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Double Taxation Treaties with the United States and Environmental Quality in Emerging Economies

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Double Taxation Treaties with the United States and Environmental Quality in Emerging Economies

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Abstract

We focus on the role of double taxation treaties on environmental quality, to our knowledge the first empirical study to do so. Tax treaties are primarily implemented to remove double taxation, which helps promote international trade and investment. However, they are also aimed to address tax evasion and avoidance, which tends to have the opposite effect. As a result, the environmental impact is unclear. Specifically, we exploit the variation in the effective dates of the United States tax treaties with emerging countries between 1990 to 2014 by applying difference-in-differences methods. We find that tax treaties significantly help reduce carbon dioxide emissions in emerging markets. This appears to be driven by the reduction in investments in pollution-intensive industries after tax treaty enactments.

Keywords: tax treaties, fiscal, air pollution, environment, emerging markets

JEL Codes: H3, H25, F18, F21

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I. 1. Introduction

Tax treaties are designed to eliminate economic and juridical double taxation by allocating taxing rights, coordinating taxing jurisdictions and definitions, as well as by providing double taxation relief (e.g., Blonigen and Davies, 2004; Leduc and Michielse, 2021). By addressing double taxation, these treaties are expected to smoothen the flow of investments, goods, and services across countries. It is believed that by doing so they can help drive global economic activities, facilitate the transfer and diffusion of innovations, affect revenues generated by countries from trade and foreign investment, and even contribute to strengthen diplomatic relations. Double taxation treaties have existed since the 1890s but became more prominent after the 1928 League of Nations convention on double taxation and tax evasion.[1] The number of tax treaties has also increased over the years from a little over 500 tax treaties in 1990 to around 3000 bilateral treaties by early 2020 (Leduc and Michielse, 2021).

It is unclear whether double taxation treaties may improve or deteriorate the environmental quality of countries, something that is neither intuitively nor theoretically clear. While it may appear that tax treaties will tend to decrease environmental quality, as trade and foreign investment will likely increase among signatory countries, it is also likely that job creation will increase, lead to a larger tax base, which may bring additional revenues and increase the fiscal space for investments in public infrastructure, including green and pollution abatement technologies as well as related regulatory efforts. Furthermore, in the case of emerging markets, tax treaties may impose considerable revenue costs that have been dominantly capital importers over the years by shifting taxing rights from capital-importing or source countries to capital exporting or residence countries (e.g., Keen et al., 2014; Jansky` and S˘edivy` 2019; Jansky` et al., 2021)[2]. Multinational enterprises may also engage in treaty shopping by diverting their investments through countries that have favorable tax treaties, which may lead to double non-taxation and loss in revenues (e.g., Beer and Loeprick, 2018; Petkova et al., 2018). The revenue cost of tax treaties in emerging countries can exacerbate their financial constraints in addressing environmental issues and engaging in climate change adaptation and mitigation activities.

[1] Other tax treaty models have emerged to account for expanded fiscal relations, increased complexity of taxing systems, changes in business sectors, and varying interests of countries, including capital-importing versus exporting and capital source versus residence countries. Notable ones are the 1977 OECD Model Double Taxation Convention on Income and on Capital and the 1980 United Nations Model Double Taxation Convention (Leduc and Michielse, 2021).

[2] For the sake of economy, when using the term "emerging" countries we also refer to low-income or developing countries along with Eastern and European countries.

Theoretically, there are two competing hypotheses that may explain the relationship between tax treaties and environmental quality. On the one hand, the Pollution Haven Hypothesis (PHH) argues that pollution-intensive industries seeking pollution havens diverge their investments to emerging countries where environmental regulations are less stringent and wages are low (Akbostanci et al., 2007). In the context where PHH holds, tax treaties are expected to unintentionally harm the environmental quality in particular in emerging countries as they reduce barriers to the international mobility of pollution-intensive industries and intrinsically discount their pollution cost. In contrast, an alternative hypothesis, the Pollution Halo Hypothesis (PHL) proposes that FDI facilitates the flow of green investments and the transfer and diffusion of pollution- abating technology to host countries (Albornoz et al., 2009). Hence, by promoting FDI, tax treaties are expected to improve environmental performance in emerging countries. In addition, tax treaties are also motivated as a means to increase tax compliance and reduce tax evasion and avoidance through transfer pricing rules, antitreaty shopping rules, and administrative cooperation and sharing tax information, making it harder for investors to hide their income from taxing authorities or use other legal means to pay less than their fair share (Blonigen and Davies, 2004; Egger et al., 2006). Tax treaties that successfully reduce tax evasion and avoidance can lower cross-border transactions and investment flows.[3]

Interestingly, the current literature on the relationship between tax treaties and environmental outcomes is scant, if any. To the best of our knowledge, our paper provides the first estimates of the causal effects of tax treaties on environmental outcomes and adds to the literature on the impact of tax treaties on foreign direct investment as a likely mechanism by uncovering heterogeneity in the effect of tax treaties across different industries. In addition, our research contributes to the broad literature on the environmental outcomes of FDI, trade, and economic development in emerging countries.

Our empirical analysis focuses on the United States bilateral tax treaties with emerging economies and proxy environmental quality using carbon dioxide emissions per capita. Carbon dioxide is an energy pollutant that is closely linked to investment and contributes almost 80% of greenhouse gas emissions globally (Foster and Bedrosyan, 2014). We exploit the variation in the introduction of these treaties across and employ two-way fixed effects (TWFE) differences-in-difference models using panel data from 1990 to 2014. We find that tax treaties with the U.S. significantly lower carbon dioxide emissions

[3] However, they may not be as effective in limiting tax evasion and avoidance as complex, broad, and heterogeneous networks of tax treaties compounded by technological advances may create rather than eliminate opportunities for avoidance (Lee and Kim, 2022).

in emerging countries over the study period. Our results remain robust to a host of specification checks, including evaluating endogeneity concerns, carrying out a placebo test, and using recent difference-in-difference estimators that account for staggered designs. Aligning with earlier literature, we also find little evidence that tax treaties significantly influence FDI between the United States and these countries. However, we find suggestive evidence that tax treaties lower FDI in pollution-heavy sectors. Understanding the environmental cost and benefit of tax treaties is fundamental for emerging countries and the global fight against climate change, considering that these provisions tend to remain in force for many years and are infrequently revised (Leduc and Michielse, 2021).

The rest of our paper is organized as follows. Section 2 discusses the literature. Section 3 presents the data. Section 4 describes our empirical approach. Section 5 provides our main results. Section 6 presents extensive robustness tests. Section 7 presents plausible mechanisms. Finally, Section 8 provides final remarks.

2. Brief Review of the Literature

The empirical literature on tax treaties has mainly focused on their impacts on foreign direct investment with no consensus on the direction of impact. A number of studies report null and negative effects of tax treaties on FDI. For instance, Blonigen and Davies (2004) find little evidence of the impact of tax treaties on U.S. inbound and outbound FDI for 1980-1999. They also find that new treaties lower the U.S. direct investment abroad. Similarly, Davies (2003) examines the impact of U.S. tax treaty renegotiations during 1996-2000 and show that tax treaty revisions do not positively affect FDI. Blonigen and Davies (2005) use 1982-1992 data of OECD countries and find that tax treaty formation does not increase FDI and even leads to a reduction in investment, conforming to the idea that treaties are in place to reduce tax evasion rather than incentivize investment. In addition, Egger et al. (2006) use 1985-2000 bilateral panel data and document a negative link of between 15 to 20 percentage points. In contrast, other researchers find a positive impact of tax treaties on FDI. For instance, Neumayer (2007) finds emerging countries that enter into tax treaties with the U.S. and other capital exporters receive increased foreign investment, with a more pronounced effect on middle-income compared to low-income countries for the period 1970-2000. Blonigen et al. (2014) use detailed firm-level data from 1987 through 2007 and report a positive impact of bilateral tax treaties, with a larger impact for U.S. firms that use differentiated inputs on FDI. Stein and Daude (2007) explore various determinants of FDI using 1997-1999 data from 17 OECD and 58 host countries and find that capital tax treaty increases outward FDI. Lejour (2014) uses geographical variables as instruments to study the impact of bilateral and multilateral treaties of OECD countries from 1985 to 2011 and finds that tax treaties increase FDI by 16 percent. Kumas and Millimet (2018) estimate the quantile treatment effect of U.S. inbound and outbound FDI from 1980 to 1990 and find that tax treaties increase FDI at the lower quantile of FDI distribution and decrease FDI at the upper quantile. Petkova et al. (2020) evaluate the effect of bilateral treaties in 138 countries by considering tax distance, the cost of channeling corporate income from one country to another, and treaty shopping and find that tax treaties that lower tax distance increase FDI by 18%. Finally, Lee and Kim (2022) account for the tax environment of recipient countries, including tax havens status, price transfer rules, Controlled Foreign Corporation (CFC) rules and find that bilateral tax treaties with the United States increase FDI inflows in emerging countries for the period 2007 to 2018.

With respect to the literature of foreign direct investment, international trade, and environmental quality the existing studies support two conflicting arguments, briefly described above. One strand of the literature maintains the pollution haven hypothesis (PHH) whereby pollution-intensive industries tend to relocate from developed countries, where stringent environmental regulations may lead to high production costs, to emerging countries, that provide pollution havens due to their low wages and lax environmental restrictions (e.g., Akbostanci et al., 2007; Al-Mulali and Ozturk, 2015; Baek, 2016; Solarin et al., 2017; Gorus and Aslan, 2019; Rana and Sharma, 2019; Bakirtas and Cetin, 2017; Koçak and Śarkguneśi, 2018; Caglar, 2020; Duan and Jiang, 2021; Jiang et al., 2022, among others. Another strands of the literature supports an opposing argument, the pollution halo hypothesis (PLH), that investment from developed countries reduces pollution in host countries by facilitating transfer and diffusion of pollution abatement technology to the host countries while the rest maintains a neutral stance or report mixed results depending on the study area (e.g., Asghari, 2013; Hao and Liu, 2015; Tang and Tan, 2015; Rafindadi et al., 2018; Mert and Caglar, 2020; Merican et al., 2007, and others). This literature also exploits heterogeneity in the FDI-pollution relationship and documents that it may depend on capital and labor endowment, the stringency of environmental regulations, and corruption in host countries. FDI may increase CO2 emissions when the level of corruption is relatively high in the host countries (Chang, 2015). For instance, recent research finds that FDI increases air pollution in countries with average capital endowment and less stringent environmental regulations and countries with high capital endowment. In contrast, FDI reduces pollution in countries with low to average capital-to-labor ratios and less lax environmental regulations (Zugravu-Soilita, 2017). Other studies emphasize that the impact of FDI on environmental performance is determined by environmental regulations in source countries and not the host country (Adeel-Farooq et al., 2021). Adeel-Farooq et al. (2021) documents that FDI from developed countries improves the environmental performance in low- and middle-income countries while those originating from emerging countries have adverse effects on environmental performance in low and lower-middle-income host countries. Another strand of literature documents that environment provision in trade agreements lowers air pollution (Baghdadi et al., 2013; Martínez-Zarzoso and Oueslati, 2018; Zhou et al., 2017) and encourages green exports from emerging countries (Brandi et al., 2020).[4]

3. Data

Our empirical analysis uses the World Bank's World Development Indicators (WDI) database.[5] WDI provides data on different aspects of global development, including information on our outcome of interest, carbon dioxide emissions per capita, and other country-level controls relevant to our analysis, such as gross domestic product (GDP) per capita, GDP per energy, percentage of fossil fuel energy consumption, population density, and the GDP growth rate. We describe these variables in Table A1 and present summary statistics in Table 1. Due to data availability, we restrict our analysis to the period from 1990 to 2014.[6]

A tax treaty's effective, signing, and ratification dates may not be the same. Following Blonigen and Davies (2004) and Blonigen et al. (2014), we consider the general effective date as the year from which a country had a tax treaty with the U.S. The effective dates of U.S. tax treaties with emerging economies come from the Internal Revenue Service and Treasury Department.[7] We present the list of emerging economies that have tax treaties with the U.S. and the corresponding effective dates of the tax treaties in Table 2 and plot the number of these countries over time in Figure 1. The number of U.S. tax treaties with emerging countries has considerably increased over the last three decades. Our study exploits this

[4] There is also some related literature via the environmental Kuznets Curve, which proposes that pollution exhibits an inverted-U relationship with economic development. The relationship has been extensively studied in the literature, but the evidence supporting it is still controversial. Guo and Shahbaz (2024) provide a review for the period 1991 to 2023.
[5] datatopics.worldbank.org/world-development-indicators/
[6] Information on GDP per energy and percentage of fossil fuel energy consumption is missing in the WDI dataset post 2014. In addition, GDP per energy data is not available before 1990. GDP per energy, as a proxy for energy efficiency, and the percentage of fossil fuel energy consumption allow us to also control for supply-side drivers of carbon dioxide emissions, given that energy is a leading source of greenhouse gas emissions and a major contributor to carbon dioxide emissions. The size of our dataset may not necessarily affect our results, as it covers the universe of data available for this period. In addition, we also implement several robustness checks to examine the validity of our results.
[7] www.irs.gov/individuals/international-taxpayers/tax-treaty-tables

variation to identify the causal effect of U.S. tax treaties on carbon dioxide emission in these countries. Although country-specific details of the provisions may vary, U.S tax treaties typically address similar issues with the main goal of mitigating double taxation and fiscal evasion (Blonigen and Davies, 2004; Egger et al., 2006; Leduc and Michielse, 2021). Other provisions, complementing these two, provide clarification on taxing definitions, allocate taxing rights across contracting states, foster administrative cooperation and tax information sharing, offer mutually agreed mechanisms to resolve tax disputes, and aim at preventing treaty shopping.

We also utilize U.S. direct investment abroad (USDIA) position or cumulative level of investment data. These data are obtained from the U.S. Bureau of Economic Analysis (BEA) and provide historical information on the U.S. cumulative level of investment by countries and industries.[8] USDIA captures investments where a U.S. person or entity has a significant influence, control, or ownership of at least 10 percent of the voting power of a business enterprise that is resident in another country. We use this data to explore whether FDI is a potential mechanism through which tax treaties affect carbon dioxide emissions in emerging countries.

4. Empirical Strategy

We exploit the variation in the timing of U.S. tax treaties across emerging economies to identify their short and long-run effect on carbon dioxide emissions. Our estimation approach compares countries with and without a U.S. tax treaty before and after the effective year of the treaty. Specifically, we estimate two-way fixed effect (TWFE) difference-in-differences model using the following specification:

$$Yct = \alpha + \gamma TTct + Xct\beta + \theta c + \lambda t + \epsilon_{ct}cct \qquad (1)$$

where Yct denotes log carbon dioxide emissions per capita in the country c in year t. The primary independent variable of interest is TTct, an indicator of tax treaty, which is a binary variable that takes a value of one if country c has a tax treaty with the U.S. in year t. The vector Xct contains a set of country-level, time varying controls as described in Tables 1 and A1. Our list of controls consists of standard covariates used in the literature to account for demand and supply-side factors that affect countries' environmental quality. We control for GDP growth and log GDP per capita as proxies for national economic development and income. We also include squared log GDP per capita to account for plausible non-linearities in the relationship between per capital income and environmental quality.

[8] www.bea.gov/international/di1usdbal

In addition, we control for fossil fuel energy consumption, GDP per unit of energy as a proxy of energy efficiency, and population density (e.g., Zugravu-Soilita, 2017; Sapkota and Bastola, 2017).

All specifications include country-fixed effect, θc and year-fixed effect, λt, to control for unobservable country-specific confounders that do not change over time and year-specific shocks that may influence carbon dioxide emissions. In all regressions, we also cluster standard errors at the country level, that is, the level at which our treatment varies to account for plausible within-country autocorrelation of residuals. Our key parameter of interest is γˆ, which provides the impact of U.S. tax treaties on per capita carbon dioxide emissions in emerging countries. Our identifying variation of γˆ comes from within and cross-country variation in the conclusion of U.S. treaties. Our TWFE estimates recover causal effects if, conditional on observed covariates and in the absence of U.S. tax treaties, environmental performance in emerging countries that have signed a tax treaty with the U.S. would have evolved similarly to the outcomes in countries without a U.S. tax treaty. This assumption is clearly untestable as we do not observe emerging countries with a U.S. tax treaty had they not signed it. However, we take several steps to provide evidence supporting this identifying assumption formally.

We begin by estimating event study analyses to examine the parallel trend assumption and decompose the estimated effect of tax treaties over time:

$$Y_{ct} = \alpha + \sum_{j=-T, j\neq -1}^{T} \gamma_j \, TT_{c,t+j} + \mathbf{X_{ct}}\boldsymbol{\beta} + \theta_c + \lambda_t + \epsilon_{ct} \qquad (2)$$

where now TTct+j is a set of mutually exclusive and collectively exhaustive indicators for years before and after the enactment of U.S. tax treaties. The negative values of j represent leads, years before the tax treaty effective year, zero represents the year a country concludes a tax treaty with the U.S., and positive values of j are lags capturing years post the implementation of tax treaties. For relative years beyond 7, we use one indicator to catch all bins before -7 and another for bins after 7. We omit one year before the effective year of the tax treaty, the reference category, and define other variables as described in Equation 1. Our estimation of the impact of tax treaties on carbon dioxide emission has a causal interpretation if the lead coefficients are statistically indistinguishable from zero. Such null results provide suggestive evidence that there are no anticipatory behaviors or differential pre-trends in countries with and without the U.S. tax treaty and that the covariate-adjusted version of the parallel trend assumption is satisfied.

We also extend our baseline specification to include country linear time trends to capture slow-moving factors within a country that are plausibly linearly correlated with the implementation of U.S. tax treaties:

$$Y_{ct} = \alpha + \gamma TT_{ct} + \mathbf{X_{ct}\beta} + \theta_c + \lambda_t + \theta_c * t + \epsilon_{ct} \quad (3)$$

where $\theta c * t$ is a country-specific linear time trend. In the alternative specification, we use a continent-specific linear time trend in Equation 3 instead of a country-specific linear time trend. However, we recommend caution when interpreting results from these two specifications as adding country- or continent-specific linear trends may reduce important identifying variation and obscure treatment effects estimates (Neumark et al., 2014).

Our main specification excludes some covariates used in the literature due to the problem of missing data, which can lead to omitted variable bias. To assess this, we examine the robustness of our findings to the inclusion of these variables. Particularly, we control for human capital, proxied by average years of schooling, industries value, measured in terms of the ratio of the value-added in the industries to GDP, trade openness, measured by the ratio of trade in goods and services to GDP, and the proportion of gross fixed capital in separate regressions (Xing and Kolstad, 2002; Chang, 2015; Sapkota and Bastola, 2017). We also re-run our baseline specification by excluding China from the analysis. Though not the primary contributor historically, today, China accounts for nearly a third of annual global carbon emissions (Crippa et al., 2022). In addition, our robustness check also presents additional regression results that account for countries' political regimes.

Further, tax treaties may be considered endogenous in some contexts, and one can argue that our treatment effect estimate is biased (Egger et al., 2006). Endogeneity between U.S tax treaties and investments is likely to be substantial with the old treaty partners compared to treaties implemented after 1980 (Blonigen and Davies, 2004). The old U.S. treaty partners are mostly advanced economies, Canada, Japan, Australia, New Zealand, and Western Europe, that are not part of our sample. In addition to this anecdotal evidence, we examine the endogeneity of U.S tax treaties and carbon dioxide emissions by controlling for lags and leads of U.S. tax treaty effective date as specified in the following regression:

$$Y_{ct} = \alpha + \sum_{k=-5}^{5} \Pi_k TT_{c,t+k} + \mathbf{X_{ct}\beta} + \theta_c + \lambda_t + \epsilon_{ct} \quad (4)$$

where $TT_{c,t+k}$ denotes indicators for lags and leads for tax treaty effective dates such that each takes the value of one for years post the lag and lead years and zero otherwise. For instance, if the effective date of the tax treaty with the U.S. is 2000, the first lead would take the value of 1 in 1999 and onwards, the second lead in 1998 and afterward, whereas the first lag would take the value of 1 in 2001 and onwards and the second in 2002 onwards. For k = 0, $TT_{c,t+k}$, is similar to the treatment indicator used in our main specification as shown in Equation 1. Coefficients of the leads, $\Pi_k \ \forall \ k < 0$, represent the anticipatory effect of U.S. tax treaties on carbon emissions per capita and $\Pi_k \ \forall \ k > 0$ are the post-tax-treaty impacts. Tax treaties are considered endogenous if the anticipation of a tax treaty significantly affects carbon dioxide emissions.

Our findings may also be driven by random factors other than tax treaties. We examine this possibility by carrying out a placebo test where we assign 1000 sets of placebo tax treaty dates to countries with a U.S. tax treaty. The placebo dates are randomly generated using a uniform distribution from 1980 to 1 year before the actual tax treaty effective year. For each set of fake dates, we define our variable of interest, tax treaty, as one for years post the fake date and zero otherwise. We then re-estimate our TWFE difference-in-differences model, specified in Equation 1 by running 1000 regressions using the set of fake dates and compute the probability of finding similar results to those with the actual effective date.

Finally, we consider recent developments in the difference-in-differences methods, documenting that TWFE estimates may be biased in staggered policy designs when dynamic and heterogeneous treatment effects exist. The bias in the TWFE estimation arises because earlier treated units, which may be experiencing heterogeneous and lagged treatment effects, are implicitly used as controls for newly treated units. Hence, our TWFE approach may be contaminated by the negative weight bias since there is variation in the timing of these treaties across emerging. To examine this, we use the Goodman-Bacon Decomposition of the average treatment effect to estimate the weights assigned to each of the two-by-two country comparison groups in our sample. This decomposition allows us to examine how much weight our TWFE imposes on two-by-two groups that use countries that had tax treaties earlier as controls for countries that implemented the treaties later. We exclude covariates in this estimation since weights assigned to the two-by-two groups in the traditional difference- in-differences estimators are independent of covariates (Goodman-Bacon, 2021).

We then estimate three recent differences-in-differences estimators that account for staggered treatment adoption and compare these findings with our TWFE results. Our first approach uses a clean control technique or stacked difference-in-differences (Stacked DID) method proposed by Cengiz et al. (2019). Our stacked DID approach considers a four-year window around each event k, defined as the effective year of the U.S. tax treaty. For each event, we choose countries with no U.S. tax treaties or those with effective years four years after the event k as controls. For each event k, countries that enacted a tax treaty with the U.S. in year k and control countries form a stack. We append the stacks and estimate our difference-in-difference model using the newly constructed stacked datasets. In particular, we estimate the following specification:

$$Y_{ctk} = \alpha + \gamma TT_{ctk} + X_{ct}\beta + \theta_c + \lambda_t + \nu_k + \epsilon_{ct} \quad (5)$$

Our stacked DID also includes stack fixed effects, ν_k, to control for unaccounted factors that may be associated with concluding a U.S. tax treaty in a given year and correlated with carbon dioxide emissions. We also follow Wing et al. (2024) and apply corrective sample weights in our regressions. The remaining variables follow an identical definition as described in Equation 1. Analogous to our TWFE model, we estimate the corresponding stacked DID event studies specification given by:

$$Y_{ctk} = \alpha + \sum_{j\neq-1,j=-T}^{T} \gamma_j \, TT_{c,t+j} + X_{ct}\beta + \theta_c + \lambda_t + \nu_k + \epsilon_{ct} \quad (6)$$

where T = 4, reflecting the four-year window around each event k, the year a country enters a tax treaty with the U.S. Our second approach employs the Extended TWFE approach proposed by Wooldridge (2021). This author argues that the identification problem with TWFE is just that of mis specified functional form and proposes an extended TWFE approach that saturates the canonical TWFE with all possible interactions between treatment indicator and time-fixed effects, treatment cohorts, and all other possible independent variables to capture time or unit-specific heterogenous treatment effects:

$$Y_{ct} = \alpha + \theta_c + X_c(\beta + \mu_t) + \sum_{g\in G} 1\,(W_c = g)\left(\tau_g + X_c\beta_g + 1\{t > g\}\left(\tau_{gt} + \bar{X}_g\beta_g\right)\right) + \epsilon_{ct} \quad (7)$$

where each treated country group implemented a tax treaty with the U.S. at time g, and $1(W_c = g)$ and $1\{t > g\}$ are indicators that a country c belongs to treatment cohort g and the periods after the enactment of the tax treaties. X_c is now a vector of pre-treatment covariates, τ_g are the treatment cohort group fixed effects, and $\bar{X}_g$ denotes treatment cohort group mean centered covariates. In this saturated model, τ_{gt} recovers an unbiased estimate of group- and time-specific treatment effects of interest and can be used to compute other weighted averages, including static and event study estimates of the impact of U.S. tax treaties.

Our last approach uses an imputation-based estimator proposed by Borusyak et al. (2024). This estimator first uses never or not-yet-treated observations to fit the TWFE model, similar to that in

Equation 1 using time-varying covariates, time, and country fixed effects. A counterfactual outcome is then imputed for each country c in year t, $\hat{Y}_{ct}(0)$. The difference between the actual outcome and the estimated counterfactual, $\omega_{ct} = \hat{Y}_{ct}(1) - \hat{Y}_{ct}(0)$, are then aggregated to obtain the effect of U.S. tax treaties on carbon dioxide emissions.

5. Results

Table 3 presents findings from our main specification, two-way fixed effects difference- in-differences. We control for all covariates as described in Table A1 and country-fixed effects in column 1. We add year-fixed effects in column 2, continent-specific linear time trends in column 3, and country-specific linear time trends in column 4. Column 2 is our preferred specification, where we control for the covariates discussed earlier, country-fixed effects, and year-fixed effects. Focusing on this specification, column 2, we find that U.S. tax treaties are associated with a 6.4% significant reduction ($p < 0.05$, i.e., statistically significant at 5%) in per capita carbon dioxide emissions in emerging countries (the rest of our regression results are interpreted in the same manner). Our results remain qualitatively similar and robust to including continent-specific and country-specific linear trends in columns 3 and 4. Specifically, we find a 6.7% ($p < 0.10$) and 5.7% ($p<0.05$) decrease in emerging economies' carbon dioxide emissions per capita post the effective date of the U.S. tax treaties in these two alternative specifications. Taken together, these results provide evidence that tax treaties with the U.S. significantly reduce per capita carbon dioxide emissions in emerging countries.

Our estimates are causal if countries with and without a U.S. tax treaty have a similar trend in per capita carbon dioxide emissions in the periods before their effective dates. To formally test a covariate-adjusted version of this assumption and estimate the effect of tax treaties over time, we carry out an event study analysis and present the resulting coefficient along with the corresponding 95% confidence intervals in Figure 2. Overall, we find supporting evidence that the conditional common trend assumption holds in our preferred specification, as all lead coefficient estimates are statistically not different from zero. We also note that it takes a few years for statistically significant reductions in carbon dioxide emissions per capita to occur after the effective year of the tax treaty.

As recent studies document that U.S. tax treaties increase FDI, (e.g., Kumas and Millimet, 2018; Lee and Kim, 2022), our findings generally support that fiscal policies that reduce friction in the flow of international trade and foreign investments help emerging countries pollute less. In addition, these findings could also be attributed to a decrease in the inflow of pollution-intensive investments to emerging countries after the treaties or improved diplomatic relationships that foster knowledge exchange and transfer of green technology. Though our analysis does not disentangle these channels, we attempt to estimate the impact of U.S. tax treaties on FDI stocks in different sectors in Section 7.

II. 6. Robustness

We take several steps to assess the robustness of our results as discussed in Section 4. We first estimate our preferred specification by controlling for additional country-level characteristics and a sub-sample that excludes China, a country with relatively high carbon emissions compared to other emerging countries. We present these results in Table 4. In addition to covariates in the preferred specification, column 1 controls for human capital, which is proxied by log average years of education. We add industries' value added to GDP in column 2. We control for the proportion of gross capital in the third column and trade openness, measured in terms of the share of exports and imports to GDP in the fourth column, and exclude China from the analysis in the fifth column. These covariates were excluded in the main results and are added in separate regressions due to data limitations as indicated by the reduction in the number of observations in Table 4.

Overall, our results remain robust to the inclusion of additional control variables and restriction of the sample size by excluding China. In particular, our coefficients of interest remain negative and statistically significant, suggesting that countries that have a tax treaty with the U.S., on average, experienced lower emissions in post-tax periods compared to their counterparts. However, the magnitude of the coefficient is slightly lower compared to the estimated effect in the main analysis after controlling for human capital, industries value- added, and gross capital, and very close to the main estimates in regression that control for trade openness and exclude China. We then re-estimate our event study model given in Equation 2 that corresponds to each regression in Table 4 to assess the parallel trend assumption and estimate the dynamic treatment effects. Our results, reported in Figure 3, support the covariate-adjusted version of the parallel trend assumption, and, similar to our main findings, we observe a statistically significant reduction in per capita carbon dioxide emissions a few years post U.S. tax treaties.

To control for countries' political environments, our regressions included a binary indicator for whether a country is democratic, based on the authoritarian regime dataset from the Quality of Government (QoG) Institute.[9] This dataset distinguishes twelve regimes based on the three most widely used modes

[9] Please see: datafinder.qog.gu.se/variable/htregtype

of political power regimes: monarchies, military regimes, and electoral regimes. Employing these 12 classifications, our binary variable takes the value one if a country is categorized as democratic and zero otherwise.[10] Table A2 and Figure A1 present the corresponding regression and event study results. Overall, our results remain qualitatively similar to those documented in the paper, where we find that tax treaties with the U.S. significantly lower carbon dioxide emissions in emerging countries over the study period.

We then examine the endogeneity of U.S. tax treaties with emerging economies. To assess the anticipatory effects of tax treaties, we estimate Equation 4, and we would conclude that U.S. tax treaties are endogenous if the coefficients of the leads are statistically indistinguishable from zero. Figure 4 provides the coefficient estimates from this analysis, with the corresponding 95% confidence intervals. We generally do not find any evidence of anticipatory behavior as our lead coefficient estimates are statistically not different from zero. These findings further add grounds to our identification strategy by suggesting that environmental performance, at least in terms of carbon dioxide emissions per capita, does not significantly influence emerging countries' decisions to enter tax agreements with the U.S.

We next carry out a placebo test to examine whether our main results happen by chance or are driven by some random component other than the tax treaties. As described above, our placebo analysis re-estimates our main specification 1000 times using 1000 sets of fake dates assigned to countries that have tax treaties with the U.S. We summarize the results our placebo test in Table 5, which includes counts of placebo coefficient estimates that are qualitatively similar to our main results, that is coefficients estimates from the placebo analysis that are negative and statistically significant. Our results suggest a 0.006 and 0.012 probability of finding negative and statistically significant estimates, at 5% and 10% levels of confidence, in the sets of placebo dates. Overall, these results support that the observed carbon dioxide emission per capita reduction in our main findings is driven by U.S. tax treaties with emerging economies.

We also evaluate the robustness of our results to changes in the way we estimate our standard errors, considering that when the proportion of treated observations is low, robust cluster standard errors may be biased downward towards zero. To assess the validity of our estimates against this plausible

[10] Following the twelve classifications in the authoritarian regime dataset, we classified no-party regimes (countries where all parties are prohibited), one-party regimes (all parties prohibited except one party), limited multiparty regimes (countries that have multiparty systems but still do not pass as being democratic), and party-less regimes (countries without political parties, although parties are not being prohibited) as non-democratic.

bias, we repeat our primary analysis and the event study estimations using wild cluster bootstrap standard error. We present the findings in Table 6 and Figure 5. Our findings remain robust to bootstrapping our standard error, where we still find a statistically significant reduction in air pollution after the effective dates of tax treaties and evidence that the covariate-adjusted version of the parallel trend assumption is satisfied.

Finally, we consider the recent insights in the difference-in-differences literature, caution- ing that TWFE may be biased in staggered treatment designs when treatment effects are heterogeneous. As discussed in Section 4, we first employ Goodman-Bacon Decomposition to disaggregate our average treatment effect estimates into two-by-two groups and examine the weight our TWFE estimator assigns to each group. Our results from Goodman-Bacon decomposition, summarized in Table 7, suggest that our TWFE estimates are mainly driven by comparing countries with U.S. tax treaties and those without the tax treaty. This treated versus never treated comparison takes about 82.5% of the weight in our main analysis, pro- viding suggestive evidence that the variation in the timing of tax treaties may have little bias in our estimation

Complementing the Goodman-Bacon decomposition, we estimate three recent difference- in-differences estimators that account for variation in the timing of the treatment and het- erogenous treatment effects. In particular, we estimate Cengiz et al. (2019)'s stacked DID estimator and include sampling weights as proposed by Wing et al. (2024), Wooldridge (2021)'s Extended TWFE, and Borusyak et al. (2024)'s imputation based estimator. We present our results in Table 8 and event study estimates in Figure 6. For easy comparison, we first reprint our main results in column 1 and present estimates from the other three difference-in-differences estimators in columns 2 to 4.

Our Stacked DID indicates that U.S. tax treaties significantly lower carbon emissions in emerging economies by 3.5% ($p < 0.05$). We find a larger, 9.1% ($p > 0.10$) decrease, though not statistically significant, in the Extended TWFE estimator. Note that the standard error in our Extended TWFE estimation is also relatively large, two to four times, compared to the standard errors in our main estimation and other approaches, which may signal that our Extended TWFE coefficient is not precisely estimated. As Wooldridge (2021) points out, the imprecise estimation in ETWE may be attributed to a large number of parameters that the method attempts to estimate, especially in our setting where the time period is relatively large. The Borusyak et al. (2024)'s imputation-based estimator, in column 4, also results in a larger, 13.8% ($p < 0.01$), statistically significant reduction in per capita carbon dioxide emissions following tax treaties. Our events study estimates, Figure 6, generally support a similar trend in per capita carbon dioxide emissions in countries with and without U.S. tax treaties before their enactment. In addition, statistically significant negative coefficients years post the effective year align with our earlier findings that tax treaties between the U.S. and emerging countries reduce carbon dioxide emissions in these countries.

III. 7 Possible Mechanisms

Tax treaties may plausibly impact air pollution in emerging economies by influencing capital flows between these countries and the United States. We examine this potential mechanism by estimating the impact of tax treaties on FDI positions of the United States in emerging economies, as motivated by the competing PHH and PHL hypotheses. As described above, the PHH hypothesis argues that companies in polluting industries will move their factories and operations to countries or regions with less strict environmental regulations to avoid the compliance costs associated with stricter standards in their home countries. Emerging countries, often prioritizing economic growth and job creation, offer a "haven" for these industries by having weaker environmental laws or less stringent enforcement, essentially using lax regulation as a way to attract foreign direct investment. In this context, tax treaties may harm the environmental quality mainly in emerging economies by reducing barriers to the international mobility of pollution-intensive industries and intrinsically discount their pollution cost. Thus, the mechanisms by which the PHH hypothesis acts is through the relocation of industries to countries with weaker regulation as opposed to countries with stricter rules. By moving to a less regulated country, companies can avoid the higher costs associated with meeting strict environmental standards in their home country, which suggests emerging nations may gain a comparative advantage in producing goods that are heavily polluting. This relocation leads to a decrease in pollution in developed countries but an increase in pollution in the host emerging countries, which may lack the resources to police the new industries effectively. By eliminating double taxation and reducing tax uncertainties, tax treaties may facilitate cross-border investment flows.

On the other hand, the PHL hypothesis argues that foreign investments promote the transfer and diffusion of green technology and can lead to improved environmental quality in the host country, which is the direct opposite of the PHH hypothesis. The core idea is that when firms from developed countries invest in emerging countries, they tend to transfer their cleaner, more efficient technologies, advanced management practices, and higher environmental standards, even if the local regulations are less strict. In particular, the mechanisms by which the PHL hypothesis acts is through technology transfer as multilateral corporations introduce newer, greener production technologies and pollution abatement methods that are often more energy-efficient than those used by local domestic firms. In addition, there may occur transfer of knowledge and management spillovers, as local firms may observe and adopt the superior environmental management skills and sustainable practices of the foreign companies, leading to a diffusion of cleaner practices throughout the host economy. Finally, there is also the fact that many large multinational firms maintain a consistent set of environmental standards across all their international operations to protect their brand reputation and avoid future liabilities, regardless of the host country's laws.

Our results show that tax treaty leads to a reduction in air pollution in emerging countries. If investment is a potential mechanisms driving the reductions in air pollution post ratification of the tax treaties, we would expect to find either improvement in the U.S. FDI positions in emerging countries, which may facilitate the transfer of green technology with accordance to PHL hypothesis or, in contrast to PHH, a decline in U.S. FDI position in pollution-heavy industries such as manufacturing, mining, and petroleum, post-enactment of tax treaties.

We carry out a difference-in-differences analysis, analogous to Equation 1, for FDIs in all industries and across five sectors: manufacturing, wholesale trade, mining and petroleum, and other industries. Table 9 presents our findings. The estimates in the first two columns are obtained by controlling for the same regressors as in our primary analysis. In the last two columns we control for additional covariates commonly used in gravity models and FDI literature. These controls include log of U.S. GDP per capita, log of absolute differences between U.S. GDP and destination country GDP, distance between U.S. and the destination country, and dummy variables for World Trade Organization (WTO) membership and Free Trade Agreements (FTA) (e.g., Blonigen et al., 2014; S. Lee and Kim, 2022). Similar to the primary analysis, we cluster standard errors at country-level in all regressions.

Our findings shown in column 2, suggest that the effect of tax treaties on cumulative U.S. FDI position in all industries is statistically indistinguishable from zero. The coefficient turns positive and remain statistically insignificant after accounting for additional covariates in column 4. However, there is noticeable heterogeneity in the effect of U.S. tax treaties on FDI across different sectors. We find that tax treaties, though not statistically significant, improves U.S. FDI position in manufacturing and wholesale trade. We find the opposite results in the mining and petroleum sector. Tax treaties significantly lower U.S. mining and petroleum FDI position in emerging economies. We also find null effects of tax treaties on U.S FDI position in other remaining industries. These findings are supported by the validity of parallel trend assumption as shown in Figure 7. The event study estimates provide additional evidence of the statistically significant short- and long-run reduction the mining and petroleum U.S FDI in these countries after the effective dates of the tax treaties.

Our results contribute to the recent studies like Kumas and Millimet (2018) and Lee and Kim (2022), that explore the impact of tax treaty on U.S. FDI. In addition, we add to these studies by uncovering meaningful heterogeneity in the effect of tax treaties across different industries, as highlighted by the statistically significant negative impact of tax treaties on U.S. FDI in pollution-intensive industries.

8. Final Remarks

To the best of our knowledge our study is the first to study the causal link between double taxation treaties and environmental impact. We focus on bilateral tax treaties between the United States and emerging economies and how such treaties may impact pollution in the form of production of carbon dioxide (CO2). To obtain causal effects, we exploit variation in the effective dates of U.S. tax treaties and estimate TWFE models and a variant of new difference-in-differences estimators that account for staggered implementation designs. Using panel data from 1990 to 2014 we find that tax treaties significantly lower carbon dioxide emissions in these countries and confirm that our results hold across a host of robustness checks.

One plausible reason that may explain our findings is that while tax treaties may increase overall foreign direct investment, they may reduce FDI stocks in pollution-intensive industries like mining and petroleum. Though we examine FDI as a potential channel, our data do not allow us to disentangle the role of other plausible mechanisms. For instance, improved diplomatic relations following tax treaties may provide opportunities for training, knowledge exchange, and technology transfer. In this regard, more research is needed to explore these and other potential mechanisms. In future research we plan to explore heterogeneity in bilateral tax treaty provisions and examine the implication of different attributes of tax treaties on environmental quality and other developmental outcomes. We also plan to examine the heterogeneous impact of double taxation treaties across different groups of emerging and developing economies. For instance, exploring whether the effects of these treaties and their specific clauses differ across countries with varying structural characteristics (resource-rich vs. resource-poor countries, manufacturing-driven vs. agriculture-dependent economies, and economies facing significant demographic pressures) and across countries with different institutional quality may be policy-relevant areas that future research could address.

Figure 1: Cumulative Number of Emerging Market Countries that have a Tax Treaty with the United States Over the Years.

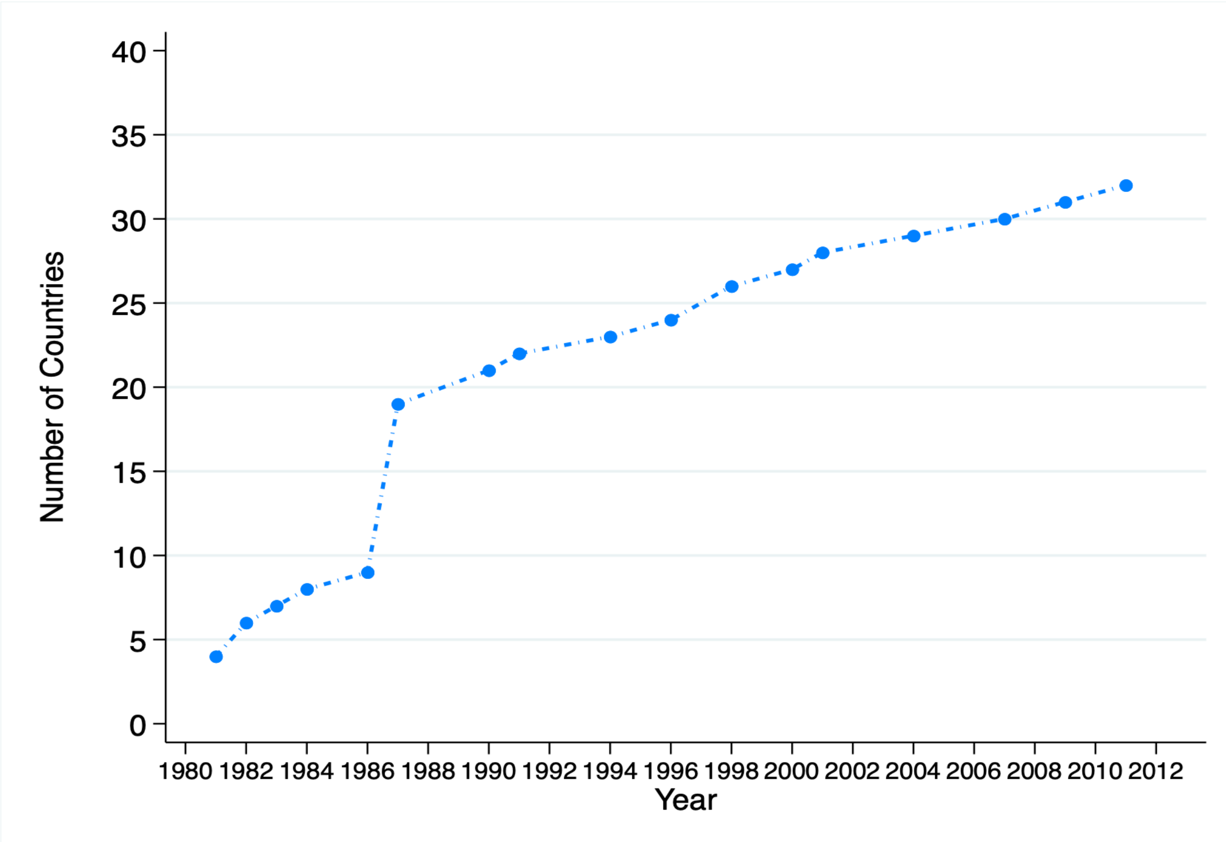
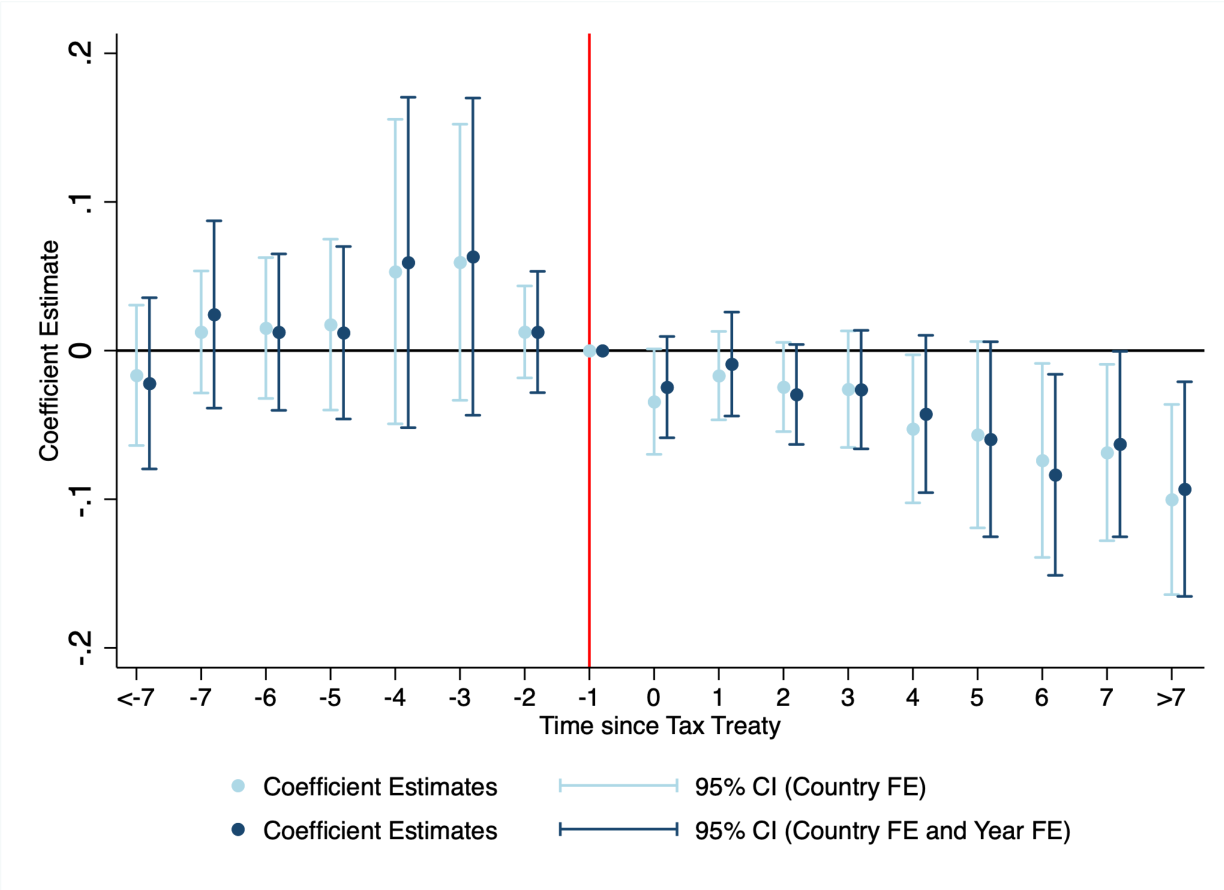
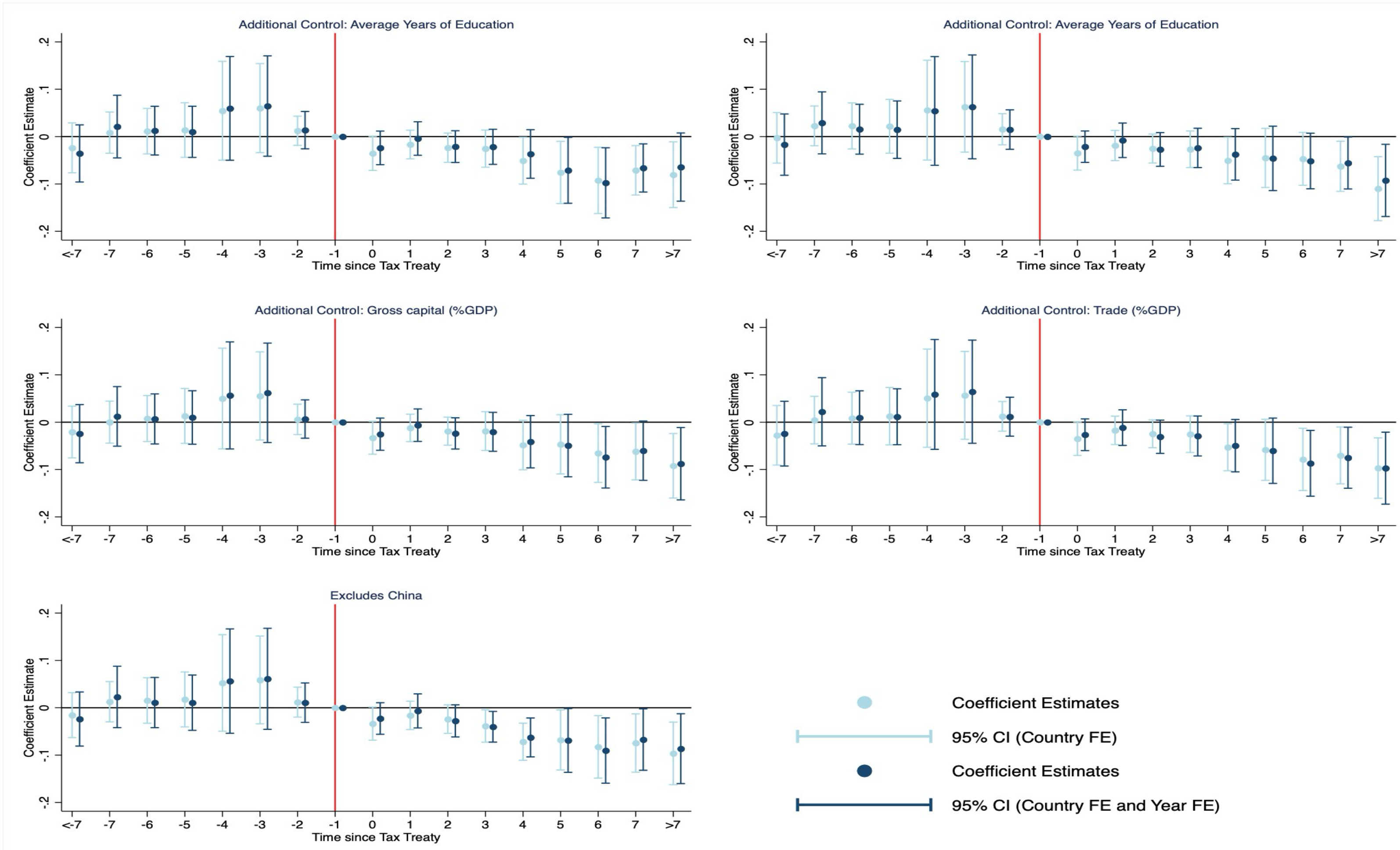


Figure 2: Event study estimates. The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014.



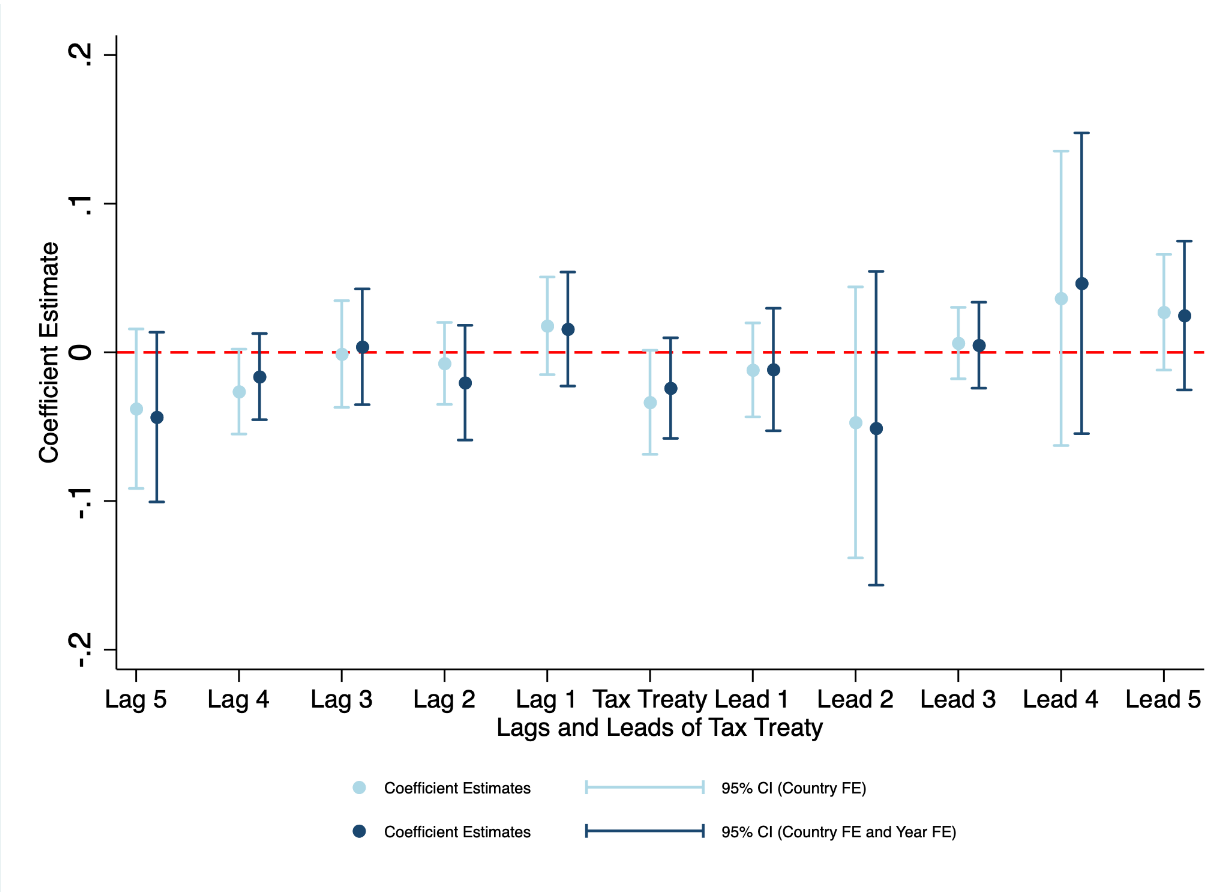
The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km of land area), and GDP growth (annual percent). Standard errors are clustered at the country level.

Figure 3: Event study estimates. The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014, Robustness Checks on the Influence of Covariates and China.



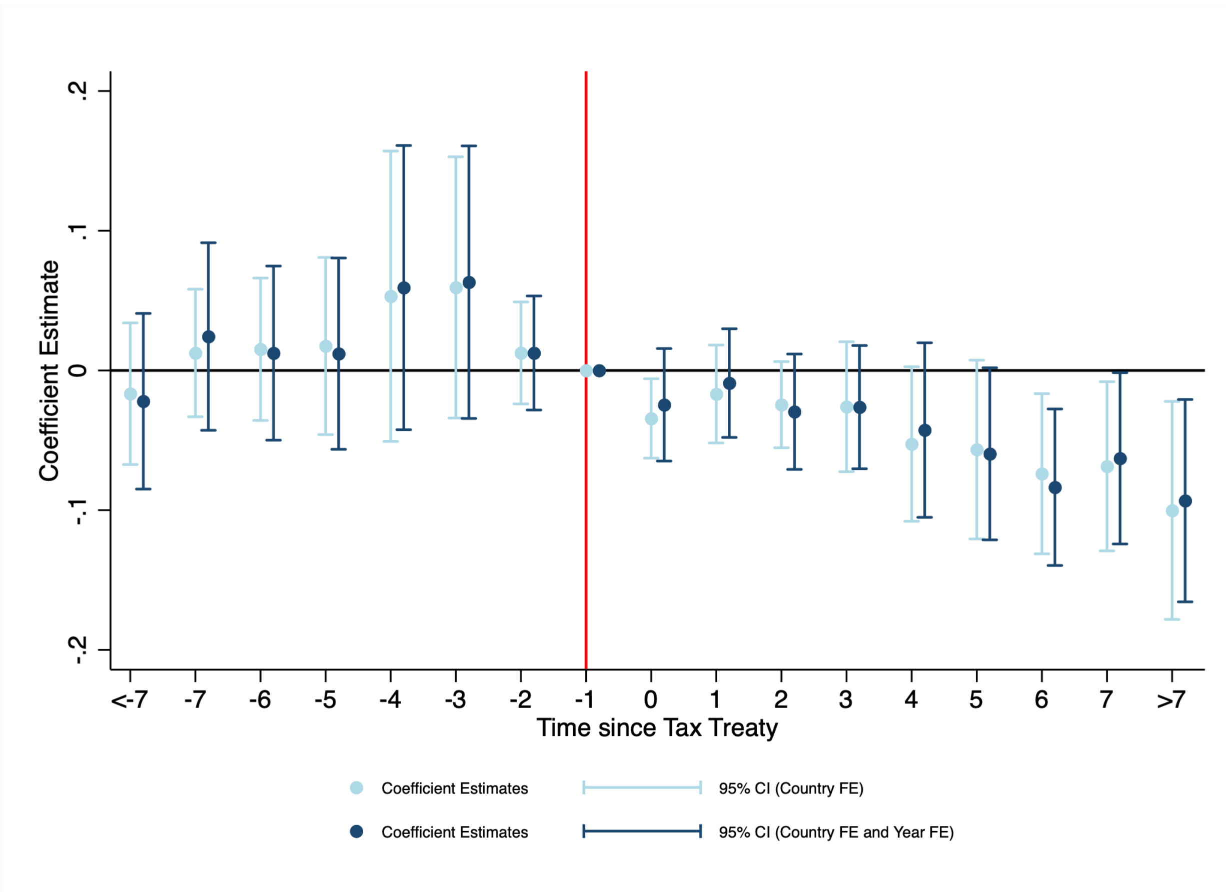
The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Standard errors are clustered at the country level.

Figure 4: Tax Treaty Lags and Leads Coefficient Estimates. The effect of lags, from five years behind, and leads, to five years ahead, of tax treaty on carbon emissions in emerging market economies, 1990-2014.



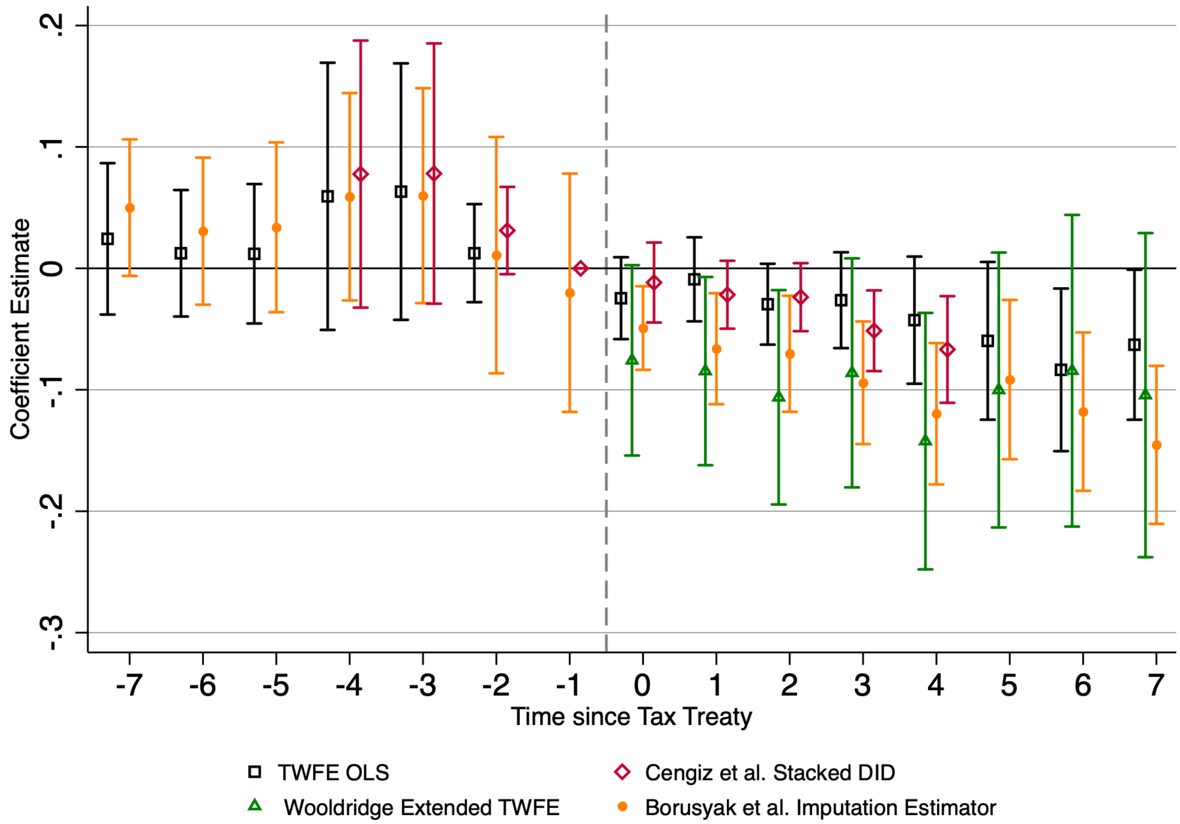
The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Standard errors are clustered at the country level.

Figure 4: Tax Treaty Lags and Leads Coefficient Estimates. The effect of lags, from five years behind, and leads, to five years ahead, of tax treaty on carbon emissions in emerging market economies, 1990-2014.



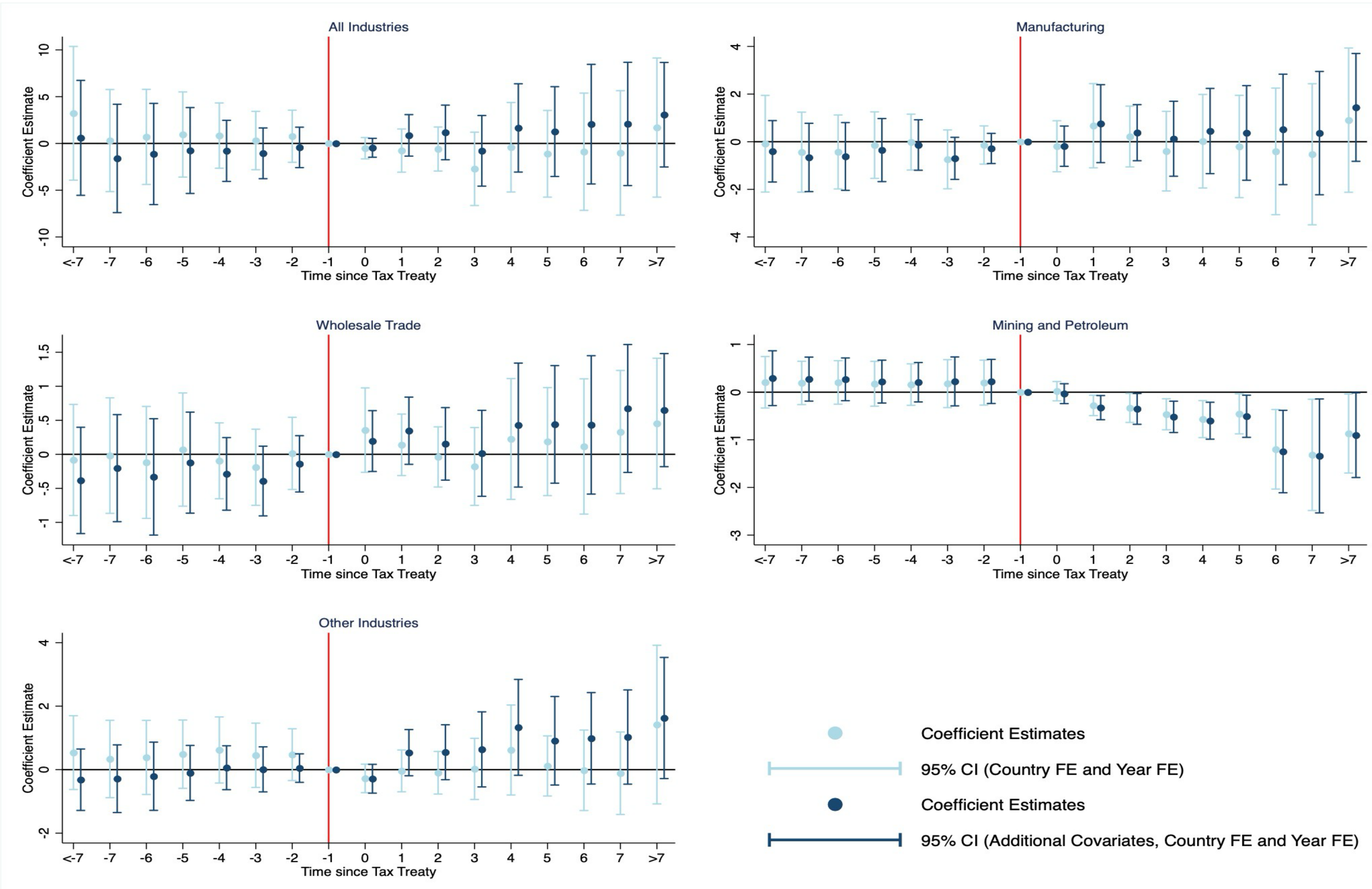
The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Standard errors are clustered at the country level.

Figure 4: Tax Treaty Lags and Leads Coefficient Estimates. The effect of lags, from five years behind, and leads, to five years ahead, of tax treaty on carbon emissions in emerging market economies, 1990-2014.



The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), GDP growth (annual percent), country fixed effects, and time fixed effects. Cengiz et al. Stacked DID also controls for stack-fixed effects. In addition, TWFE OLS controls for an indicator that accumulates lags and leads beyond seven, and Borusyak et al. Imputation Estimator controls for lag eight to ten. Standard errors are clustered at the country level.

Figure 7: Event study estimates. The effect of tax treaty on United States foreign direct investment positions in emerging market economies, 1990-2014.



The dependent variable is the U.S. foreign direct investment (in million US$). Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Standard errors are clustered at the country level.

Table 1: Descriptive statistics, 1990-2014.

	Mean	SD
Outcome		
Log CO_2 per capita	0.406	1.483
Tax Treaty		
Tax treaty	0.267	0.443
Log GDP per capita (US$, 2010)	7.964	1.176
Squared log GDP per capita (US$, 2010)	64.80	19.11
Log GDP per energy	2.064	0.609
Fossil fuel energy consumption (Percent of total)	59.55	33.59
Log population density (people per sq.Km of land area)	4.080	1.418
GDP growth (annual percent)	4.161	6.925
Observations	2,240	

Table 2: United States Tax Treaties Effective Dates.

Country	Effective Date
Bangladesh	Jan. 1, 2007
Barbados	Jan. 1, 1984
Bulgaria	Jan. 1, 2009
China	Jan. 1, 1987
Commonwealth of Independent States*	Jan. 1, 1987
Cyprus	Jan. 1, 1986
Egypt	Jan. 1, 1982
India	Jan. 1, 1991
Indonesia	Jan. 1, 1990
Jamaica	Jan. 1, 1982
Kazakhstan	Jan. 1, 1996
Malta	Jan. 1, 2011
Morocco	Jan. 1, 1981
Pakistan	Jan. 1, 1960
Philippines	Jan. 1, 1983
Romania	Jan. 1, 1974
Russia	Jan. 1, 1994
South Africa	Jan. 1, 1998
Sri Lanka	Jan. 1, 2004
Thailand	Jan. 1, 1998
Trinidad and Tobago	Jan. 1, 1970
Tunisia	Jan. 1, 1990
Ukraine	Jan. 1, 2001
Venezuela	Jan. 1, 2000

* The U.S.-U.S.S.R. income tax treaty applies to the countries of Armenia, Azerbaijan, Belarus, Georgia, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, and Uzbekistan. Source: www.irs.gov/individuals/

Table 3: The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014.

	(1)	(2)	(3)	(4)
Tax treaty	-0.069**	-0.064**	-0.067*	-0.057**
	(0.032)	(0.032)	(0.034)	(0.026)
Pre-treaty Mean	0.201	0.201	0.201	0.201
R^2	0.988	0.988	0.989	0.992
Within Adjusted R^2	0.666	0.667	0.672	0.768
Observations	2,240	2,240	2,240	2,240
Country FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Continent-specific linear trends	No	No	Yes	No
Country-specific linear trends	No	No	No	Yes

The dependent variable is the log of CO_2 emissions per capita. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Standard errors clustered at the country level are in parentheses. * p<0.10, **p<0.05, ***p<0.01

Table 4: The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014, Robustness Checks on the Influence of Other Covariates and China.

	(1)	(2)	(3)	(4)	(5)
Tax treaty	-0.054*	-0.058*	-0.055*	-0.066*	-0.065**
	(0.032)	(0.032)	(0.030)	(0.033)	(0.031)
Pre-treaty Mean	0.211	0.175	0.216	0.223	0.201
R^2	0.989	0.989	0.988	0.988	0.988
Within Adjusted R^2	0.663	0.672	0.664	0.654	0.660
Observations	2,125	2,127	2,079	2,038	2,215
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Continent-specific linear trends	No	No	No	No	No
Country-specific linear trends	No	No	No	No	No

The dependent variable is the log of CO_2 emissions per capita. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Additionally, regression in column (1) controls for log average years of education, column (2) controls for industries value added to GDP, column (3) controls for the proportion of gross capital, column (4) controls for trade openness, and column (5) excludes China from the analysis. Standard errors clustered at the country level are in parentheses. * p<0.10, **p<0.05, ***p<0.01

Table 5: The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014, Placebo Test.

Average placebo estimate	-0.002 (0.039)
Placebo coefficient < 0	430
Placebo coefficient < 0 and significant at 5% level	6
Placebo coefficient < 0 and significant at 10% level	12
Observations	1,640

The dependent variable is the log of CO_2 emissions per capita. The effect of the tax treaty with the United States was estimated for placebo (fake) dates. Placebo dates were obtained by assigning random effective tax treaty dates to countries with tax treaties with the United States in 1,000 trials. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), GDP growth (annual percent), country fixed effects, and year fixed effects. Standard errors in parentheses are clustered at the country level. * p<0.10,

**p<0.05, ***p<0.01

Table 6: The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014, Wild Cluster Bootstrap Standard Errors.

	(1)	(2)	(3)	(4)
Tax treaty	-0.069** [-0.133,-0.005] (0.066)	-0.064** [-0.127,-0.001] (0.064)	-0.067* [-0.135,0.000] (0.060)	-0.057** [-0.109,-0.005] (0.045)
Pre-treaty Mean	0.201	0.201	0.201	0.201
Adjusted R^2	0.988	0.988	0.988	0.991
Within Adjusted R^2	0.666	0.667	0.672	0.768
Observations	2,240	2,240	2,240	2,240
Country FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Continent-specific linear trends	No	Yes	Yes	Yes
Country-specific linear trends	No	Yes	Yes	Yes

The dependent variable is the log of CO_2 emissions per capita. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). 95% Confidence Interval and p-value from wild cluster bootstrap are in square and angle brackets. * p<0.10,

**p<0.05, ***p<0.01

Table 7: Goodman-Bacon Decomposition (Goodman-Bacon et al., 2019). The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014.

	(1) Weight	(2) Average DD Estimate
Difference in Difference Estimate		-0.104
Earlier Treated vs. Later Control	0.011	-0.115
Later Treated vs. earlier Control	0.021	-0.115
Treated vs. Never treated	0.825	-0.119
Treated vs. Already treated	0.143	-0.014

Notes: Estimates excludes controls.

Table 8: The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014. Difference-in-differences estimators.

	(1) TWFE OLS	(2) Cengiz et al. Stacked DID	(3) Wooldridge Extended TWFE	(4) Borusyak et al. Imputation Estimator
Tax treaty	-0.064**	-0.035**	-0.091	-0.138***
	(0.032)	(0.015)	(0.062)	(0.031)
Pre-treaty Mean	0.201	0.179	0.201	0.201
R^2	0.988	0.990	0.983	
Within Adjusted R^2	0.667	0.521	0.169	
Observations	2,240	5,238	1,782	1,782
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stack FE	No	Yes	No	No
Continent-specific linear trends	No	No	No	No
Country-specific linear trends	No	No	No	No

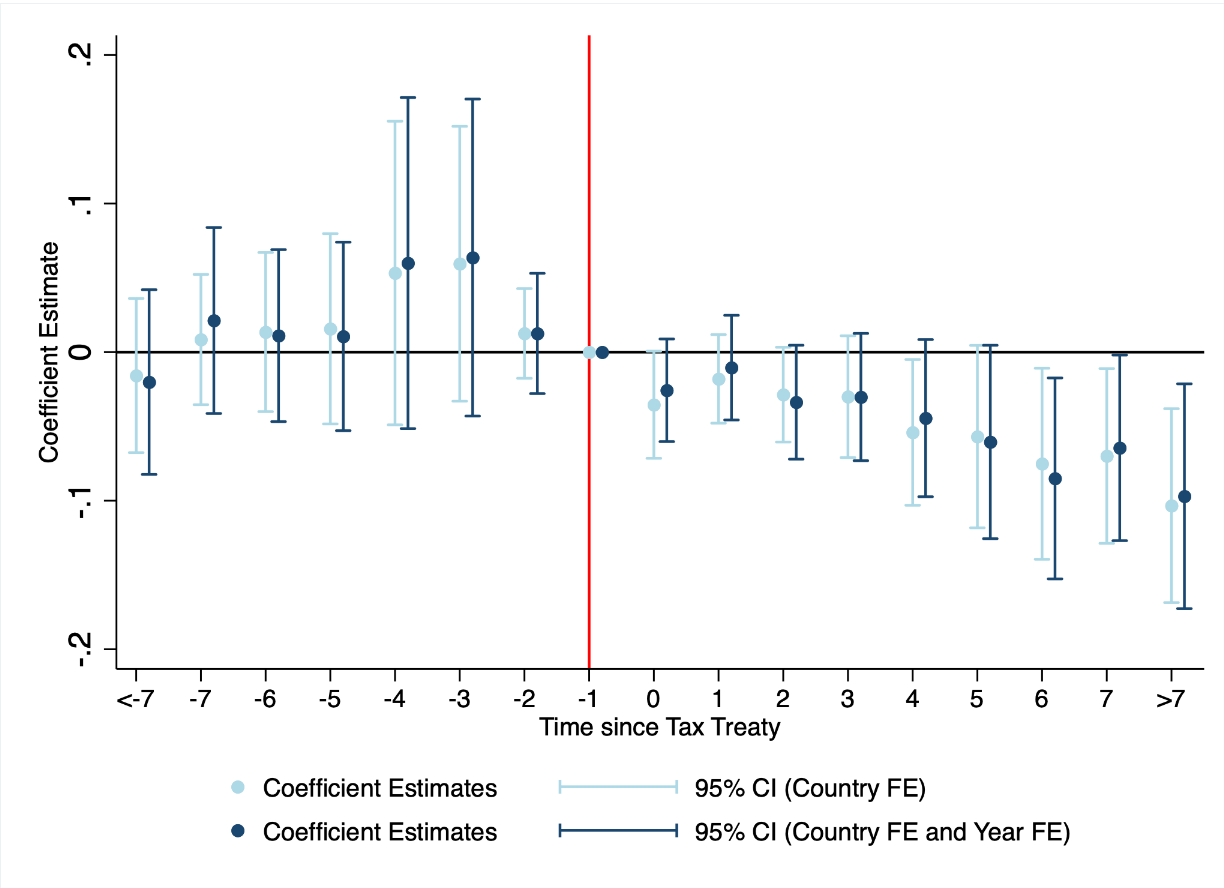
The dependent variable is the log of CO_2 emissions per capita. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). 95% Confidence Interval and p-value from wild cluster bootstrap are in square and angle brackets. * p<0.10, **p<0.05, ***p<0.01

Table 9: The effect of tax treaty on United States foreign direct investment positions in emerging market economies, 1990-2014.

	(1)	(2)	(3)	(4)
All Industries				
Tax treaty	-2.578	-1.171	1.970	1.885
	(2.767)	(2.302)	(2.821)	(2.730)
Pre-treaty Mean	4.837	4.837	4.837	4.837
R^2	0.725	0.738	0.761	0.766
Within Adjusted R2	0.279	0.298	0.372	0.373
Observations	1,340	1,340	1,340	1,340
Manufacturing				
Tax treaty	-0.549	0.328	0.980	0.925
	(1.161)	(0.770)	(0.877)	(0.795)
Pre-treaty Mean	1.515	1.515	1.515	1.515
R^2	0.833	0.851	0.897	0.900
Within Adjusted R2	0.295	0.354	0.561	0.565
Observations	1,084	1,084	1,084	1,084
Wholesale Trade				
Tax treaty	-0.107	0.256	0.613	0.604
	(0.287)	(0.337)	(0.409)	(0.420)
Pre-treaty Mean	0.362	0.362	0.362	0.362
R^2	0.451	0.478	0.491	0.502
Within Adjusted R2	0.159	0.179	0.216	0.213
Observations	1,070	1,070	1,070	1,070
Mining and Petroleum				
Tax treaty	-0.752**	-0.675**	-0.766**	-0.757**
	(0.293)	(0.302)	(0.302)	(0.310)
Pre-treaty Mean	0.545	0.545	0.545	0.545
R^2	0.685	0.690	0.689	0.695
Within Adjusted R2	0.138	0.129	0.143	0.137
Observations	1,021	1,021	1,021	1,021
Other Industries				
Tax treaty	-0.124	-0.050	1.079	0.931
	(0.563)	(0.529)	(0.695)	(0.680)
Pre-treaty Mean	1.117	1.117	1.117	1.117
R^2	0.589	0.605	0.648	0.661
Within Adjusted R2	0.061	0.081	0.194	0.207
Observations	1,329	1,329	1,329	1,329
Additional Covariates	No	No	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Continent-specific linear trends	No	No	No	No
Country-specific linear trends	No	No	No	No

The dependent variable is the U.S. foreign direct investment (in million US$). Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. km. of land area), and GDP growth (annual percent). Additional covariates in columns 3 and 4 are log U.S. GDP per capita, log absolute values of differences in GDP difference between U.S. and destination country, distance between countries, and indicators of WTO membership, GATT, and regional trade agreements (RTA). 95% Confidence Interval and p-value from wild cluster bootstrap are in square and angle brackets. * p<0.10, **p<0.05, ***p<0.01

Figure A1: Event study estimates. The effect of tax treaty on carbon emissions in emerging market economies, 1990-2014, accounting for the political regimes of countries.



The dependent variable is the log of CO_2 emissions per capita. Controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq.Km of land area), GDP growth (annual percent), and political regime classification. Standard errors are clustered at the country level.

Table A1

Description of Variables

Variable	Description
CO_2 per capita	Carbon dioxide emissions per capita, including emissions from fossil fuels burning, cement manufacturing, fuel consumption and gas flaring.
Tax Treaty	Double taxation bilateral tax treaty between the United States and an emerging country. It takes the value of one if the effective date of the tax treaty and years post the effective date.
GDP per capita	Gross Domestic Product divided by midyear population in constant 2010 US dollars.
GDP per Energy	Gross Domestic Product in 2017 constant international dollars using purchasing power parity rates per kilogram of oil equivalent of energy use.
Fossil Fuel Energy Consumption	Fossil fuel energy consumption comprises coal, oil, petroleum, and natural gas products (percent of total).
Population Density	Midyear population counting all residents regardless of legal status or citizenship, except for refugees, divided by land area in square kilometers (people per square kilometer of land area).
GDP Growth	Annual percentage growth rate of GDP at market prices based on constant local currency.
Education	Average number of years of education received by people aged 25 and older, converted from educational attainment levels using official duration for each level.
Industries Value Added	Industry (including construction) corresponding to ISIC divisions 05-43 and including manufacturing (ISIC divisions 10-33) as value added (percent of GDP)
Gross Capital Formation	Gross fixed capital formation, outlays on additions to the fixed assets of the economy plus net changes in the level of inventories, as a share of GDP.
Trade Openness	Sum of exports and imports of goods and services measured as a share of GDP.

Sources: (i) CO_2 per capita, GDP per capita, GDP per Energy, Fossil Fuel Energy Consumption, Population Density, GDP Growth, Industries Value Added, Gross Capital Formation, Trade Openness are from the World Development Indicators, World Bank: databank.worldbank.org/source/world-development-indicators ; (ii) Tax treaty is from the US Internal Revenue Service: www.irs.gov/individuals/; (iii) Education data come from World Development Indicators and UNESCO Institute for Statistics (2020), Barro and Lee (2018), ICF Macro Demographic and Health Surveys, UNICEF Multiple Indicator Cluster Surveys and OECD (2019b).

Table A2: The effect of tax treaty on carbon emissions on emerging market economies, 1990-2014, accounting for the political regimes of countries.

	(1)	(2)	(3)	(4)
Tax treaty	-0.071**	-0.066*	-0.069*	-0.056**
	(0.034)	(0.033)	(0.035)	(0.026)
Year FE	No	Yes	Yes	Yes
Pre-treaty Mean	0.201	0.201	0.201	0.201
R^2	0.988	0.988	0.989	0.992
Within Adjusted R2	0.666	0.667	0.672	0.768
Observations	2240	2240	2240	2240

The dependent variable is the log of CO_2 emissions per capita. Each regression controls for log GDP per capita (US$, 2010), squared log GDP per capita (US$, 2010), log GDP per energy, fossil fuel energy consumption (percent of total), log population density (people per sq. Km of land area), GDP growth (annual percent), and political regime classification. Standard errors clustered at the country level are in parentheses. * p<0.10, **p<0.05, ***p<0.01

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