The limits of cross-border environmental policies: Trade diversion as leakage*

Ryan Abman, Hattie Jenkins, and Clark Lundberg†

Abstract

Global environmental externalities are one of the most pressing policy challenges of the modern era. Unilateral policy options to address global externalities are limited, however, by sovereignty and a general difficulty in achieving environmental objectives across national borders. We study an emerging trade policy tool used in cross-border environmental policies—environmental standards for imports—using a European Union program aimed at mitigating illegal timber harvest in tropical timber exporting countries. Through bilateral agreements with partner countries, the program established de facto import restrictions through supply chain transparency and certification requirements on forest-products. We find that the policy led to a diversion of partner country exports away from the EU towards other markets, particularly in Asia, and had no discernible reductions on forest loss. Our findings highlight the role that trade diversion can play as a leakage mechanism in such cross-border environmental policies.

JEL Codes: O13, Q32, D72
Keywords: Environmental policy, trade policy, governance, deforestation, cross-border policy

*This project has benefited from helpful feedback from Martin Hedemann-Robinson, Robert Heilmayr, Scott Holladay, Daniel Kaffine, Richard Klotz, Michele Ruta, Yuting Yang, participants of the AERE session at the Western Economic Association International Summer meetings and the CU Environmental and Resource Economics Workshop.

†Abman: Department of Economics, San Diego State University (email: rabman@sdsu.edu). Jenkins: Department of Agricultural and Resource Economics, University of California, Davis (email: hejenkins@ucdavis.edu). Lundberg: Department of Economics, San Diego State University (email: clundberg@sdsu.edu).

1 Introduction

Global environmental externalities are one of the most pressing policy challenges of the modern era. Unilateral policy options to address global externalities are limited, however, by sovereignty and a general difficulty in achieving environmental objectives across national borders. Nevertheless, many countries have pursued strategies to extend their domestic policy reach through "cross-border" policies targeting economic and environmental activity inside foreign nations' sovereign borders. These cross-border approaches to environmental policy must overcome the dual challenge of providing sufficient incentives to encourage counterparty participation while, at the same time, offer enough structure to achieve meaningful impacts.

These objectives are typically at odds. At one end of this spectrum are large multilateral environmental agreements like the Paris Accord and the Montreal Protocol. However, greater participation in the policy formation process comes with greater contracting frictions which have, historically, led to weaker environmental agreements.[1] Indeed, the literature has documented challenges of negotiating agreements across large, stable coalitions while meaningfully addressing global externalities (Aichele and Felbermayr, 2012; Kellenberg and Levinson, 2014; Martimort and Sand-Zantman, 2016).

Because of these limitations, bilateral trade policy has emerged as a preferred tool to introduce incentives and enforceability by conditioning market access on environmental commitments from trade partners. One prominent approach which has proliferated in recent decades uses preferential market access as an incentive to establish environmental commitments under plurilateral trade agreements. This policy approach leverages preferential tariffs to make domestic markets relatively more attractive to counterparties, thereby introducing opportunities to impose environmental conditions for such preferential access. Abman *et al.* (2024) find that these preference-based approaches can be effective vehicles for cross-border environmental policies—deforestation-related conditions in trade agreements successfully mitigate forest loss that would otherwise occur following trade liberalization.

In contrast, another increasingly common approach seeks to *restrict* market access unless environmental policy targets are met. These types of policies are typically unilateral or bilateral

[1] The Montreal Protocol is one of the few exceptions to this characterization. It has been adopted by nearly every country in the world and been effective at addressing environmental externalities (Gonzalez *et al.*, 2015; McKenzie *et al.*, 2019; World Meteorological Organization, 2018).

in scope. The European Union's 2023 legislation on deforestation-free imports—which requires that products imported into the EU have not contributed to global deforestation—is emblematic of this approach. In this type of framework, foreign country exports cannot enter domestic markets unless they conform with particular environmental regulations. However, with such restriction-based policies, compliance costs are unlikely to be offset by preferential access, making domestic markets relatively *less* attractive. This can undermine the goals of cross-border environmental policies by introducing the likelihood of policy leakage through the diversion of trade away from the restricted market. Despite widespread attention from policy-makers, environmentalists and the general public, the impacts of these restriction-based cross-border policies has not been empirically investigated in a rigorous and systematic way.

In this paper, we evaluate the effectiveness of such market access restrictions using another European Union cross-border trade instrument: the European Union's Forest Law Enforcement, Governance, and Trade (FLEGT) program. FLEGT represents an important attempt to induce governance reform in the timber sectors of tropical countries to reduce illegal logging. The program is implemented through bilateral agreements, wherein the European Union supplies technical assistance with the reform of local forestry institutions (and in some cases, financial support) and then imposes requirements for transparency and sourcing of forest product imports from the partner country. These import requirements reduce de facto access to EU markets.

We study the impacts of the FLEGT program in the nine partner countries that had signed agreements by 2020.[2] We combine detailed, product-level data on bilateral trade flows with spatially-explicit, remotely-sensed estimates of forest loss from 2000 through 2022. We use synthetic differences-in-differences to estimate the impacts of signing the agreement on changes to the value and destinations of forest product exports as well as changes in forest loss (both country-wide and inside established protected areas) from partner countries.

We find significant evidence of trade diversion away from European markets, with a 33 percent decline in the share of forest product exports to the EU from FLEGT partner countries. This trade diversion effect is driven by lower value chain products that are directly targeted by FLEGT import restrictions—we estimate that the EU share of these low-value-chain exports

[2]These countries include Ghana, Cameroon, The Central African Republic, The Republic of Congo, Liberia, Indonesia, Vietnam, Honduras, and Guyana.

falls by 45 percent. We find significant evidence that these diversion effects direct exports to East Asian markets. We find no evidence that forest loss is reduced in respose to the FLEGT program—either country-wide or within protected areas. Our results suggest that the effectiveness of this restriction-based cross-border policy was likely undermined by the availability of alternative markets for forest products with weaker restrictions on supply-chain transparency and no formal rules barring the importation of illegal timber.

This paper contributes to three separate literatures. First, we contribute to the empirical literature on international approaches to environmental externalities. Multilateral approaches like international environmental agreements (IEAs) are one proposed tool to manage global environmental issues. However, the voluntary nature often implies that there are little or no costs to violation of the agreement. Some empirical work has found that such IEAs have failed to achieve their aims. Examples include the Kyoto Protocol (Aichele and Felbermayr, 2012) and the Basel Convention (Kellenberg and Levinson, 2014). However, Heid and Márquez-Ramos (2023) finds that the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appears to have improved outcomes for listed species, but these effects are weaker in countries with higher prevalence of corruption and lower income. To address the voluntary nature of these agreements, some have proposed connecting environmental outcomes to trade agreements (referred to as "issue linkage" by Maggi (2016)) to achieve better environmental and resource management. Environmental (and other non-trade) provisions can be enforced via enforcement mechanisms embedded in the RTA, while the improved market access incentivizes counterparties to join. While there is not much empirical literature on the effectiveness of these approaches, Abman *et al.* (2024) find that forest and biodiversity conservation provisions in RTAs offset the otherwise expected increase in forest loss that arises after a trade agreement enters into force. In this paper we offer new insights into policy approaches that emphasize market access *restrictions*. While the FLEGT program does offer benefits to induce participation through technical assistance and continued timber product market access to the EU, they are not embedded in a broader set of trade policy reforms and tariff reductions that would ensure the ongoing desirability of EU markets.

Second, we contribute to the empirical literature on governance and resource management. The empirical literature typically finds non-monotonic relationships between national gover-

nance quality and natural resource exports (Ferreira and Vincent, 2010; Isaksen and Richter, 2019; Wendland *et al.*, 2014). In this work, characteristics of national governance are measured at the aggregate level, with the implication that, for example, the prevelance of corruption broadly will spillover into the management of the natural resource sector. The FLEGT policy represents an interesting attempt to reform governance in a particular natural resource sector without affecting the broader governance environment.

Finally, the narrowest area of research to which we contribute is the empirical work assessing the effectiveness of the EU's FLEGT program. Our key contribution to this literature is in providing what we believe to be the first paper to empirically study the impacts of this policy across the first nine participating countries using quasi-experimental methods. As noted in a recent FLEGT literature review, "almost all relevant studies are case reports that use qualitative data and focus on only one country at a time" (Villanueva *et al.*, 2023, p.1).[3] Nonetheless, the studies have raised questions about the FLEGT program such as the willingness and ability to comply with legal standards set by the program (Acheampong and Maryudi, 2020), the ability of the program to benefit smallholders and encourage participation (Lesniewska and McDermott, 2014; Neupane *et al.*, 2019; Satyal, 2018) and the potential for trade diversion to Asia (Bosello *et al.*, 2013). Brusselaers and Buysse (2018) study timber exports from Cameroon following the VPA entry into force using a vector-autoregression approach and find that timber exports from Cameroon to the EU decreased. Our consideration of all participating countries and the application of quasi-experimental approaches to study both forest loss and trade outcomes offers a complement to the existing work.

2 FLEGT Background

The European Union's Forest Law Enforcement, Governance, and Trade program was developed by the EU as a means to reduce illegal logging and deforestation associated with EU forest product imports. The original so-called Action Plan was adopted in 2003 and subsequent regulation passed in 2005[4] which emerged out of the first phase of EU efforts to curb deforesta-

[3] In fact, Villanueva *et al.* (2023) state, "future research should focus on more countries; use a greater range of methods, including comparative experimental designs; explore possible intended effects on under-researched categories; and systematically investigate unintended effects on other categories within and outside the forestry sector."

[4] Council Regulation (EC) No 2173/2005 of 20 December 2005 on the establishment of a FLEGT licensing scheme for imports of timber into the European Community

tion. These regulations established a legal framework for the bilateral agreements—referred to as voluntary partnership agreements (VPAs). VPAs are bilaterally negotiated between the EU and timber exporting partner countries. Despite the term "voluntary" (which refers to the decision of a country to sign and enter into the agreement), these VPAs are legally binding agreements wherein the EU attempted to enact effective supply-side controls on forest legality and source-transparency. The ultimate goal in the VPA system is to establish a domestic licensing scheme in the partner countries (referred to as Timber Legality Assurance Schemes or TLAS) that the EU could rely on. Timber products with these licenses would then enjoy free circulation throughout the EU. To date, only Indonesia has managed to fully implement a licensing scheme. While details of the VPAs differ by partner country, they all share the similar components: a definition of legally produced timber according to the laws of the partner country, controls over the timber supply chain within the partner country, systems of verification and supply chain controls, designation of the institutions to manage license issuance, and an outline of the independent monitoring to take place (Hedemann-Robinson, 2024). To assist in the process, the EU offered partner countries technical and financial assistance, though this varied by country.[5]

In 2010, the EU also adopted complementary demand-side legislation in the form of the EU Timber Regulation (EUTR)[6] which prohibited the placement of illegal timber in the EU market.[7] In contrast to FLEGT's cross-border supply-side interventions and customs regulations, the EUTR governed domestic EU firms placing timber on the EU market, requiring that any so-called "operators" exercise due diligence in verifying the legality of timber products. EUTR governed timber products from any source country, however, FLEGT-licensed timber products were not subject to any additional verification that came along with the EUTR. The EU later expanded its efforts to reduce deforestation beyond just timber product exports, under the recognition that agricultural land expansion is also a critical driver of deforestation and forest degradation, in its second phase outlined in a 2019 report[8]. Subsequent regulation passed

[5] A 2015 EU audit points out that, by that time, Liberia and the Central African Republic had received 1.9 and 6.8 million euro respectively in financial assistance to implement their VPA whereas Côte d'Ivoire had received none despite having more than 10 times the value of exports to the EU than the others.(ECA, 2015)

[6] The EU Timber Regulation entered into force in 2013.

[7] Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market

[8] COM(2019)352, European Commission Communication *Stepping up Action to Protect and Restore the World's Forests*

in 2023[9] codified this commitment and repealed the more limited ban in illegal timber exports from 2010.

3 Data

We combine a variety of different data sets from publicly-available sources. We use bilateral trade data from the Centre for Prospective Studies and International Information's (CEPII) BACI dataset, which harmonizes UN Comtrade data for 200 countries at the product level (6 digit HS product code).[10] Given the scope of the FLEGT program, we focus on forest-derived products (i.e. timber and processed wood products), which we characterize as either high or low value chain goods based on the level of processing required to produce it.[11] The value of these bilateral trade flows were collapsed to the exporter level and importing countries were designated into regions determined by Gaulier and Zignago (2010). The importing countries which were not designated to a region within the report were manually imputed based on the location of the country. The result is a panel dataset of wood product exports by value and destination region.

Our forest loss data comes from the Global Forest Change dataset (Hansen *et al.*, 2013). This dataset provides spatially-explicit estimates of forest cover in the year 2000 and annual forest loss from 2001 to 2022 at a spatial resolution of 30 meters for the entire terrestrial surface of the earth. We aggregate spatially explicit annual forest loss measures to the country-level. In our estimates, we use both the total annual hectares of forest loss as well as the rate of forest loss (square kilometers lost in a given year relative to total tree cover in the year 2000).

To proxy observable forest loss that is plausibly illegal, we use data on protected areas from UNEP-WCMC (2023) which provides spatially explicit information on nearly 300,000 protected

[9] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010

[10] BACI reconciles bilateral trade flows reported by exporters with those reported by importers. While assessing the reliability of each reporting country, the data attempts to harmonize reporting values (e.g. CIF costs reported in import values vs. free on board (FOB) export values).

[11] For example, product code '440342' corresponds to "Wood and articles of wood; wood charcoal wood in the rough, whether or not stripped of bark or sapwood, or roughly squared – teak" and would be classified as a low value chain product. An example of a product classified as high value chain is product code '482010' which corresponds to "Registers, account books, note books, order books, receipt books, letter pads, memorandum pads, diaries and similar articles." For parsimony we have not tabulated the full list of product code value classifications but it is available upon request.

areas covering 244 countries and territories. Because protected areas have been established over time, we use only land that lies in protected areas that were established by 2006 in order limit the potential for confounding forest loss that occurred before protection.[12] 2006 predates the earliest FLEGT negotiations and insulates us from any selection bias that might have occurred due to correlation between the FLEGT program and local protected area policies.

We create three different outcomes by aggregating annual forest loss across different categories of protected land by country and year. First, we consider forest loss across all protected area categories, regardless of designation. Second, we limit forest loss outcomes to only those protected areas with the most strict designations which do not allow for any form of sustainable harvest/use (IUCN categories Ia, Ib, and II). Finally, we limit our forest loss outcome to those that have weaker restrictions for land use (IUCN categories III-VI).[13]

We limit our sample to less-developed countries in the tropics and omit some small island nations such as the Marshall Islands, Dominica, Tonga, etc. India is ommitted as it does not appear in the harmonized BACI trade database. Our final estimation sample consists of 106 countries from 2000–2022.[14]. We present summary statistics in Table A.1 in the Appendix.

4 Empirical approach

We identify the effects of the FLEGT program on both forest loss and timber export outcomes using the synthetic difference-in-differences approach developed by Arkhangelsky *et al.* (2021). The approach is a combination of synthetic control matching and difference-in-differences with two-way fixed effects whereby the counterfactual group is selected from a weighted average of potential control observations. Specifically, we estimate the following model:

$$\underset{\beta,\alpha,\delta}{\operatorname{argmin}} \left\{ \sum_i \sum_t \left(y_{it} - \alpha_i - \delta_t - \beta Agreement_{it}\right)^2 \hat{\omega}_i^{sdid} \hat{\lambda}_t^{sdid} \right\} \tag{1}$$

[12] An alternative approach would be to examine forest loss in all protected areas after they are established. We opt against this approach as the sample of protected land changes overtime and complicates the interpretation of changes in forest loss in protected areas. For example, increasing the total protected land could lead to decreases in the rate of forest loss in protected land by increasing the denominator, even if there was no appreciable change in activity. For this reason, we choose an approach that keeps the total land constant through the sample period.

[13] Because many listed protected areas in the dataset do not have official IUCN categories, the first outcome contains more protected areas than the union of our other two outcomes.

[14] Our forest loss sample includes 101 countries from 2001–2022, omitting countries without any forest cover as well as the year 2000 for all countries due to Hansen *et al.* (2013) temporal coverage

In the model above, y_{it} is the outcome of interest (either a measure of forest loss or timber product exports). α_i is a country-specific fixed effect that controls for all time-invariant factors that determine average forest loss or timber exports for a given country. δ_t is year fixed effect that controls for all year-to-year unobservable factors that affect forest loss and timber exports across all countries in our estimation sample, such as year-to-year changes to global timber prices or the introduction of the EUTR which affected imports from all countries, not just those from FLEGT partner countries. $Agreement_{it}$ is an indicator variable that takes the value of 1 for countries that have signed a FLEGT VPA and 0 otherwise.[15] β is our coefficient of interest and represents the average treatment effect on the treated on forest loss or timber exports. Synthetic difference-in-differences departs from traditional difference-in-differences in the inclusion of $\hat{\omega}_i^{sdid}$ and $\hat{\lambda}_t^{sdid}$, control group weights and time weights. These weights ensure that the counterfactual group is comprised of a weighted average of never-treated countries that best match the pre-treatment trends in outcomes of the 7 countries for which a VPA enters into force. All standard errors are calculated following the bootstrap procedure described in Arkhangelsky *et al.* (2021).[16]

Synthetic difference-in-differences is an ideal approach in our setting for two key reasons. First, we have a small number of treated countries that may have very heterogeneous patterns in timber product exports and forest loss for which a simple average of all other tropical, less-developed countries may not be an ideal counterfactual. By selecting a weighted average of countries that minimize the pre-treatment difference in trends, synthetic difference-in-difference offers a more credible counterfactual and prevents bias from diverging pre-trends in our outcome variables. Second, the synthetic difference-in-differences approach is valid in settings where treatment timing is varied. The concern with difference-in-difference approaches is that the reported average treatment effect on the treated (ATT) is comprised of different comparisons of early-treated, later-treated, and never-treated groups. Issues arise as the comparison before and after treatment for the late group may be compared to changes in

[15] We define treatment timing based on VPA signature, rather than ratification, due to the likely timing of producer responses. We expect that compliance efforts and/or trade diversion will begin happening in anticipation of EU market access changes once the VPA enters into force.

[16] Ideally, we would use the jackknife procedure for estimating standard errors as it performs better in small sample settings. However, this approach is only feasible if all treatment cohorts contain more than 1 treated unit which is not the case in our empirical setting. Arkhangelsky *et al.* (2021) also introduce a placebo approach as an alternative to bootstrap standard errors but this requires the assumption of homoskedasticity across units which we believe is too restrictive in our setting.

the already-treated group which can bias difference-in-difference estimates. However, the synthetic difference-in-difference approach is robust to this issue as the comparisons are only made between the treated and never-treated groups. Separate ATT values are estimated for each cohort and the overall ATT estimate is a weighted average of the cohort-specific ATT estimates. As noted in Table 1, the FLEGT VPAs were signed in different years across the nine countries, and thus the robustness to the bias that may otherwise arise in standard difference-in-difference estimators is a very desirable property of synthetic difference-in-difference in this empirical setting.

5 Results

We present synthetic difference-in-difference estimates on forest-product exports from the signing of the FLEGT VPA in Table 2. This table presents coefficient estimates of β from equation (1) across a wide variety of timber product outcomes. The first two columns present the ATT estimates of the inverse hyperbolic sine (asinh) of total forest product export value to all destinations in column (1) and the inverse hyperbolic sine of total forest product exports to the EU in column (2)).[17] After signing a VPA, total forest product exports remain unchanged but the value of forest product exports to the EU declines dramatically, by roughly one third.[18]

In Columns (3)–(6) we present estimates on export ratios. Column (3) estimates the model on the value of timber product exports to the EU divided by value of total timber product exports—i.e. the share of timber product exports sent to the EU from the partner countries. The estimates are consistent with those in the previous columns and indicate that the share of timber product exports to the EU fall by 8.7 percentage points which is one third of the pre-treatment share. In Column (4) we test whether the VPA induced a change in the composition of timber product exports by using the ratio of high value chain timber product exports to total timber product exports. If the VPA encouraged countries to increase their exports of higher value chain products (like furniture, finished paper products, etc.) rather than export primary timber commodities, we would expect to see this ratio increase in response to a VPA. Our estimates

[17] We use the asinh transformation as a standard alternative to a log-linear model to manage cases in which export observations in a given year may be zero.

[18] Estimates using the level of exports yield qualitatively similar results, though they are less precisely estimated: relatively little change in the value of exports, but an average decline in EU exports of 68 million 2015 USD—about 31 percent of the pre-treatment mean.

indicate no significant change and thus no systematic change to the composition of the timber product exports.

In light of the finding in Column (4), we test whether there are differences in the export diversions for high value chain timber products and low value chain timber products. Columns (5) and (6) present results on the EU share of high value chain timber product exports and the EU share of low value chain timber product exports respectively. We find no effect from the VPA on high value chain timber product exports, but a large and significant reduction in the share of low value chain exports sent to the EU—precisely the types of timber products covered by the FLEGT program. Taken together, the results presented in Table 2 indicate that the bilateral agreements led to economically (and statistically) significant declines in timber product exports from partner countries to the EU, but did not reduce total timber product exports nor did it change the composition of their exports with regards to high or low value chain products. The declines we observe are present for the kinds of products that would be affected by the VPA, but not for high value chain timber products.

We examine trade diversion *destinations* in Table 3. Each column corresponds to forest product export shares across different regions. We find large and significant increases in forest product exports to Asia (Column (1)) which appear to be concentrated in East Asia (Column (2)) with no increase to South Asia (Column (3)). We do not see any significant changes in export shares to Non-EU European countries (Column (4)), North America (Column (5)), Latin America (Column (6)) or Africa (Column (7)).

To study the dynamic effects of the policy and rule out results being driven by pre-existing diverging trends, we estimate synthetic control event studies following Ciccia (2024) and present these graphs in Figure 1. Individual lead/lag estimates are a weighted average of cohort-specific comparisons between treated countries and the weighted average of controls selected for that cohort in a given year relative to signing the VPA. Though we calculate estimates for 18 years prior through 15 years after the signing of the agreement, only the coefficients on 8 years prior through 5 years after signing are identified from all 9 treated countries. These figures present dynamic estimates around the signing of the VPA on four outcomes: the share of timber product exports to the EU (panel a), the share of low value chain product exports to the EU (panel b), the share of high value chain product exports to the EU (panel c), and the share of timber

product exports to Asia (panel d). These figures indicate no differential trends leading up to the signing of the VPAs in any of the four outcomes—suggesting that the synthetic difference-in-differences matching approach provides suitable counterfactuals in all four cases. Following the signing of the VPA, the plots indicate declines in the share of timber exports to the EU, especially for low value chain timber products. There appears to be no change in the share of high value chain products sent to the EU (again, as these were not likely to be impacted by the regulation) and there is a large and sustained increase in the share of timber product exports to Asia.

In the appendix, we also report in Table A.2 individual country treatment effects on EU timber export shares, EU low value chain export shares, and the Asia timber product export shares using synthetic difference-in-differences while isolating treatment to a single country. While we observe considerable heterogeneity in effect sizes and lower precision in single country ATT estimates, 8 out of the 9 point estimates in Panels (A) and 7 out of 9 point estimates in Panel (B) are negative with magnitudes largely ranging from 16 to 48% reduction relative to pre-treatment mean (excluding estimates with positive point estimates). In Panel (C), 8 out of the 9 individual treatment effects on the share of timber product exports to Asia are all positive and large in magnitude relative to pre-2008 means (with the exception of Indonesia). We present graphs of the individual country outcomes and their synthetic counterfactuals in Figures A.2 - A.4 in the Appendix.

We turn to estimates on forest loss outcomes in Table 4. Panel A presents estimates on the levels of forest loss (measured in km^2) while Panel B presents estimates on the rate of forest loss (annual loss divided by total baseline forest cover). For country-wide forest loss (Column (1)), both measures of loss indicate noisy positive effects. The coefficient estimates are large relative to the pre-2008 mean of the nine participating countries, but the standard errors are also large, reflecting a lack of precision. Columns (2)–(4) present estimates of forest loss in different sets of protected areas established by 2006. Results in Column (2) indicate no effect on forest loss across all protected areas and results in Column (3) also indicate no effects for protected areas with strict classifications (i.e. classifications that prohibit all sustainable use and/or development). For those protected areas with the less-strict classifications, we find a marginally significant increase (at the 10%) in the levels of forest loss inside these boundaries

(Column (4) of panel A) but no such significant effects in terms the rate of forest loss (Column (4) of panel B). Overall, we find no significant evidence that the FLEGT program reduced illegal timber harvest, as measured through forest loss in protected areas. In fact, we find weak, or suggestive, evidence that FLEGT may have actually *increased* forest loss in less stringently protected areas.

While the evidence from satellite-derived estimates of forest loss do not indicate reductions in overall forest loss or reductions in forest loss inside protected areas, we are careful to acknowledge that this is an imperfect measure of illegal logging and likely does not fully capture the ecological benefits of forest governance reform. Reforms to timber concessions, processes, or changes in methods used for harvesting may offer important benefits that we are unable to systematically assess given the limitations of our global datasets. While forest loss inside strict protected areas is one manifestation of illegal logging, there are many others that may have been impacted by the FLEGT VPA.

6 Concluding remarks

We find that the FLEGT policy has had little overall impact on forest loss across program partner countries—the nominal goal of this cross-border policy. Instead, the policy lead to a change in the destination of the exports from partner countries as they reduced the share of their exports to the EU and increased the share of exports to other markets—Asia in particular. While there are many aspects of forest governance and illegal logging we are unable to systematically capture across our wide sample of countries, the results in this paper suggest that the availability of other markets without binding import regulations on timber offered partner countries an opportunity to continue exporting timber products with few reforms.

There are many important avenues for future work that are either beyond the scope of this paper or are unanswerable due to the state of the data at the time of writing. Our measure of illegal logging is admittedly coarse, forest loss inside strict protected areas. There are many ways that forest products can be illegally harvested that are not measured in our setting. In Liberia, for example, chainsaw-milled timber is exempted from sourcing and reporting requirements for small-scale domestic consumption but is increasingly being illegally exported to circum-

vent commercial monitoring and reporting requirements.[19] Likewise, tree selection criteria like trunk diameter restrictions and habitat locations may all have important implications for the social cost of timber harvesting. We are unable to systematically consider these factors in this paper. Future studies that incorporate these considerations could provide useful insight on potential benefits of the FLEGT program that our current strategy cannot identify. More broadly, there are opportunities for theoretical work to identify the role of the relative *size* of restricted markets on the trade diversion effect which has important implications for the effectiveness of cross-border policies.

Our paper highlights an important shortcoming of cross-border policies that condition trading partner access to domestic markets on policy reforms in sovereign foreign nations. The availability of other destination markets allows exporters to circumvent the market access regulations and divert their exports elsewhere. Such trade diversion in this setting functions as policy leakage—intended results are undermined as products can find other destinations with lower barriers. This is a critical finding that threatens to undermine many contemporary cross-border policies like the EU's 2023 deforestation free-supply chain legislation and carbon border adjustment mechanism. This shortcoming is also particularly salient when contrasted with preference-based policies like environmental provisions in trade agreements which the literature has found to be an effective form of cross-border environmental policy.

.

[19] https://news.mongabay.com/2024/05/new-illegal-logging-threatens-liberias-forests-amid-vague-ban/

References

Abman, R., Lundberg, C. and Ruta, M. (2024) The effectiveness of environmental provisions in regional trade agreements, *Journal of the European Economic Association*, p. jvae023.

Acheampong, E. and Maryudi, A. (2020) Avoiding legality: Timber producers' strategies and motivations under flegt in ghana and indonesia, *Forest Policy and Economics*, **111**, 102047.

Aichele, R. and Felbermayr, G. (2012) Kyoto and the carbon footprint of nations, *Journal of Environmental Economics and Management*, **63**, 336–354.

Arkhangelsky, D., Athey, S., Hirshberg, D. A., Imbens, G. W. and Wager, S. (2021) Synthetic difference-in-differences, *American Economic Review*, **111**, 4088–4118.

Bosello, F., Parrado, R. and Rosa, R. (2013) The economic and environmental effects of an eu ban on illegal logging imports. insights from a CGE assessment, *Environment and Development Economics*, **18**, 184–206.

Brusselaers, J. and Buysse, J. (2018) Implementation of the EU-Cameroon Voluntary Partnership Agreement policy: Trade distortion, rent-seeking and anticipative behavior, *Forest Policy and Economics*, **90**, 167–179.

Ciccia, D. (2024) A short note on event-study synthetic difference-in-differences estimators, *arXiv preprint arXiv:2407.09565*.

ECA (2015) Special Report: EU support to timber-producing countries under the FLEGT action plan, Tech. Rep. 13, European Court of Auditors.

Ferreira, S. and Vincent, J. R. (2010) Governance and timber harvests, *Environmental and Resource Economics*, **47**, 241–260.

Gaulier, G. and Zignago, S. (2010) Baci: International trade database at the product-level. the 1994-2007 version, Working Papers 2010-23, CEPII.

Gonzalez, M., Taddonio, K. N. and Sherman, N. J. (2015) The montreal protocol: how today's successes offer a pathway to the future, *Journal of Environmental Studies and Sciences*, **5**, 122–129.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S., Tyukavina, A., Thau, D., Stehman, S., Goetz, S., Loveland, T. *et al.* (2013) High-resolution global maps of 21st-century forest cover change, *Science*, **342**, 850–853.

Hedemann-Robinson, M. (2024) *Combating Deforestation: The Evolving Legal Framework of the EU on Forest Law Enforcement, Governance and Trade*, Edward Elgar Publishing.

Heid, B. and Márquez-Ramos, L. (2023) International environmental agreements and imperfect enforcement: Evidence from CITES, *Journal of Environmental Economics and Management*, **118**, 102784.

Isaksen, E. T. and Richter, A. (2019) Tragedy, property rights, and the commons: Investigating the causal relationship from institutions to ecosystem collapse, *Journal of the Association of Environmental and Resource Economists*, **6**, 741–781.

Kellenberg, D. and Levinson, A. (2014) Waste of effort? International environmental agreements, *Journal of the Association of Environmental and Resource Economists*, **1**, 135–169.

Lesniewska, F. and McDermott, C. L. (2014) FLEGT VPAs: Laying a pathway to sustainability via legality lessons from Ghana and Indonesia, *Forest Policy and Economics*, **48**, 16–23.

Maggi, G. (2016) Issue linkage, in *The Handbook of Commercial Policy* (Eds.) K. Bagwell and R. W. Staiger, Elsevier, Amsterdam, Netherlands, vol. 1B, chap. 9, pp. 513–564.

Martimort, D. and Sand-Zantman, W. (2016) A Mechanism Design Approach to Climate-Change Agreements, *Journal of the European Economic Association*, **14**, 669–718.

McKenzie, R., Bernhard, G., Liley, B., Disterhoft, P., Rhodes, S., Bais, A., Morgenstern, O., Newman, P., Oman, L., Brogniez, C. *et al.* (2019) Success of montreal protocol demonstrated by comparing high-quality uv measurements with "world avoided" calculations from two chemistry-climate models, *Scientific Reports*, **9**, 1–13.

Neupane, P., Wiati, C., Angi, E., Köhl, M., Butarbutar, T., Gauli, A. *et al.* (2019) How REDD+ and FLEGT-VPA processes are contributing towards SFM in Indonesia–the specialists' viewpoint, *International Forestry Review*, **21**, 460–485.

Satyal, P. (2018) Civil society participation in REDD+ and FLEGT processes: Case study analysis from Cameroon, Ghana, Liberia and the Republic of Congo, *Forest Policy and Economics*, **97**, 83–96.

UNEP-WCMC (2023) Protected areas map of the world, December 2023, data available from www.protectedplanet.net, Accessed on 12-23-2024.

Villanueva, F. D. P., Tegegne, Y. T., Winkel, G., Cerutti, P. O., Ramcilovic-Suominen, S., McDermott, C. L., Zeitlin, J., Sotirov, M., Cashore, B., Wardell, D. A. *et al.* (2023) Effects of EU illegal logging policy on timber-supplying countries: A systematic review, *Journal of environmental management*, **327**, 116874.

Wendland, K. J., Lewis, D. J. and Alix-Garcia, J. (2014) The effect of decentralized governance on timber extraction in European Russia, *Environmental and Resource Economics*, **57**, 19–40.

World Meteorological Organization (2018) Executive summary: Scientific assessment of ozone depletion: 2018, World Meteorological Organization, Global Ozone Research and Monitoring Project, Report No. 58, Geneva, Switzerland.

7 Tables

Table 1: FLEGT participation by country

Country	Negotiations Began	Agreement Signed	Agreement Ratified	Entry into Force
Ghana	2007	2008	2009	2009
Cameroon	2007	2010	2011	2011
Cent African Rep	2009	2010	2011	2012
Republic of Congo	2008	2009	2013	2013
Liberia	2009	2011	2013	2013
Indonesia	2007	2011	2013	2014
Vietnam	2010	2017	2018	2019
Honduras	2013	2018	2021	2022
Malaysia	2007			
Dem Rep Congo	2010			
Gabon	2010			
Guyana	2012	2018		
Ivory Coast	2013			
Laos	2017			
Thailand	2017			

Notes: The table above lists all countries currently participating in or in negotiations with the EU's FLEGT VPA. Blank values indicate that, as of this paper, the country has not yet progressed to that stage. 'Negotiations' refers to the year in which the negotiations began, 'Agreement' corresponds to the year in which the agreement was signed, 'Ratified' is the year the agreement was ratified after completing the required domestic processes, and 'Entry into force' is the year the VPA officially began.

Table 2: Estimates of FLEGT Agreements on forest timber product exports

	(1)	(2)	(3)	(4)	(5)	(6)
	Export Value (Asinh)		Export Shares			
	Total Exports	EU Exports	EU Export Share	High VC Export Share	EU Share HV Exports	EU Share LV Exports
Agreement Signed	0.00937	-0.428**	-0.0873***	-0.0350	-0.00146	-0.116***
	(0.322)	(0.210)	(0.0302)	(0.0408)	(0.0569)	(0.0335)
Pretreat. Mean	1402.9	219.8	0.262	0.274	0.149	0.255
Effect relative to mean	–	–	-0.333	-0.128	-0.010	-0.455
No Obs	2438	2438	2438	2438	2438	2438

Notes: The table presents synthetic difference in difference estimates of average treatment effects on the treated for the FLEGT participating countries across eight different outcomes. Columns (1) and (2) present results on the inverse hyperbolic sine (asinh) of the export values. Column (3) is the share of total timber exports value sent to the EU (the ratio of EU export value to total export value). Column (4) is the share of high value exports (the total value of high value exports divided by the total value of all exports). Column (5) is the share of high value chain timber exports sent to the EU (the ratio of high value chain exports to the EU divided by the total value of high value chain exports), and column (8) is the share of low value chain timber exports value sent to the EU (the ratio of low value chain exports to the EU divided by the total value of low value chain exports). Pretreatment mean refers to the mean of the outcome variable between 2001 and 2008 for the FLEGT participating countries. In columns (1) and (2) the mean presented in the total export value and EU export value averages (in millions of 2015 USD), not the pretreatment mean of the asinh transformed values. The effect relative to the mean presents the ratio of the ATT to the pretreatment mean. Statistical significance denoted by ** and *** correspond to the $p < 0.05$ and $p < 0.01$ levels, respectively.

Table 3: Estimates of FLEGT Agreements on timber export diversion destination

	(1) Asia	(2) East Asia	(3) South Asia	(4) Non-EU Euro	(5) Nor Am	(6) Lat Am	(7) Africa
Agreement Signed	0.184***	0.176***	0.00245	-0.100	-0.00158	0.0223	-0.0406
	(0.0634)	(0.0591)	(0.00233)	(0.0675)	(0.00212)	(0.0141)	(0.0323)
Pretreat. Mean	0.207	0.204	0.003	0.085	0.006	0.113	0.067
Effect relative to mean	0.886	0.865	0.784	-1.180	-0.286	0.198	-0.608
No Obs	2438	2438	2438	2438	2438	2438	2438

Notes: The table presents synthetic difference in difference estimates of average treatment effects on the treated for the FLEGT participating countries. All outcomes are the share of timber exports to a particular region (the value of the timber product exports to that region divided by total timber product exports). Statistical significance denoted as follows, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Estimates of FLEGT Agreements on forest loss outcomes

Panel A: Annual Area of Forest loss (km2)

	(1) All Forest	(2) PA Loss All	(3) PA Loss Strict	(4) PA Loss Weak
Agreement Signed	385.08	26.07	6.741	18.55*
	(411.40)	(31.44)	(10.04)	(10.66)
Pretreat. Mean	1528.42	64.459	24.642	28.795
Effect relative to mean	0.252	0.404	0.274	0.644
No Obs	2222	2354	1738	1760

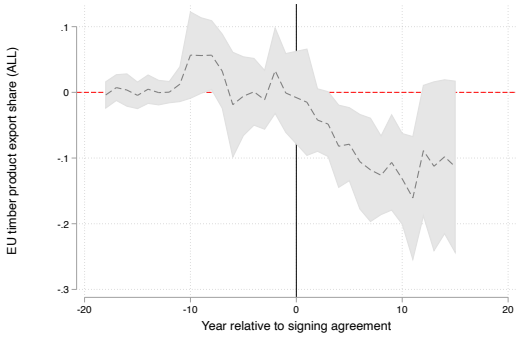
Panel B: Rate of forest loss

	(1) All Forest	(2) PA Loss All	(3) PA Loss Strict	(4) PA Loss Weak
Agreement Signed	0.000961	0.000384	-0.000411	0.000338
	(0.00148)	(0.000822)	(0.000441)	(0.000947)
Pretreat. Mean	0.002	0.001	0.001	0.002
Effect relative to mean	0.471	0.272	-0.601	0.185
No Obs	2222	2354	1738	1760

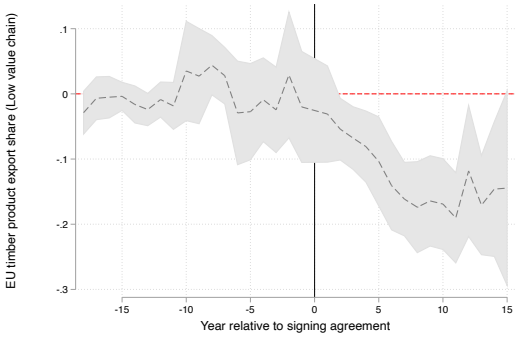
Notes: The table presents synthetic difference in difference estimates of average treatment effects on the treated for the FLEGT participating countries across three different outcomes. Panels A and B correspond to different measures of forest loss with panel A presenting results on the number of hectares of annual forest loss and panel B presenting the rate of forest loss (annual forest loss divided by baseline total forest area). Column (1) uses the total forest loss throughout the country, column (2) is the total forest loss inside all protected areas established by 2006 regardless of their designation, column (3) uses the forest loss inside strictly-designated protected areas (IUCN Categories I and II), while column (4) uses forest loss in protected areas of lower categories. Pretreatment mean refers to the mean of the outcome variable between 2001 and 2008 for the FLEGT participating countries. The effect relative to the mean presents the ratio of the ATT to the pretreatment mean. Statistical significance denoted by * corresponds to the $p < 0.1$ level.

Figure 1: Synthetic difference-in-difference event-study estimates of VPA signature on export shares

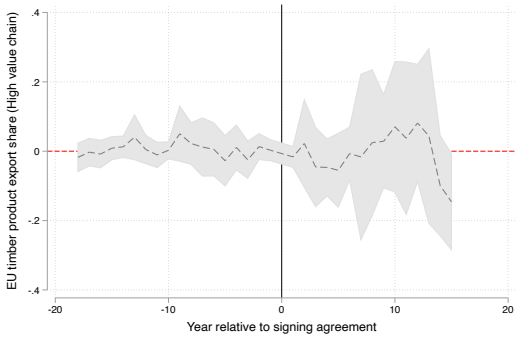
(a) EU Timber Product Export Share - ALL



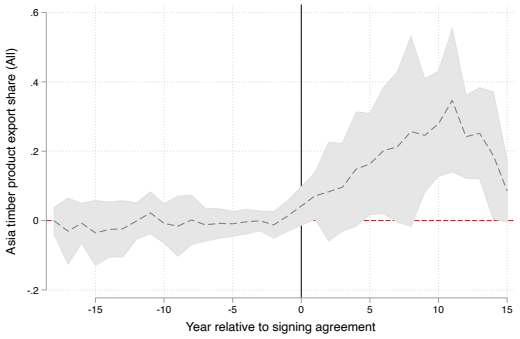
(b) EU Timber Product Export Share - Low Value Chain



(c) EU Timber Product Export Share - High Value Chain



(d) Asia Timber Product Export Share



Notes: The graphs above present event study plots of average year-by-year effects across treatment cohorts for different designs using the approach outlined by Ciccia (2024). Panel (a) presents estimates on the share of the country's timber exports that go to the EU, panel (b) presents estimates on the share of low-value chain timber products exported to the EU, panel (c) presents estimates on the share of high-value chain timber product exports to the EU, and panel (d) presents the share of the country's timber product exports to Asia.

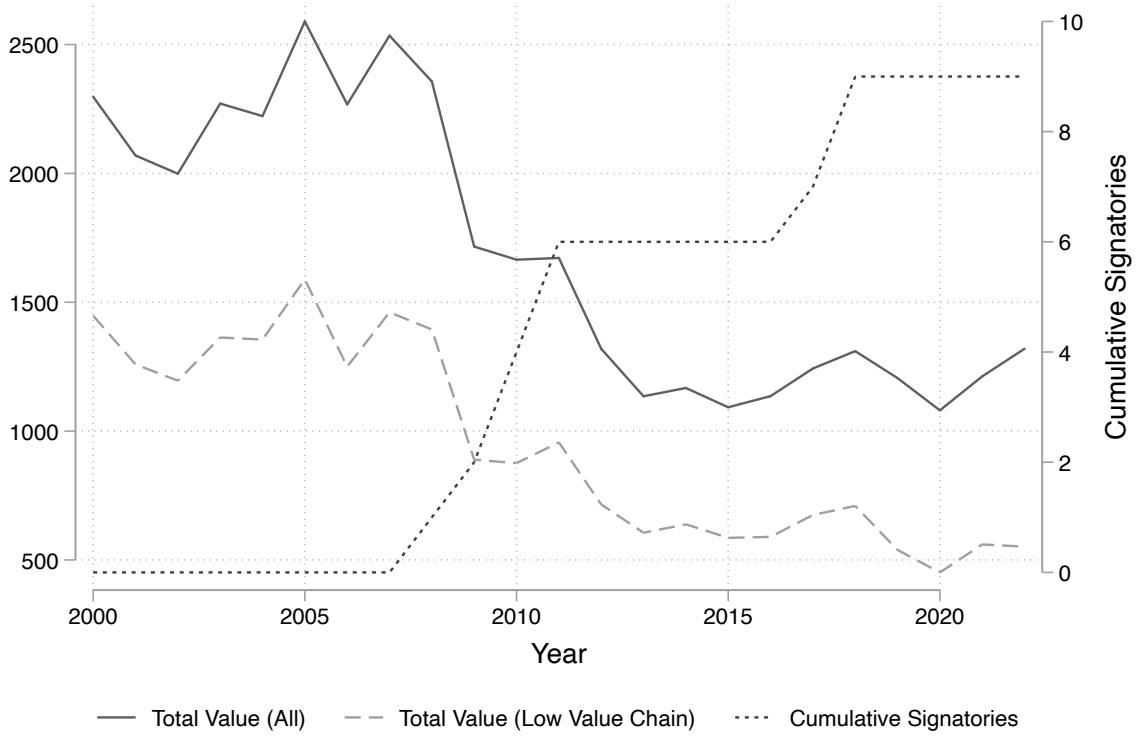
A Appendix - Supplementary Tables and Figures

Table A.1: Summary statistics

	Mean	Std	No Obs
World Export Value - All Timber Products (mUSD)	809.4	3420.5	2438
EU Export Value - All Timber Products (mUSD)	89.01	430.0	2438
World Export Value - Low Value Chain (mUSD)	235.7	733.0	2438
EU Export Value - Low Value Chain (mUSD)	24.47	82.72	2438
EU Portion of Timber Export Value	0.113	0.177	2438
Asia Portion of Timber Export Value	0.234	0.294	2438
Africa Portion of Timber Export Value	0.186	0.285	2438
Non EU Europe Portion of Timber Export Value	0.0276	0.0807	2438
North America Portion of Timber Export Value	0.00733	0.0312	2438
Latin America Portion of Timber Export Value	0.156	0.279	2438
Total Baseline Forest Cover (km^2)	1088.69	3566.45	2222
Rate of Forest loss	0.00202	0.00320	2222
Total Forest Cover in PA (km^2)	405.36	1486.30	2090
Rate of Forest Loss in PA	0.00297	0.0127	2090
Total Forest Cover in Strict PA (IUCN Cat Ia, Ib, II)	135.37	338.82	1738
Rate of Forest Loss in Strict PA	0.00302	0.0270	1738
Total Forest Cover in Lower PA (IUCN Cat III-VI)	165.92	605.90	1760
Rate of Forest loss in Lower PA (IUCN Cat III-VI)	0.00324	0.0172	1760

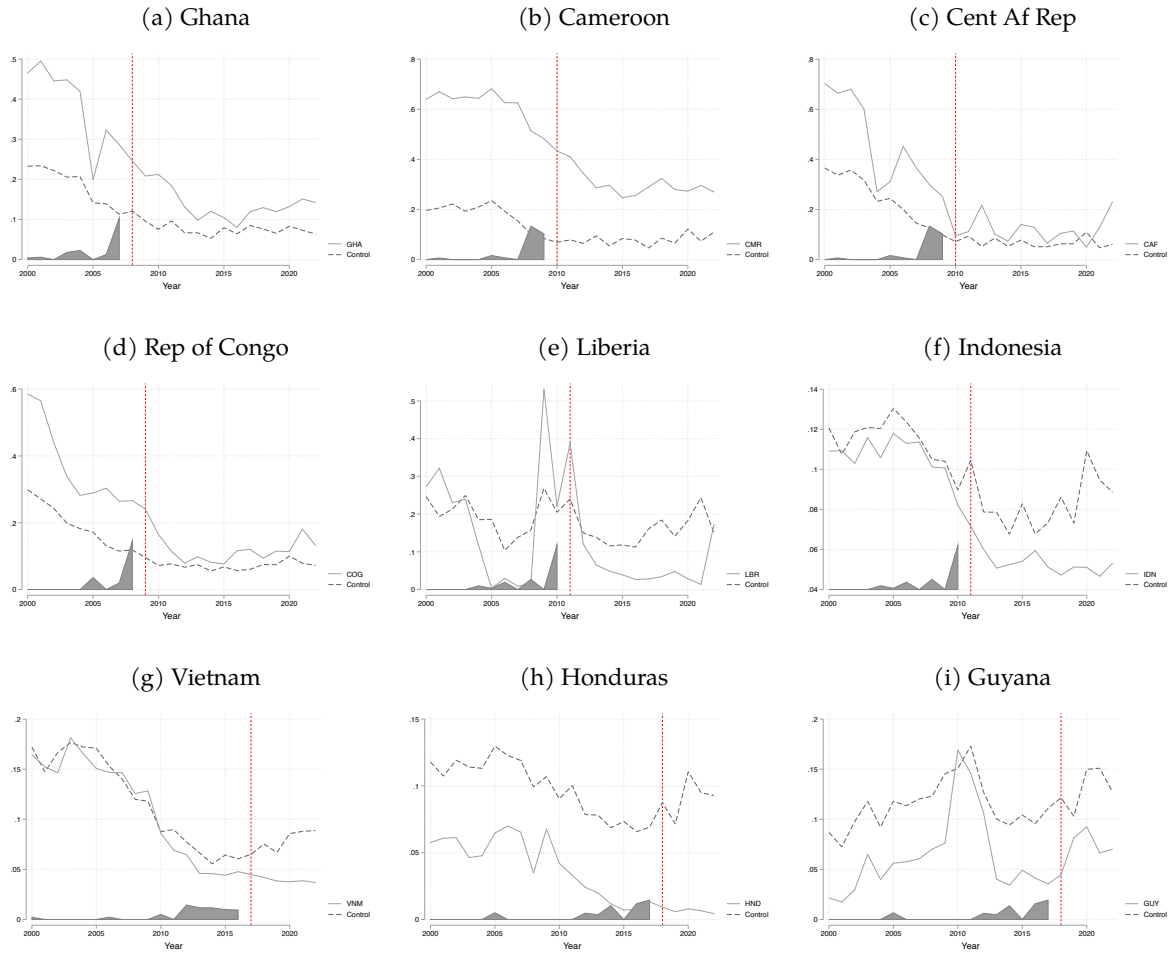
Notes: This table presents summary statistics across a wide array of export variables and forest cover and forest loss variables.

Figure A.1: EU Import Values from all 9 FLEGT VPA Partner Countries



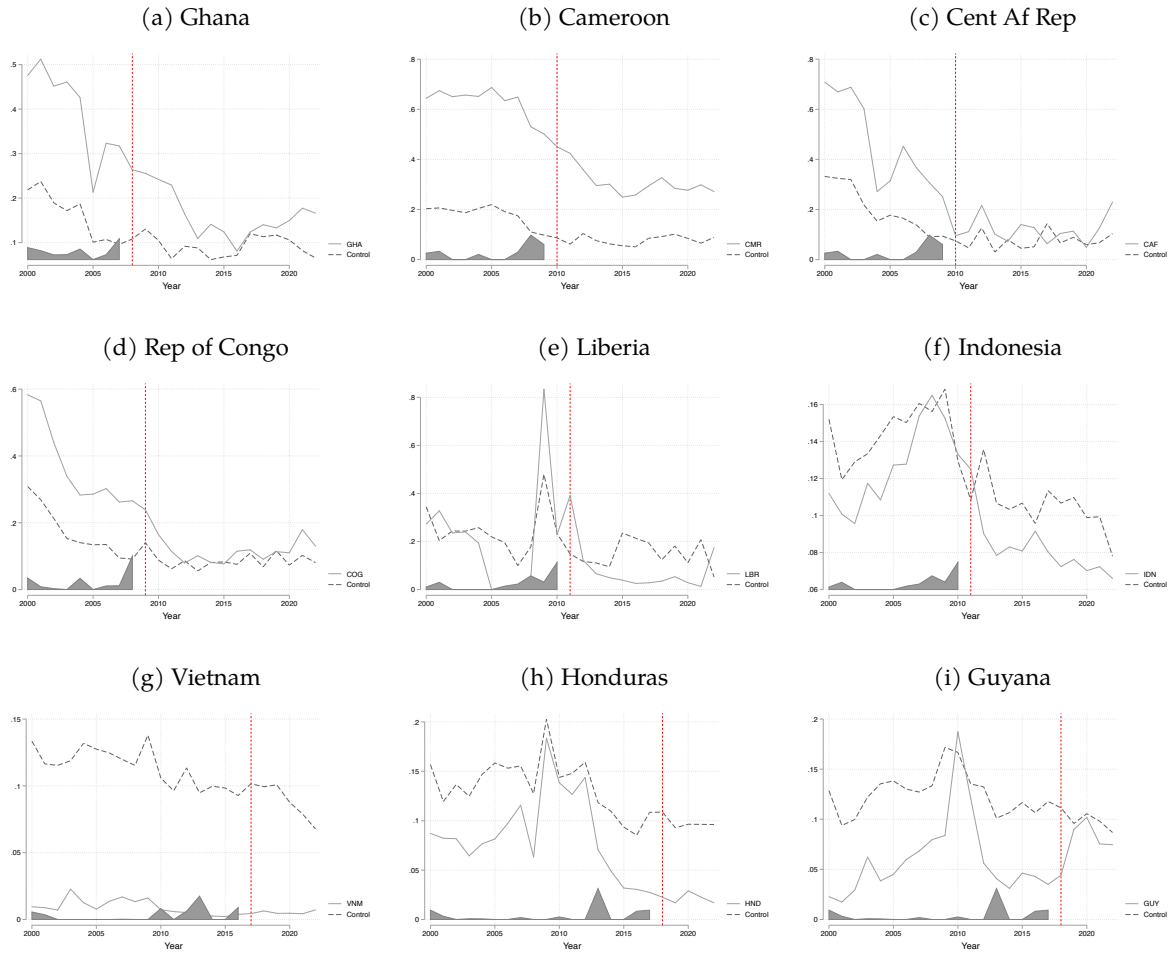
Notes: The graph above plots the value of EU timber imports from the 9 eventual FLEGT VPA signatory countries. The solid line plots the real value of all timber product imports in millions of 2015 USD and the dashed line plots the real value of all low value chain timber product imports in millions of 2015 USD. The dashed line plots the cumulative signatories at any year from 2000 to 2022.

Figure A.2: Individual Country Synthetic Difference-in-difference plots - EU timber product export share



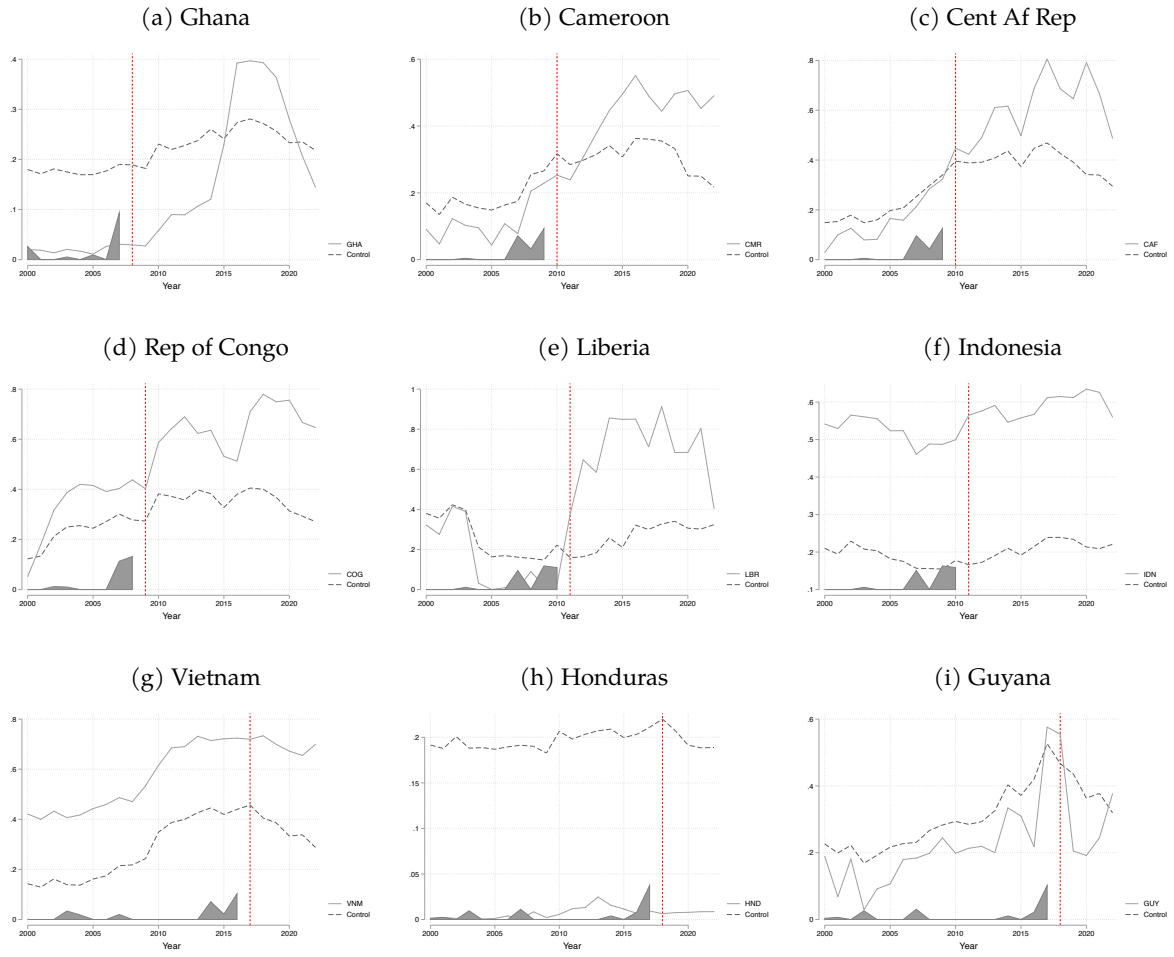
Notes: The graphs above present individual country synthetic difference-in-differences plots. Individual country annual EU export share is plotted by the solid line and the weighted average of donor country EU export shares is plotted as the dashed line. The vertical line indicates the year the VPA entered into force for the particular country. The shaded grey area below indicates the time weights.

Figure A.3: Individual Country Synthetic Difference-in-difference plots - EU low value chain timber product export share



Notes: The graphs above present individual country synthetic difference-in-differences plots. Individual country annual EU share of low value chain timber product exports is plotted by the solid line and the weighted average of donor country EU export shares is plotted as the dashed line. The vertical line indicates the year the VPA entered into force for the particular country. The shaded grey area below indicates the time weights.

Figure A.4: Individual Country Synthetic Difference-in-difference plots - Asia timber product export share



Notes: The graphs above present individual country synthetic difference-in-differences plots. Individual country annual share of timber product exports to Asia is plotted by the solid line and the weighted average of donor country EU export shares is plotted as the dashed line. The vertical line indicates the year the VPA was signed for the particular country. The shaded grey area below indicates the time weights.

Table A.2: Individual country ATT estimates on key trade outcomes

Panel A: EU Export Share

	(1) GHA	(2) CMR	(3) CAF	(4) COG	(5) LBR	(6) VNM	(7) IDN	(8) HND	(9) GUY
Agreement Signed	-0.124	-0.182*	-0.113	-0.0925	-0.0506	-0.0251	-0.0219	-0.0271	0.000138
	(0.110)	(0.0995)	(0.0963)	(0.0988)	(0.0774)	(0.0897)	(0.0718)	(0.0556)	(0.0556)
Pretreat. Mean	0.370	0.633	0.483	0.370	0.138	0.153	0.110	0.057	0.046
Effect relative to mean	-0.336	-0.287	-0.233	-0.250	-0.368	-0.164	-0.199	-0.479	0.003
No Obs	2254	2254	2254	2254	2254	2254	2254	2254	2254

Panel B: EU Low Value Chain Export Share

	(1) GHA	(2) CMR	(3) CAF	(4) COG	(5) LBR	(6) VNM	(7) IDN	(8) HND	(9) GUY
Agreement Signed	-0.171	-0.196**	-0.185**	-0.156*	-0.0680	0.0152	-0.0193	-0.0222	0.0458
	(0.117)	(0.0841)	(0.0834)	(0.0886)	(0.0721)	(0.0763)	(0.0738)	(0.0946)	(0.0946)
Pretreat. Mean	0.383	0.642	0.487	0.369	0.147	0.012	0.123	0.083	0.047
Effect relative to mean	-0.448	-0.305	-0.379	-0.422	-0.463	1.219	-0.157	-0.266	0.974
No Obs	2254	2254	2254	2254	2254	2254	2254	2254	2254

Panel C: Asia Export Share

	(1) GHA	(2) CMR	(3) CAF	(4) COG	(5) LBR	(6) VNM	(7) IDN	(8) HND	(9) GUY
Agreement_signed	0.117	0.181	0.237	0.154	0.586***	0.0502	0.0583	0.00482	-0.0475
	(0.138)	(0.147)	(0.146)	(0.139)	(0.141)	(0.133)	(0.149)	(0.127)	(0.127)
Pretreat. Mean	0.383	0.642	0.487	0.369	0.147	0.012	0.123	0.083	0.047
Effect relative to mean	0.306	0.281	0.488	0.417	3.991	4.023	0.474	0.058	-1.010
No Obs	2254	2254	2254	2254	2254	2254	2254	2254	2254

Notes: The table presents synthetic difference in difference estimates of individual country average treatment effects on the treated for the FLEGT participating countries across three key trade outcomes using the year the VPA enters into force as the treatment variable. Each column corresponds to one of the 9 countries. Panel A presents country-level estimates of the share of timber product exports to the EU. Panel B presents the share of low value chain timber product exports to the EU. Panel C presents country-level estimates of the share of timber product exports to Asia. As these models include only one treated country, standard errors are calculated via the placebo approach outlined in Arkhangelsky *et al.* (2021). Statistical significance denoted as follows, *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: Estimates of FLEGT entry into force on forest timber product exports

	(1) Total Exp (mUSD)	(2) EU Exp (mUSD)	(3) EU Exp Share
Entry into Force	180.1	-43.26	-0.0564*
	(199.2)	(43.72)	(0.0329)
Pretreat. Mean	1773.864	281.033	0.322
Effect relative to mean	0.102	-0.154	-0.175
No Obs	2438	2438	2438

Notes: The table presents synthetic difference in difference estimates of average treatment effects on the treated for the FLEGT participating countries across three different outcomes. Column (1) is the total value of timber exports (in millions of 2015 USD), column (2) is the total value of timber exports sent to the EU (in millions of 2015 USD), and column (3) is the share of total timber exports value sent to the EU (the ratio of EU export value to total export value). Pretreatment mean refers to the mean of the outcome variable between 2001 and 2008 for the FLEGT participating countries. The effect relative to the mean presents the ratio of the ATT to the pretreatment mean. Statistical significance denoted by * corresponds to the $p < 0.1$ level.

Table A.4: Estimates of FLEGT entry into force on forest timber product exports along value chain

	(1) High Val Exp Share	(2) EU Share High Val Exp	(3) EU Share Low Val Exp
Entry into Force	0.0115	0.0143	-0.104***
	(0.0261)	(0.0616)	(0.0331)
Pretreat. Mean	0.274	0.183	0.309
Effect relative to mean	0.042	0.078	-0.336
No Obs	2438	2438	2438

Notes: The table presents synthetic difference in difference estimates of average treatment effects on the treated for the FLEGT participating countries across three different outcomes. Column (1) is the share of high value exports (the total value of high value exports divided by the total value of all exports), column (2) is the share of high value chain timber exports sent to the EU (the ratio of high value chain exports to the EU divided by the total value of high value chain exports), and column (3) is the share of low value chain timber exports value sent to the EU (the ratio of low value chain exports to the EU divided by the total value of low value chain exports). Pretreatment mean refers to the mean of the outcome variable between 2001 and 2008 for the FLEGT participating countries. The effect relative to the mean presents the ratio of the ATT to the pretreatment mean. Statistical significance denoted by *** corresponds to the $p < 0.01$ level.