising of low- and middle-income countries, the TRIPS implementation is associated with greater trade in low-IPR intensive industries.

7.2 Average effects in patent-, trademark-, and copyright-intensive industries

In this section, we analyze the heterogeneity of the impacts within the high-IPR-intensive group. In particular, we analyze the impact of $TRIPS_{ij,t}$ on trade flows in patents-, trademark-, and copyright-intensive industries. Table 5 indicates a significant positive impact of $TRIPS_{ij,t}$ on trade among member countries in each of the three industry types. Specifically, compliance with the

Figure 8 Cohort-specific TRIPS effects in High-IPR and Low-IPR intensive industries



Notes: The figure presents the cohort-specific ETWFE estimates of TRIPS in High-IPR and Low-IPR intensive industries. The 95% confidence intervals were obtained from standard errors clustered by country pair.

TRIPS agreement is associated with an increase of about 64% in trade flows in trademark-intensive industries, followed by 44% in patent-intensive industries, and 35% in copyright-intensive industries.

Complementing the aggregate TRIPS estimates from Table 5 with a set of event-time-specific effects across patent-, trademark-, and copyright-intensive industries, the results depicted in Figure 9 show that the positive effect of TRIPS compliance on trade flows persists over time in each of the three industry types, consistent with the results reported in Table 5. The magnitude of the effect of TRIPS-compliance increases for up to eleven years after the agreement's inception, before gradually tapering off, a pattern consistent with that observed for aggregate trade flows in the benchmark estimates (see Figure 4).

Next, we analyze the average trade response to TRIPS across different treatment-timing cohorts within each industry type. Our findings are displayed in Figure 10. The results suggest that treatment-timing-cohorts exhibit distinct trade responses to TRIPS across patent-, trademark-, and copyright intensive industries. Specifically, our estimates for patent- and trademark-intensive industries turn out to be similar in magnitude for early-complying cohorts, whereas for cohorts

Table 5 Average TRIPS effects on trade in patent-, trademark-, and copyright-intensive industries

	(1) *Patent*	(2) *Trademark*	(3) *Copyright*
$TRIPS_{ij,t}$	0.363***	0.496***	0.229***
	(0.021)	(0.026)	(0.038)
Observations	11,161,371	3,283,874	1,174,658
Exporters	147	147	147
Importers	147	147	147
Industries	45	14	5
Years	21	21	21
Coefficients	109	109	109
$Exporter \times Industry \times Year\ FE's$	Yes	Yes	Yes
$Importer \times Industry \times Year\ FE's$	Yes	Yes	Yes
$Exporter \times Importer \times Industry\ FE's$	Yes	Yes	Yes

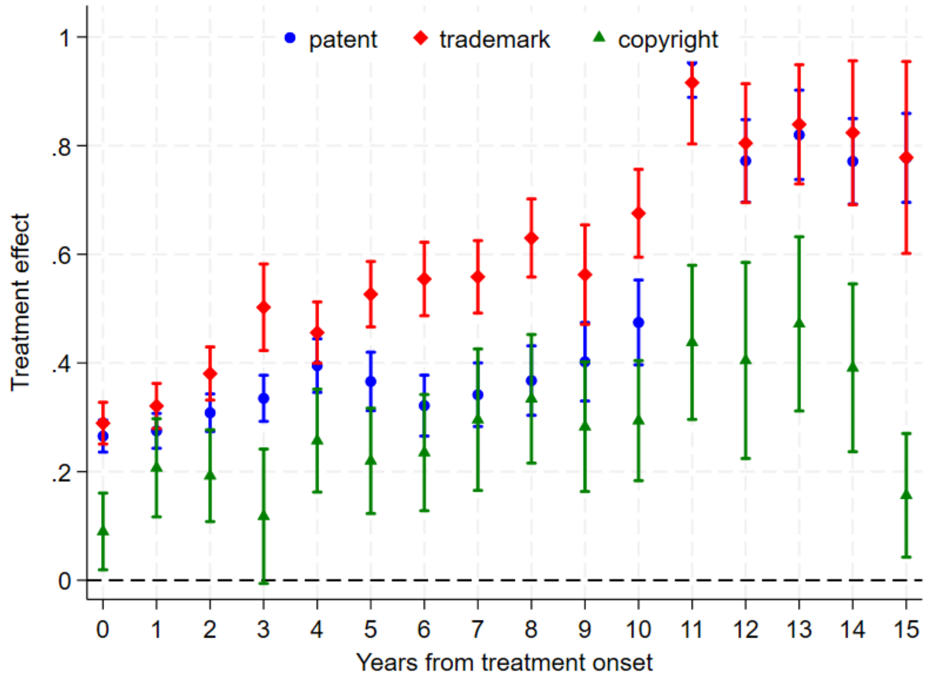
Notes: The table reports the PPML estimates of equation (7) using the ETWFE estimator, which implements a heterogeneity-robust staggered DiD method. Column (1) reports the ETWFE TRIPS estimates for patent-intensive industries, Column (2) for trademark-intensive industries, and Column (3) for copyright-intensive industries. Standard errors clustered by country pair are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

that complied with the agreement during the 2000–2005 period, the ETWFE TRIPS estimates are relatively stronger in trademark-intensive industries. Finally, trade flows in copyright-intensive industries exhibit a stronger response to TRIPS among later-complying cohorts.

8 Conclusion

The agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), adopted under the auspices of WTO in 1994, requires WTO member states to implement and enforce minimum standards of protection for nearly all major forms of intellectual property, with the stated objective of promoting innovation and facilitating the diffusion of technology. Moreover, given the reluctance of developing and least-developed countries to implement the TRIPS-related reforms, the agreement allowed disparate deadlines for member states. As a result, one of the most economically significant features of TRIPS was its staggered adoption, which led to a natural cross-country variation in the timing of legislative reforms related to IPRs, an aspect that we exploit in our analysis, unlike most existing studies on these issues.

Figure 9 Event-time specific TRIPS effects in Patent-, Trademark-, and Copyright-intensive industries

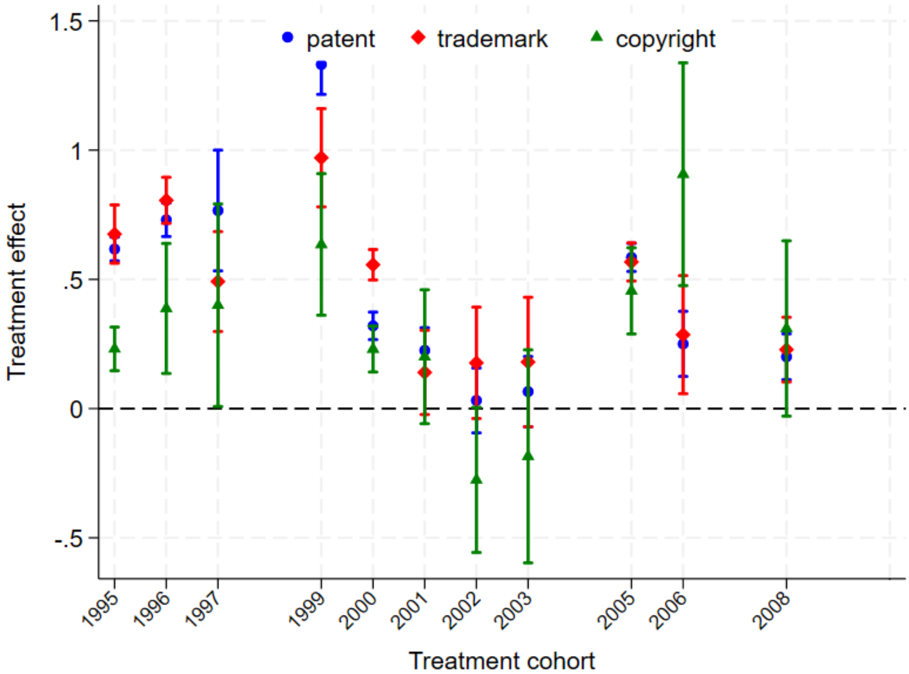


Notes: The figure presents the event-time-specific ETWFE estimates of TRIPS in Patent-, Trademark-, and Copyright-intensive industries. The 95% confidence intervals were obtained from standard errors clustered by country pair.

Furthermore, the existing empirical literature examining the impact of IPRs on trade relies extensively on the TWFE gravity model, which may yield biased estimates in staggered difference-in-differences designs due to 'forbidden comparisons' that use already-treated units in the comparison group. To address this limitation, we follow Nagengast and Yotov (2025), that nests the extended TWFE (ETWFE) estimator à la Wooldridge (2023) within the structural gravity framework to estimate the impact of compliance with TRIPS agreement on international trade.

Our results reveal a significant positive impact of TRIPS compliance on trade. We find the TRIPS effects to be quite heterogeneous across cohorts, with relatively larger effects observed for the earlier compliers. The event-study estimates further indicate that the magnitude of these effects increases over time throughout the period of investigation, suggesting that the impact of TRIPS is long-lasting. The conclusions drawn from the aggregate trade flows remain valid when examining the trade response to TRIPS at the disaggregated industry level that exhibit varying sensitivity to intellectual property. Robustness analyses further confirm the validity of our benchmark results.

Figure 10 Cohort-specific TRIPS effects in Patent-, Trademark-, and Copyright-intensive industries



Notes: The figure presents the cohort-specific ETWFE estimates of TRIPS in Patent-, Trademark-, and Copyright-intensive industries. The 95% confidence intervals were obtained from standard errors clustered by country pair.

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A Appendix

Table A1 List of sample countries

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

Note: The classification criteria for countries in High-income, Developing, and Least-developed groups, respectively is based on World Bank classification. The top 20 innovative countries in the high-income group are ranked based on USPTO patents as of 1993. Countries in *italics* are those that self-designated as developing when they joined WTO.