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Analyzing the Impact of EU's Legality Requirements Policies on Sustainable Timber and Sawnwood Trade—Focusing on Tropical Wood Trade

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Abstract: This study analyzes the impact of the EU's policy to prohibit the import of illegally harvested timber on the trade of tropical timber and sawnwood. The analysis uses a difference-in-differences approach based on gravity models, with panel data from over 193 countries that trade tropical timber and sawnwood. The result of the analysis shows that the European Union Timber Regulation (EUTR) reduces the trade of illegally harvested timber. It further suggests that the EUTR caused a relatively larger reduction in tropical sawnwood (−0.21%) than that of tropical timber (0.07%). In addition, the Voluntary Partnership Agreement (VPA) appeared to cause a significant reduction in tropical sawnwood (−0.07~−0.05%), whereas tropical timber did not appear to have been significantly impacted. In particular, the reduction in timber exports in countries that have signed the VPA, which aims to encourage exports of legally produced timber, has significant implications for both the EU and timber exporters preparing for the VPA, as both parties strive to expand the VPA. The results of this study suggest that the EU needs to make additional efforts to address the decline in exports from countries that signed the VPA.

Keywords: wood legal requirements; tropical timber and sawnwood; gravity equation; difference-in-differences

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1. Introduction

Tropical forests are not only a biodiversity hotspot but also provide various ecosystem services, as well as serve as a carbon sink [1,2]. However, tropical forests are being destroyed by land use changes, development, and the illegal production of tropical timber. Some notable previous studies have reported that illegal timber production is caused by poverty and government corruption in timber-producing countries [3–6]. Recently, the world has formed a consensus on the importance of forest conservation and restoration, including tropical forests, as seen in the "COP26 Glasgow Summit Declaration". In this declaration, 133 countries committed to "halt deforestation, excluding sustainable forest management and the production of legally harvested timber, by 2030 through sustainable forest management." The international organizations related to the timber trade, such as the FAO and International Tropical Timber Organization (ITTO), point out the problems of illegal timber as follows: First, timber producers face the risk of punishment for not following the laws of the timber-producing country. Therefore, illegal timber producers want to receive monetary compensation for the risk of punishment associated with further logging. In addition, illegal timber avoids legitimate taxes and undermines fair competition with legally produced timber in the international timber market based on the competitive price advantage gained. Therefore, illegal timber is one of the barriers to sustainable trade. In this regard, Chatham House in the UK reported that illegal timber accounts for about

20% of the total timber production and about 50% of the trade volume of their examined countries [7]. Second, deforestation in tropical forests, which in part takes place through illegal logging, converts forests into agricultural land or other uses. The problem with this is that it eliminates the opportunity to restore the forest through reforestation. This is a major obstacle to preserving tropical forests and the sustainable use of tropical timber. Factors such as agricultural expansion, logging and wood extraction, infrastructure development, mining, urbanization, fire, climate change, and cattle ranching play significant roles in exacerbating deforestation. However, illegal logging stands out as one of the most serious contributors. In this regard, according to FAO reports, tropical arable land accounted for 90% of the deforested areas from 1990 to 2020. Among them, an average of 138,000 hectares of tropical forests disappeared annually from 1990 to 2000 and 93,000 hectares annually from 2015 to 2020 [8].

In addition to the problem caused by the trade of illegally produced tropical timber, the ITTO has also mentioned issues with the trade patterns. Tropical timber is mainly produced in underdeveloped or developing countries and exported to timber processing countries, where it is turned into wood products such as plywood and sawnwood before being exported to developed countries, the major consumers of timber products [9]. However, the timber transformation process is changing. The 1990–2020 period saw significant investment in developing countries, aimed at transitioning their timber production and exports from roundwood to sawnwood and plywood.

Given this international supply chain for timber, developed countries, as the main consumers of timber, can be said to have a role and responsibility in protecting tropical forests and promoting sustainable use of timber.

After discussions on preventing illegal logging at the United Nations Conference on Environment and Development held in Rio in 1992, measures related to illegal logging were discussed at the G8 Summit held in Birmingham, UK, in 1998. Based on these discussions, major timber-importing countries, such as the US and the EU, established the timber legal requirement system to restrict the trade of illegally logged and produced timber. The core of this system is to prove that the timber should be legally produced [10].

Various studies have been conducted on the eradication of illegal logging. Among them, Tzoulis et al. refer to a wood tracking information system that utilizes various digital technologies for product identification, logging, and monitoring, including barcodes, quick response (QR) codes, radio-frequency identification (RFID), and microchips, in addition to existing punching and painting and log-tracking methods [11]. Thompson and Magrath argue that transparency, law enforcement, and active engagement of local communities in addressing the problem of illegal logging are necessary to prevent the production and distribution of illegal wood [12].

From an economic perspective, Giurca evaluated the relationship between the demand for legal logging and the transition towards tropical timber imports and non-coniferous wood produced in temperate regions, which resulted in the introduction of legal requirements [13]. By estimating the import substitution elasticity of temperate hardwood, they showed temperate hardwood could replace tropical timber. They also argued that efforts should be made to reduce the demand for tropical timber. Rougieux and Jonsson attempted to estimate the import-demand elasticity for tropical hardwoods and temperate hardwoods and analyzed the effect of the European Union Timber Regulation (EUTR) [14]. The results showed no clear substitution or complementary relationship between temperate hardwoods and tropical hardwoods.

Legal requirements for logging were introduced in 2008, led by the United States with the extension of the Lacey Act to the timber trade, and it has since been implemented in major wood-consuming countries and regions such as the EU, Australia, Indonesia, Japan, Korea, and China with the goal of sustainable forest management and wood trade [15]. However, to promote sustainable wood trade worldwide, the legal requirements that are currently implemented in some wood-consuming countries need to be expanded to include

more countries. In this context, this study aims to evaluate whether the legal requirement system for wood introduced by the EU is promoting sustainable wood trade.

Although a considerable amount of time has passed since the implementation of the legal requirement for logging, few studies have evaluated its effects. The present study aims to conduct an empirical analysis of the policy effects implemented in the EU by combining the gravity model and the difference-in-differences model. The rarity of such empirical analysis models in previous studies suggests that the present study can significantly contribute to filling the existing research gap. Moreover, results can quantitatively demonstrate the extent to which this policy promotes the trade of sustainably produced timber and contributes to sustainability, which could provide significant implications for future policymaking.

2. Timber Legal Regulations and Trade of Tropical Timber

2.1. EU-FLEGT and Sustainable Forest Management

The EU's Timber Legal Regulations were established to prevent forest degradation caused by illegal logging, promote biodiversity, and address climate change through sustainable forest management. Proposed by the EU in response to issues related to the trade of illegal timber, the Forest Law Enforcement, Governance, and Trade (FLEGT) was introduced as a follow-up measure to the 2002 World Summit on Sustainable Development.

The EU FLEGT includes two systems. First, the EU Timber Regulation (EUTR), which was established in 2013, prohibits the import of illegal timber from the demand side. Second, the Voluntary Partnership Agreement (VPA) was initiated with the establishment of the EU FLEGT Action Plan and encourages the production and export of legal timber from the supply side [16]. The key to the EU FLEGT is due diligence, which is based on three main procedures made mandatory for the operator, i.e., who first introduces timber and timber-based products on the EU market. First, an access to information analysis is conducted, which involves examining documents and data to prove the legality of timber production and trade related to illegal logging. This includes identifying harvested species, quantities, producing countries, information on all operators in the supply chain, and compliance with regulations in the production area and country. Next, a risk assessment is carried out. The operator should assess the risk of having illegal timber in his supply chain based on the information identified above and considering the criteria set out in the regulation. In addition, the complexity of the supply chain is considered to examine the possibility of illegal timber being mixed into the timber products production process. Finally, risk mitigation aims to reduce the risk of illegal timber production. At the national level, policies, regulations, and measures are introduced to ensure compliance with regulations in the timber-producing country, while at the business level, a legal compliance officer is appointed for risk management, who carries out inspections. Due diligence imposes monitoring obligations on businesses that import and distribute timber and timber-based products, and the EU allows imports of timber that have been proven to be legal.

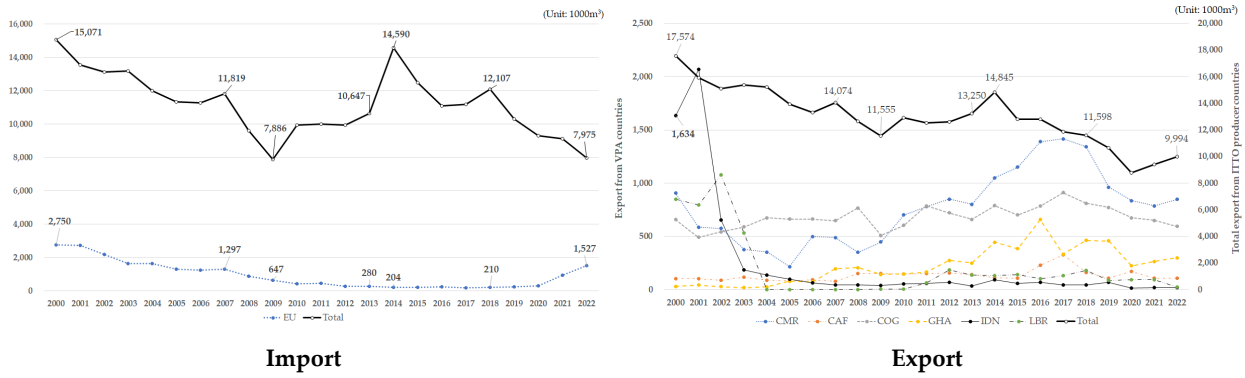
Voluntary Partnership Agreements (VPAs) are made with countries that export timber and timber-based products. VPAs establish a system in which legal timber can be produced by supporting the introduction of a due diligence system in the timber-exporting country. In this regard, the consent of the timber-exporting country is required for the ratification of the VPA. However, the negotiation and ratification of VPAs with timber-exporting countries take a relatively long time. After the VPA is completed, the EU issues a FLEGT license, certifying that the timber has been legally produced.

In December 2019, the EU announced the European Green Deal, a comprehensive plan spanning all social sectors to achieve climate neutrality in the EU by 2050. The New EU Forest Strategy 2030 is a major part of this plan. The strategy expands the scope of the EU Timber Regulation (EUTR), which restricts the trade of illegal timber, and includes the prevention of deforestation and the implementation of the EU Deforestation Regulation (EUDR, established in 2023). The main goal of the EUDR is to prohibit products related

to deforestation from entering the EU market, including timber produced from forests harvested after 31 December 2021, as well as agricultural products.

2.2. Current Status of Tropical Timber and Sawnwood Trade

Figure 1 displays the total import trends of tropical timber as well as those of the EU. Globally, imports of tropical timber declined until 2009. In particular, the 2008 U.S. Financial Crisis reduced global aggregate demand, thereby causing a larger decline in imports of tropical timber [17]. As the global economy improved from 2010, imports of tropical timber peaked in 2014 before decreasing again in 2015. On the other hand, the imports of tropical timber for the EU declined until 2013, when the EUTR was enacted, but remained flat thereafter. What is characteristic of these values for the EU is that imports of tropical timber surged in a relatively short period from 2020 to 2022. As such, the cause behind the increase in the EU's imports of tropical timber since 2021 is believed to be due to the EUDR enactment, which is more strictly regulated than the EUTR. The EUDR restricts the import of timber and timber-based products produced in forest-only and forest-deteriorated areas. Therefore, importers that import timber into the EU temporarily increased their imports to secure tropical timber in preparation for the expected supply risk of tropical timber following the introduction of the EUDR.



Import **Export**

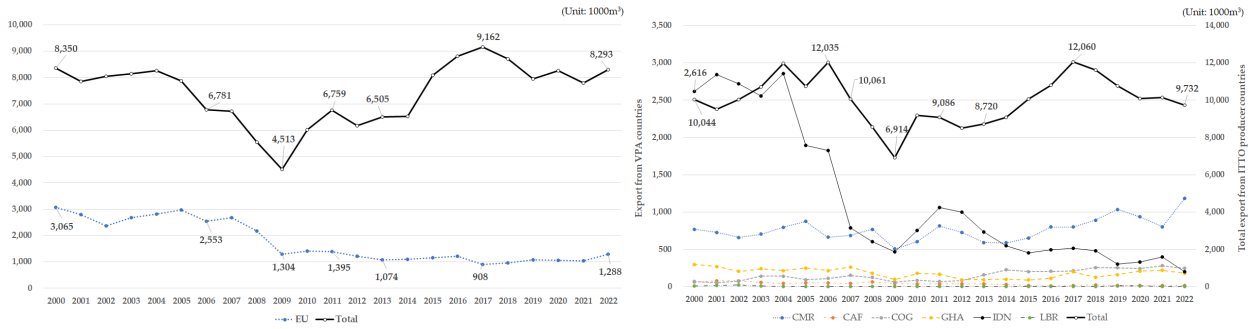
Figure 1. Trends of demand and export for tropical timber from 2000 to 2022. Reference: ITTO [18].

Figure 1 shows the total export volume of tropical timber for member countries of the ITTO as well as that of the VPA. Globally, the export volume of tropical timber is on a gradual decline, but the export volume increased from 2010 to 2014. During this period, these countries included Ghana (GHA, 2010), Cameroon (CMR, 2011), the Central African Republic (CAF, 2012), the Republic of Congo (COG, 2013), Liberia (LBR, 2013), and Indonesia (IDN, 2014). At the moment only Indonesia has completed the mutual recognition process of the VPA, which has materialized with the implementation of the import-export procedures referable to the FLEGT license. For the other countries signatory to VPA agreements, membership alone is not necessarily a guarantee that all the timber exported to the EU is legal.

The trend of tropical timber exports in countries that approved the VPA is as follows; After the VPA was ratified, Cameroon (CMR) saw a significant increase in tropical timber exports. Before 2009, Cameroon (CMR) had fewer timber exports than the Republic of Congo (COG). However, exports of tropical timber increased from 2010 and began to decrease again in 2017. Simultaneously, the export volume of tropical timber in the Republic of Congo (COG) increased slightly, but it is showing a relatively constant export volume compared to Cameroon (CMR). Indonesia (IDN) has implemented a policy to ban the export of timber since 2001. Therefore, it shows that despite the ratification of the VPA, Indonesia's tropical timber exports did not increase.

Figure 2 displays the total import trends of tropical sawnwood as well as those of the EU. Globally, the trend of sawnwood imports decreased from 2000 to 2009 and increased from 2010. Additionally, the EU's tropical sawnwood imports showed the same pattern

as the trend of international tropical sawnwood imports until 2009. However, since 2009, the declining trend in imports has slowed, transitioning into a gradual decline. Notably, imports of tropical sawnwood increased in 2022, which is believed to be due to the effect of the EUDR, as previously mentioned.



Import **Export**

Figure 2. Trends of import and export for tropical sawnwood from 2000 to 2022. Reference: ITTO [18].

Figure 2 displays the global trend of tropical sawnwood as well as that of countries approving the VPA. First, the global export volume of tropical sawnwood shows a decreasing trend until 2009. However, from 2010, the export volume of tropical sawnwood increased until 2017. Accordingly, the aforementioned countries ratified the VPA, and despite the opening of a sales channel to export legally produced tropical sawnwood to countries where the timber legal requirement system was introduced, no remarkable increase in tropical sawnwood exports could be observed.

The U.S. implemented quantitative easing policies to overcome the 2008 financial crisis, which has led to an increase in imports and exports of tropical sawnwood since 2009. To prevent a recession, the U.S. central bank lowered the benchmark interest rate, thereby increasing the supply of money on the market. As a result, it is believed that the increased liquidity increased the demand for construction and, by extension, the demand for timber, including tropical timber, which was a byproduct of the construction industry. Interestingly, since 2009, the export volume of tropical sawnwood gradually increased, while the export volume of tropical timber has continued to decline.

3. Methodology

3.1. Gravity Model with Difference-in-Differences

The gravity model has been proven to be an effective tool for analyzing changes in trade patterns in various studies [19–24]. In the logarithmic form of the gravity model shown in Equation (1), it is understood that the trade volume ($Trade_{i,j}$) of goods is influenced by the gravity variables of the importing and exporting countries (i.e., *GDP per capita*, population) and the distance ($Dist_{i,j}$) between the trading partners [25–27]. *GDP per capita* is a variable representing the purchasing power parity of each trading country and $POP_{i,j}$ represents the economy size of tropical timber importing and exporting countries. In particular, the distance between trading partners plays a role as a proxy for trade barriers, such as transportation costs, cultural differences, and market accessibility [28,29]. Additionally, the effects of policies that affect changes in trade volume can be analyzed by inserting dummy variables.

$$Trade_{i,j} = \alpha_0 + \alpha_1 Dist_{i,j} + \alpha_2 GDP\ capita_i + \alpha_3 GDP\ capita_j + \alpha_4 POP_i + \alpha_5 POP_j + \alpha_6 Dummy_{i,j},\ (i \neq j). \quad (1)$$

The equation representing the difference-in-differences method is composed of the dependent variable ($Trade_{i,j}$), representing the policy outcome, the variable (t_i) indicating policy status (0 before policy implementation, 1 after policy implementation), the variable ($treat_i$) indicating whether the unit received the policy intervention (0 for the control group,

1 for the treatment group), and the interaction term ($t_i \times treat_i$) between the two. The policy effect is represented by the coefficient of the interaction term, which is denoted as

$$Trade_{i,j} = \alpha + \beta(t_i) + \gamma(treat_i) + \theta(t_i \times treat_i) + \varepsilon_i, \ (i \neq j). \quad (2)$$

By combining Equations (1) and (2), we can derive a difference-in-differences equation based on the gravity model [30].

3.2. Empirical Model for Analyzing the Effects of EUTR

The policy effect of the EUTR can be expressed as Equation (3) in logarithmic form. The policy variable ($treat_{EU,j}$), which represents the treatment group in this equation, is a dummy variable for EU countries that have introduced legal requirements for timber on importing countries (i) that import from exporting countries (j). The time variable (t_{2013}), which represents a period of policy implementation, is set to 1 for the period after the introduction of the EUTR in 2013 and 0 for the period prior. The interaction variable ($treat_{EU,j} \times t_{2013}$), which combines these two variables, represents the policy effect of the EUTR. Since the EUTR prohibits the import of illegal timber, it can be expected that the estimated coefficient for this interaction variable will be negative. In addition to the variables related to the policy effect of the EUTR, the model includes the variables related to the factors affecting the change in the import volume of tropical timber. First, Equation (3) is an equation aimed at analyzing the trend in tropical timber.

Tropical timber, along with other types of timber, is known to have derived demand from the construction industry [31,32]. To reflect this characteristic of the timber industry, this study adds a proxy variable, the percentage of construction production ($Cons\ GDP_i$) within the total GDP of an importing country. The results of prior studies mention the substitutability between non-coniferous and coniferous timber, which includes tropical non-coniferous timber [33–35]. Therefore, the production of coniferous timber ($Cnfrsawn_i$) of the importing country is a variable explaining the import volume of tropical timber under the premise that the purpose of importing tropical timber is to produce tropical sawnwood. It is believed that the import volume of tropical timber has a substitutable relationship with the import volume of topical sawnwood. Figure 1 suggests that the global import volume of tropical timber was consistently decreasing. Conversely, Figure 2 suggests that the global import volume of tropical sawnwood increased. The export quantity of tropical sawnwood ($Export\ NCSawn_j$) is included to control its influence on the tropical timber trade.

Equation (4) refers to the amount of tropical sawnwood imports. The basic specifications of the equation, such as gravity variables and policy variables, are the same as in Equation (3). However, Equation (4) differs in that it takes into consideration the characteristics of the sawnwood market. One of the reasons countries import tropical sawnwood is that it may be more cost-efficient than importing raw tropical timber and processing it into sawnwood. To express this situation, wages ($Wage_i$) were used as a proxy variable for the cost of producing sawnwood using raw timber. In other words, as the cost of processing tropical timber into sawnwood increases, the import volume of tropical timber will decrease.

$$\begin{aligned} ln\left(Trade_{i,j}^{timber}\right) = {} & \alpha_0 + \alpha_1 ln(Dist_{i,j}) + \alpha_2 ln(GDP\ capita_i) + \alpha_3 ln\left(GDP\ capita_j\right) + \alpha_4 ln(POP_i) + \alpha_5 ln(POP_j) + \alpha_6 ln(Cons\ GDP_i) \\ & + \alpha_7 ln(Cnfrsawn_i) + \alpha_8 ln\left(Export\ NCSawn_j\right) + \beta(treat_{EU,j}) + \gamma t_{2013} + \theta(treat_{EU,j} \times t_{2013}) + \varepsilon_{i,j} \qquad (i \neq j). \end{aligned} \quad (3)$$

$$\begin{aligned} ln\left(Trade_{i,j}^{sawnwood}\right) = {} & \alpha_0 + \alpha_1 ln(Dist_{i,j}) + \alpha_2 ln(GDP\ capita_i) + \alpha_3 ln\left(GDP\ capita_j\right) + \alpha_4 ln(POP_i) + \alpha_5 ln(POP_j) + ln(Cons\ GDP_i) \\ & + \alpha_6 ln(Cnfrsawn_i) + \alpha_7 ln(Wage_i) + \beta(treat_{EU,j}) + \gamma t_{2013} + \theta(treat_{EU,j} \times t_{2013}) + \varepsilon_{i,j} \qquad (i \neq j). \end{aligned} \quad (4)$$

3.3. Empirical Model for Analyzing the Effects of EUTR as Well as VPA

Equations (5) and (6) are empirical equations designed to simultaneously analyze the effect of the prohibition of illegal timber imports due to EUTR and the increase in imports of legally produced timber due to VPA. The analysis of the policy effects of the VPA was approached in the same manner as the analysis of the EUTR policy effects in

Equations (3) and (4) above. Specifically, it can be expressed through a dummy variable indicating the country that has signed the VPA ($treat_{i,VPAs}$), a time variable indicating the point of ratification ($t_{Ratified}$), and an interaction term representing the interaction between these two variables ($treat_{i,VPAs} \times t_{Ratified}$). The policy effect of the VPA is interpreted as the coefficient of this interaction term.

Countries that have approved the VPA include Ghana (GHA, 2010), Cameroon (CMR, 2011), the Central African Republic (CAF, 2012), the Republic of Congo (COG, 2013), and Liberia (LBR, 2013). In addition, Indonesia approved the VPA in 2014 [36]. However, Indonesia was excluded from the analysis as it implemented an export ban policy for timber and sawnwood and sanctions within the time period range of the analysis data.

As highlighted in the previous case of Indonesia (IDN), the ratification of a VPA does not necessarily lead to the immediate production of legally sourced timber. This is because the EU must provide education to establish and operate a national system for timber legality. In other words, a certain amount of time is required for the effects of the implemented policy before timber-exporting countries can export legitimately produced timber. However, since there is no information on this, the analysis assumes that legally produced timber begins its exportation in the year the VPA is ratified.

These equations represent the relationship between the factors influencing the change in the import volume of tropical timber and tropical sawnwood, respectively. These expressions include gravity variables, variables related to the policy effect of the EUTR, and economic variables affecting tropical wood imports as described above.

$$\begin{aligned} ln\left(Trade_{i,j}^{timber}\right) = \alpha_0 + \; & \alpha_1 ln(Dist_{i,j}) + \alpha_2 ln(GDP\ capita_i) + \alpha_3 ln\left(GDP\ capita_j\right) + \alpha_4 ln(POP_i) + \alpha_5 ln\left(POP_j\right) + \alpha_6 ln(Cons\ GDP_i) + \alpha_7 ln(Cnfrsawn_i) \\ & + \alpha_8 ln\left(Export\ NCSawn_j\right) + \beta(treat_{EU,j}) + \gamma t_{2013} + \theta(treat_{EU,j} \times t_{2013}) + \sum \delta(treat_{i,VPAs}) + \sum \eta\left(t_{Ratified}\right) + \sum \sigma\left(treat_{i,VPAs} \times t_{Ratified}\right) \\ & + \varepsilon_{i,j} \qquad (i \neq j). \end{aligned} \tag{5}$$

$$\begin{aligned} ln\left(Trade_{i,j}^{sawnwood}\right) = \; & \alpha_0 + \alpha_1 ln(Dist_{i,j}) + \alpha_2 ln(GDP\ capita_i) + \alpha_3 ln\left(GDP\ capita_j\right) + \alpha_4 ln(POP_i) + \alpha_5 ln\left(POP_j\right) + ln(Cons\ GDP_i) + \alpha_6 ln(Cnfrsawn_i) + \alpha_7 ln(Wage_i) \\ & + \beta(treat_{EU,j}) + \gamma t_{2013} + \theta(treat_{EU,j} \times t_{2013}) + \sum \delta(treat_{i,VPAs}) + \sum \eta\left(t_{Ratified}\right) + \sum \sigma\left(treat_{i,VPAs} \times t_{Ratified}\right) + \varepsilon_{i,j} \qquad (i \neq j). \end{aligned} \tag{6}$$

The analysis is conducted using both pooled OLS and panel regression models. In the pooled regression model, robust standard errors (RSE) are used for calculating standard errors, which is suitable for producing significant results by reducing the size of the standard errors, especially when numerous variables are included in the model, as seen in Equations (5) and (6). The coefficient estimates can be considered robust if they exhibit minimal variation with the inclusion or exclusion of variables. From this perspective, the RSE is one method to maintain the robustness of the analytical model [37]. However, in trade data related to timber, the issue of heteroscedasticity due to unobservable variables such as culture and preferences cannot be ruled out. Furthermore, the RSE is not particularly effective in controlling for heteroscedasticity [38,39]. Therefore, this study employs a panel regression model and Poisson pseudo-maximum likelihood (PPML), which are effective in controlling for heteroscedasticity, in the analysis. Panel regression models are divided into random effects models and fixed effects models. The Hausman test is employed to determine the appropriate model between random effects and fixed effects models, and if the test result is statistically significant, the fixed effects model is deemed more suitable. Specifically, the fixed effects model is effective in controlling for heteroscedasticity stemming from unobserved country-specific characteristics. However, when time-invariant variables are present, there is a risk that these variables may be omitted from the analysis.

In addition, trade data by country often include instances where trade volume is recorded as zero, depending on the unit of measurement. If log-type regression analysis is performed on 'zero' trade cases, where the dependent variable (such as import volume) is $'0,'$ a selectivity bias can occur, as observations with a value of $'0'$ are excluded from the analysis. Common issues in gravity models include heteroscedasticity and 'zero' trade. These issues can be addressed using the PPML method [40]. The panel regression analysis is carried out using both fixed effects and PPML models.

4. Data

The subjects of analysis are tropical timber and tropical sawnwood. The trade data for these subjects are collected using the relevant HS codes of tropical timber (44.0341, 44.0342, 44.0349) and tropical sawnwood (44.0612, 44.0692, 44.0721~3, 44.0725~9) based on the FAO's classification system [41]. The period of analysis is from 2000 to 2022, and the panel data consist of trade relations of 193 countries around the world. Here, the report country is the country that imports, whereas the partner country is the country that exports to the report country. In addition, countries involved in the EUTR and VPA are the treatment groups, and other countries correspond to control groups.

Meanwhile, following its withdrawal from the EU after Brexit in 2020, the United Kingdom introduced the United Kingdom Timber Regulation (UKTR), which is based on the EUTR. Given its policies are consistent with the EUTR, the UK was included in the same treatment group as the EU for the purposes of analysis.

Table 1 presents the summary statistics for the data used in the analysis. Statistical data provided by the UN Comtrade were used for the import volume of tropical timber and tropical sawnwood as well as the export volume of tropical sawnwood [42]. The unit of measurement is weight in tons. The global average import volume of tropical timber for the EU and non-EU member states was 2911 tons and 7032 tons, respectively. In addition, the average import volume of tropical wood for the EU and non-EU member states was 888 tons and 1205 tons, respectively. The reason for a large amount of average tropical timber and tropical sawnwood imports from countries in the control group is that countries that import large quantities of timber, such as China, are included in the control group.

Table 1. Summary statistics of tropical timber and sawnwood.

		Tropical Timber				Tropical Sawnwood				Unit	References
		Reporter (*i*)		Partner (*j*)		Reporter (*i*)		Partner (*j*)			
		EUTR	Control	VPAs	Control	EUTR	Control	VPAs	Control		
$Import_i$	#Obs.	2973	6817	-	-	11,934	35,140	-	-	Ton	[42]
	Min	0	0	-	-	0	0	-	-		
	Max	328,980	1,928,100	-	-	112,664	3,299,397	-	-		
	Mean	2911	7032	-	-	888	1205	-	-		
	St. dev.	14,047	59,758	-	-	4980	32,375	-	-		
$Dist_{i,j}$	#Obs.	4847	10,937	1502	14,282	11,916	34,393	5509	40,800	km	[43]
	Min	19	60	184	19	19	10	190	10		
	Max	18,247	19,630	15,717	19,630	19,586	19,772	19,116	19,772		
	Mean	4598	6783	6694	6050	5201	6207	6938	5815		
	St. dev.	3529	4647	2850	4582	3856	4455	3325	4433		
$GDP\ capita_{i,j}$	#Obs.	4852	11,006	1506	14,329	11,934	34,990	5626	41,288	USD/capita	[44]
	Min	11,526	118	253	110	11,526	110	180	110		
	Max	133,712	123,091	3754	133,712	133,712	123,091	4788	133,712		
	Mean	39,767	15,278	1677	17,688	40,654	18,700	1770	20,017		
	St. dev.	15,949	19,261	822	20,179	15,942	20,946	1088	20,697		
$POP_{i,j}$	#Obs.	4852	11,008	1506	14,376	11,934	34,990	5626	41,378	Million	
	Min	44	2	313	2	44	2	290	1		
	Max	8380	141,717	3348	141,717	8380	141,717	27,550	141,717		
	Mean	3501	33,646	1576	10,935	3373	13,182	6869	11,567		
	St. dev.	2720	53,130	935	27,164	2789	32,780	9707	29,101		
$GDP\ Cons_i$	#Obs.	4852	11,044	-	-	11,934	34,203	-	-	%	[45]
	Min	10.4	0.8	-	-	10.4	2.4	-	-		
	Max	41.5	84.7	-	-	41.5	85.9	-	-		
	Mean	21.9	29.7	-	-	22.1	29.0	-	-		
	St. dev.	4.3	11.7	-	-	4.4	11.6	-	-		
$Cnfrsawn_i$	#Obs.	4852	7938	-	-	11,934	23,973	-	-	Thousand m^3	[41]
	Min	39	0	-	-	39	0	-	-		
	Max	25,335	69,187	-	-	25,335	69,187	-	-		
	Mean	4172	8518	-	-	4977	8217	-	-		
	St. dev.	5943	14,699	-	-	6518	15,977	-	-		
$Exprt\ NCTsawn_j$	#Obs.	-	-	882	12,177	-	-	-	-	Ton	[42]
	Min	-	-	0	0	-	-	-	-		
	Max	-	-	59,805	3,937,851	-	-	-	-		
	Mean	-	-	2316	62,270	-	-	-	-		
	St. dev.	-	-	10,450	247,025	-	-	-	-		
$Wage_i$	#Obs.	-	-	-	-	7590	26,750	-	-	USD	[46]
	Min	-	-	-	-	342	0.01	-	-		
	Max	-	-	-	-	2604	4386	-	-		
	Mean	-	-	-	-	1431	479	-	-		
	St. dev.	-	-	-	-	488	577	-	-		

The Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) provides information on the gravity model and consists of basic data such as trade distance, language, and political category [43]. The trade distance ($Dist_{I,j}$) indicates the distance between the capital cities of the trading partners. Regarding the trade of tropical timber, the trade distance (4598 km) of EU member states was found to be relatively close to that of non-EU timber states (6783 km). However, among the countries that export tropical timber, the average trade distance (6694 km) of countries involved in the VPA was farther than the average trade distance (6050 km) of non-VPA countries.

Data from the World Bank were used for GDP per capita ($GDP\ capita_{I,j}$) and population ($POP_{I,j}$), while statistical data from UN Data were used for the production output of the construction industry's production output ($GDP\ Cons_i$) [44,45]. Data for the production of coniferous ($Exprt\ NCTsawn_j$) were provided by the FAO. The unit of measurement for this variable is in cubic meters, which is different from the unit of measurement of tropical timber imports and tropical sawnwood imports and exports.

The average monthly wage ($Wage_i$) is a proxy variable for the production cost of timber [46]. Therefore, this variable was used to analyze the effect of changes in the import volume of timber.

5. Estimation Results

5.1. Estimation Results of the Effects of EUTR

Table 2 presents the results of analyzing the policy effect based on Equation (3) of the EUTR using PPML, pooled robust regression, and a fixed effects model that is more appropriate compared to the random effects model according to the Hausman test at the 1% significance level. The policy effect estimated using the difference-in-differences approach with PPML shows that the import quantity of tropical timber decreased by −0.19% due to the EUTR. The analysis using pooled robust regression and panel regression also shows a decrease in the import quantity of tropical timber, ranging from −1.32% to −1.21%. As expected, the policy effect of the EUTR is found to reduce the import quantity of tropical timber. Compared to the results of previous studies, when considering the policy effect of the EUTR on the reduction in the EU's imports of non-coniferous timber in the range of −0.45%~−0.05%, it can be concluded that the policy effect of the EUTR appeared at a relatively similar level [39]. Existing studies have mentioned that the policy effect of the EUTR is at a national level, therefore showing a consistent decrease in imports.

Table 2. Estimation results of the effects of EUTR.

	Tropical Timber			**Tropical Sawnwood**		
	PPML (*z*-Value)	**Pooled Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**	**PPML (*z*-Value)**	**Pooled Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**
Cons	1.31 *** (14.05)	3.24 *** (6.66)	30.75 *** (3.57)	1.07 *** (14.08)	1.90 *** (4.99)	8.41 ** (2.16)
$\ln\left(Dist_{i,j}\right)$	−0.03 *** (−4.18)	−0.18 *** (−4.83)	(omitted)	−0.04 *** (−8.28)	−0.18 *** (−6.85)	(omitted)
$\ln(GDP\ capita_i)$	0.05 *** (4.43)	0.41 *** (7.77)	0.88 *** (5.50)	0.07 *** (6.92)	0.49 *** (9.84)	0.96 *** (9.52)
$\ln\left(GDP\ capita_j\right)$	−0.05 *** (−9.11)	−0.25 *** (−7.40)	−0.54 *** (−3.91)	−0.05 *** (−18.85)	−0.39 *** (−23.98)	−0.71 *** (−9.64)
$\ln(POP_i)$	0.14 *** (22.16)	0.84 *** (26.55)	−3.98 *** (−4.23)	0.11 *** (29.42)	0.61 *** (31.66)	−0.47 (−1.04)
$\ln\left(POP_j\right)$	−0.01 ** (−2.53)	−0.11 *** (−3.85)	1.08 ** (2.08)	0.02 *** (7.48)	0.02 * (1.77)	0.70 *** (3.71)

Table 2. *Cont.*

	Tropical Timber			Tropical Sawnwood		
	PPML (*z*-Value)	**Pooled Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**	**PPML (*z*-Value)**	**Pooled Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**
$\ln(Cnfrsawn_i)$	−0.04 *** (−7.99)	−0.23 *** (−9.19)	0.02 (0.29)	−0.03 *** (−12.96)	−0.19 *** (−14.27)	−0.20 *** (−4.13)
$\ln(Wage_i)$	-	-	-	0.05 *** (5.93)	0.20 *** (4.98)	−0.24 *** (−3.83)
$\ln\left(Exprt\ NCTsawn_j\right)$	−0.02 *** −5.85)	−0.12 *** (−7.79)	−0.05 *** (−3.07)	-	-	-
$\ln(Cons\ GDP_i)$	0.12 *** (5.40)	0.58 *** (5.25)	0.71 *** (4.25)	0.05 *** (4.52)	0.14 ** (2.12)	0.82 *** (8.62)
$\left(treat_{EU,j}\right)$	0.15 *** (7.28)	0.84 *** (7.78)	(omitted)	0.07 *** (5.24)	0.37 *** (5.05)	(omitted)
(t_{2013})	0.09 *** (5.23)	0.18 * (1.73)	0.36 *** (3.51)	0.04 *** (3.67)	−0.26 *** (−4.48)	−0.22 *** (−4.10)
$\left(treat_{EU,j} \times t_{2013}\right)$	−0.19 *** (−5.97)	−1.32 *** (−7.81)	−1.21 *** (−8.66)	−0.07 *** (−3.31)	−0.39 *** (−3.14)	−0.24 *** (−2.66)
#Obs	5350	5965	5965	13,516	14,988	14,988
F-test	-	171.34 ***	28.06 ***	-	205.61 ***	41.60 ***
Pseudo Log-likelyhood	−11,839.75	-	-	−29,651.47	-	-
R^2 (within)	0.26	0.26	(0.06)	0.12	0.13	(0.03)
Hausman test	-	-	84.34 ***	-	-	78.92 ***

Note ***: Significant level < 1%, **: Significant level < 5%, *: Significant level < 10%.

The analysis of the policy effect of the EUTR on tropical sawnwood imports found that import volume was reduced in the range of −0.39%~0.07%. Additionally, one can see that the estimate of the policy effect using the PPML method is relatively small. This is consistent with previous studies on the effect of policy on timber imports [47].

5.2. Estimation Results of the Effects of EUTR as Well as VPA

Table 3 presents the simultaneous effects of EUTR and VPA. The Hausman test results show that the fixed effects model is more appropriate at the 1% significance level. The main estimation results can be summarized as follows; Firstly, among the gravity variables, it is found that a 1% increase in trade distance ($Dist_{i,j}$) leads to a −0.20%~−0.03% decrease in tropical timber imports. Also, when the gross domestic product per capita ($GDP\ capita$) of the tropical timber exporting country increases by 1%, the tropical timber imports decrease by 0.63% in the fixed effect model.

The fact that exporting countries' GDP per capita has a negative relationship with the timber trade highlights some differences between timber production and exports. As discussed in a previous study [39], the effect of GDP per capita on timber exports can vary depending on the context of the analysis. As the GDP per capita of developing countries increases, the production (and, as a result, export) of tropical timber decreases due to deforestation or to increased enforcement of legal production, which can result in a negative relationship between the GDP of exporting countries and the export volume of tropical timber. Other studies [48] have pointed out the replacement of forest (wood) fuel with fossil fuels as GDP per capita grows in developing countries. For example, timber production in China decreased after GDP per capita passed a notable turning point [49]. One of the main causes of deforestation in Southeast Asia, Africa, and South America is

attempts at converting forests into land for the cultivation of high-value palm oil, cocoa, and soybeans, which leads to a decrease in timber exports, although GDP per capita may increase.

Table 3. Estimation results of the effects of the EUTR and VPA (tropical timber).

	PPML (*z*-Value)	**Pooled Robust Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**
$Cons$	1.27 *** (13.59)	3.06 *** (6.28)	34.97 *** (3.89)
$\ln\left(Dist_{i,j}\right)$	−0.03 *** (−4.87)	−0.20 *** (−5.42)	(omitted)
$\ln(GDP\ capita_i)$	0.04 *** (3.34)	0.36 *** (6.73)	0.83 *** (5.05)
$\ln\left(GDP\ capita_j\right)$	−0.04 *** (−6.41)	−0.16 *** (−4.58)	−0.63 *** (−4.45)
$\ln(POP_i)$	0.14 *** (21.31)	0.83 *** (25.65)	−4.33 *** (−4.49)
$\ln\left(POP_j\right)$	0.00 (−0.76)	−0.06 ** (−2.08)	0.93 * (1.68)
$\ln(Cnfrsawn_i)$	−0.03 *** (−6.98)	−0.21 *** (−8.29)	0.02 (0.24)
$\ln\left(Exprt\ NCTsawn_j\right)$	−0.02 *** (−6.34)	−0.13 *** (−8.27)	−0.04 ** (−2.51)
$\ln(Cons\ GDP_i)$	0.12 *** (5.79)	0.63 *** (5.72)	0.81 *** (4.69)
$\left(treat_{EU,j}\right)$	0.17 *** (7.94)	0.92 *** (8.17)	(omitted)
$\left(treat_{i,GHA}\right)$	−0.02 (−0.39)	0.16 (0.49)	(omitted)
$\left(treat_{i,CMR}\right)$	0.31 *** (8.17)	1.85 *** (6.86)	(omitted)
$\left(treat_{i,COG}\right)$	0.29 *** (7.18)	1.57 *** (5.35)	(omitted)
$\left(treat_{i,LBR}\right)$	0.14 * (1.69)	1.02 ** (1.98)	(omitted)
$\left(t_{2010}\right)$	0.03 (1.08)	0.23 * (1.75)	0.13 (1.16)
$\left(t_{2011}\right)$	0.00 (0.14)	−0.18 (−1.17)	0.06 (0.49)
$\left(t_{2013}\right)$	0.08 *** (3.63)	0.15 (1.15)	0.34 *** (3.10)
$\left(treat_{EU,j} \times t_{2013}\right)$	−0.21 *** (−6.67)	−1.39 *** (−8.30)	−1.26 *** (−8.89)
$\left(treat_{i,GHA} \times t_{2010}\right)$	0.10 (1.24)	0.58 (1.20)	0.61 (1.28)
$\left(treat_{i,CMR} \times t_{2011}\right)$	−0.07 (−1.47)	−0.10 (−0.29)	0.05 (0.16)
$\left(treat_{i,COG} \times t_{2013}\right)$	−0.04 (−0.57)	0.20 (0.41)	−0.55 (−1.46)
$\left(treat_{i,LBR} \times t_{2013}\right)$	0.03 (0.25)	0.80 (0.95)	1.46 ** (2.06)
#Obs	5350	5965	5965
F-test	-	97.68 ***	17.64 ***
Pseudo log-likelihood	−11,776.37	-	-
R^2 (within)	0.28	0.28	(0.06)
Hausman test	-	-	112.77 ***

Note ***: Significant level < 1%, **: Significant level < 5%, *: Significant level < 10%.

Furthermore, the positive or negative relationship, the estimates for the importing country's coniferous sawnwood production, the export volume of the exporting country, and the production volume of the construction industry, all of which affect the change in the import volume of tropical timber, were found to be similar to the results of Tables 2 and 3. In addition to the policy effect of the EUTR, factors affecting the import volume of tropical timber and tropical sawnwood include coniferous sawnwood production ($Cnfrsawn_i$) and the export volume of tropical sawnwood ($Exprt\ NCTsawn_j$). The results suggest that when the production of coniferous sawnwood in the importing country increases by 1%, the import volume of tropical timber decreases in the range of −0.13%~−0.02%. These results appear to reflect the trend of the export volume of tropical timber in Figure 1 and the export volume of tropical sawnwood in Figure 2. Additionally, when the production of the construction industry increased by 1%, the import volume of tropical timber increased in the range of 0.12%~0.81%.

The result of the analysis of the policy effect of the EUTR on tropical sawnwood suggests that the import volume of the EU, which is a treatment group, decreased in the range of −1.39%~−0.21% relative to the import volume of the control group. This was similar to the policy effect of the EUTR on tropical timber in Table 2. The result of the analysis of the changes in the EU's tropical timber imports from VPA countries showed that exports from Liberia (LBR) increased by 1.46% in the fixed effects model relative to those that did not approve the VPA. However, Ghana (GHA), Cameroon (CMR), and the Republic of Congo (COG) appeared to not be significantly influenced by the VPA. The Central African Republic (CAF) was excluded from the model due to perfect collinearity.

The analysis results in Table 4 show that a 1% increase in per capita GDP of the importing country increases the import of tropical sawnwood in the range of 0.07% to 0.94%. In addition, a 1% increase in the per capita GDP of the exporting country decreases the import of tropical sawnwood in the range of −0.70% to −0.04%. These results were similar to the previous analysis results for tropical timber. Considering the existence of a supply chain in which tropical timber is used as a raw material in producing tropical sawnwood, the analysis results in Table 4 can be understood in the same context as the description of the GDP per capita mentioned above.

Population size is a significant variable in that it represents the labor supply to produce sawnwood, as well as the size of the economy that consumes the produced sawnwood. When the population of the importing country (POP_i) increases by 1%, tropical timber trades increase by 0.11% to 0.63%, except in the fixed effect model. In contrast, a 1% increase in the population of the exporting country (POP_j) results in an increase in tropical timber trade of 0.03% to 0.57%, respectively. However, in the fixed-effect model, the population of the importing and exporting countries is not estimated to be statistically significant. PPML results show that when the population of an importing country increases by 1%, the volume of timber imports increases by 0.11%, which is consistent with the existing research that indicates that economic growth, represented by the population size, in exporting countries leads to an increase in consumption in the exporting country [50].

The amount of sawnwood produced by importing countries, which affects the import volume of tropical sawnwood, as well as the minimum wages of importing countries, were included in the models with statistical significance. The marginal effects of these factors are as follows: When the coniferous sawnwood production ($Cnfrsawn_i$) of the importing country increases by 1%, the import volume of tropical sawnwood decreases in the range of −0.20%~−0.03%. This shows that they are substitutable, as previously shown in the relationship between the production of tropical and coniferous sawnwood. The marginal effect of the minimum wage ($Wage_i$) of the importing country was analyzed such that a 1% increase in the minimum wage of the importing country increases the import volume of tropical sawnwood in the range of 0.05%~0.20%, excluding the Fixed Effects model. In addition, a 1% increase in construction industry production ($Cons\ GDP_i$) increases the import amount of tropical sawnwood in the range of 0.06%~0.85%. This suggests that the demand for timber and sawnwood is primarily derived from the construction industry.

Table 4. Estimation results of the effects of EUTR as well as VPA (Tropical sawnwood).

	PPML (*z*-Value)	**Pooled Robust Regression (*t*-Value)**	**Fixed Effect (*t*-Value)**
$Cons$	0.99 *** (12.83)	1.63 *** (4.22)	9.89 ** (2.45)
$\ln(Dist_{i,j})$	−0.04 *** (−9.26)	−0.20 *** (−7.81)	(omitted)
$\ln(GDP\ capita_i)$	0.07 *** (6.87)	0.49 *** (9.77)	0.94 *** (9.28)
$\ln\left(GDP\ capita_j\right)$	−0.04 *** (−11.84)	−0.30 *** (−17.04)	−0.70 *** (−8.95)
$\ln(POP_i)$	0.11 *** (30.35)	0.63 *** (32.13)	−0.51 (−1.12)
$\ln(POP_j)$	0.03 *** (10.02)	0.06 *** (4.18)	0.57 *** (2.96)
$\ln(Cnfrsawn_i)$	−0.03 *** (12.73)	−0.19 *** (−13.88)	−0.20 *** (−4.10)
$\ln(Wage_i)$	0.05 *** (5.92)	0.20 *** (4.94)	−0.25 *** (−3.89)
$\ln(Cons\ GDP_i)$	0.06 *** (4.82)	0.16 ** (2.46)	0.85 *** (8.49)
$(treat_{EU,j})$	0.07 *** (4.96)	0.36 *** (4.85)	(omitted)
$(treat_{i,GHA})$	0.28 *** (10.95)	1.41 *** (8.88)	(omitted)
$(treat_{i,CMR})$	0.20 *** (7.91)	1.10 *** (7.64)	(omitted)
$(treat_{i,COG})$	0.40 *** (15.91)	2.22 *** (12.86)	(omitted)
$(treat_{i,CAF})$	0.02 (0.45)	−0.03 (−0.11)	(omitted)
$(treat_{i,LBR})$	−0.08 (−0.97)	−0.51 (−1.38)	(omitted)
(t_{2010})	−0.02 (−1.07)	−0.05 (−0.62)	0.08 (1.12)
(t_{2011})	0.01 (0.35)	−0.04 (−0.37)	−0.01 (−0.12)
(t_{2012})	−0.04 ** (−2.06)	−0.21 * (−1.83)	−0.11 (−1.22)
(t_{2013})	0.08 *** (4.16)	−0.08 (−0.78)	−0.18 ** (−2.33)
$(treat_{EU,j} \times t_{2013})$	−0.07 *** (−3.44)	−0.39 *** (−3.22)	−0.25 *** (−2.73)
$(treat_{i,GHA} \times t_{2010})$	−0.07 ** (−2.11)	−0.07 (−0.33)	0.01 (0.07)
$(treat_{i,CMR} \times t_{2011})$	−0.05 * (−1.69)	0.12 (0.54)	0.46 ** (2.40)
$(treat_{i,CAF} \times t_{2012})$	0.10 (1.58)	0.70 ** (2.02)	0.15 (0.44)
$(treat_{i,COG} \times t_{2013})$	−0.01 (−0.14)	0.51 ** (2.10)	0.54 ** (2.44)
$(treat_{i,LBR} \times t_{2013})$	−0.07 (−0.55)	0.21 (0.39)	0.63 (0.67)
#Obs	13,516	14,988	14,988
F-test	-	124.76 ***	22.89 ***
Pseudo Log-likelihood	−29,414.80	-	-
R^2 (within)	0.16	0.16	(0.03)
Hausman test	-	-	81.27 ***

Note ***: Significant level < 1%, **: Significant level < 5%, *: Significant level < 10%.

The EUTR results in a decrease in tropical timber imports by −0.39% to −0.07%. This is also consistent with the range of the estimated effects of the EUTR analyzed in Table 2. The policy effect of the EUTR has not been analyzed in previous studies. Only one previous study discusses the reasons for the possible negative effects of the EUTR on the timber trade [51].

The countries that saw an increase in the import volume of sawnwood to the EU due to the VPA are the Central African Republic (CAF, 0.70%) and the Republic of Congo (COG, 0.51%~0.54%). However, the results of the PPML analysis for these countries did not show statistical significance. In addition, the policy effects for Cameroon (CMR) appeared to be ambiguous depending on the analysis method. The PPML analysis showed that only Ghana (GHA) had a decrease in export volume since signing the VPA. This is contrary to the previous study's results, which showed that Ghana's tropical timber exports have increased since it approved the VPA. The policy effect of the VPA on tropical timber in this study did not show consistent results [52].

6. Discussion

As a result of the analysis, it was found that the policy effect of the EUTR reduced the import volume of tropical timber and tropical sawnwood. Changes in timber imports are affected not only by the policy effect of the timber legal requirement system but also by the economic situation of the timber-importing country. Among the factors, one must note the production of coniferous sawnwood in the importing country ($Cnfrsawn_i$) and the minimum wage ($Wage_i$). Regarding the production of coniferous sawnwood in the importing country ($Cnfrsawn_i$), a recent study has revealed that temperate forests in the EU have lost many resources but have been restored through intensive sustainable forest management and afforestation over the past thirty years [53]. This suggests that producing coniferous timber in temperate forests with sustainable forest techniques is effective in protecting tropical forests that are being degraded and diversified by reducing the amount of tropical timber and tropical sawnwood imports. The increase in production costs, represented by the minimum wage ($Wage_i$) of the importing country, means that it is more efficient to import processed sawnwood than to import raw timber and process it into sawnwood [54].

One may suggest that the policy effect of the EUTR has reduced the import volume of tropical timber in the EU. Previous studies have reported that the imports of coniferous and non-coniferous sawnwood have decreased in the range of –0.32%~−0.05% and −0.44%~−0.05%, respectively [39]. Compared to previous studies, the decline in tropical sawnwood import volume found in this study was relatively similar (i.e., −0.39%~−0.07%). The reason for this is that the EUTR's due diligence is implemented at a national level; therefore, it is considered consistent with the rate of decrease in imports.

Meanwhile, the EU certifies that the timber produced in states approving the VPA is legal. Therefore, one can expect the VPA to cause an increase in imports for the EU from states approving the VPA. However, the analysis results in this study were different, and Liberia (LBR) was the only country in which the EU's tropical timber imports increased. However, no statistical significance could be obtained in the analysis results for the PPML. In addition, the results of the PPML analysis for tropical sawnwood showed that the export volume from countries involved in the VPA decreased. Nonetheless, consistent results could not be obtained, as ambiguous results were found depending on the country and the analysis method.

Regarding the decrease in imports of tropical sawnwood from countries involved in the VPA, previous studies have analyzed a decreased competition in the EU market for VPA countries exporting plywood [55]. Therefore, it has been mentioned that countries approving the VPA require policy support to strengthen their capacity to implement due diligence to promote the export of legally produced timber [39]. Consequently, the EU needs to consider a support policy to strengthen the capacity to implement due diligence so that countries approving the VPA can promote the production and export of legal timber.

7. Conclusions

Forests are becoming increasingly important due to their function as effective carbon sinks in response to climate change. Tropical forests have high productivity compared to forests in other climate zones and are important for both carbon sequestration and biodiversity conservation. However, tropical forests are mainly distributed in developing countries, where illegal logging is taking place in violation of timber production regulations to exploit economic gains.

The problem of illegal logging can be divided into environmental and economic aspects. From an environmental perspective, illegal tropical timber producers excessively cut down forests to compensate for the risk of punishment with economic gains. As a result, forest degradation occurs rapidly, and biodiversity also decreases. From an economic perspective, by avoiding taxes that should be paid according to timber production regulations, illegal producers use the competitiveness gained from the international timber market to hinder fair competition.

To prevent the destruction of tropical forests, it is necessary to eradicate the production of illegal tropical timber and prevent forest deforestation to achieve sustainable forest management. In line with this, the EU established the FLEGT Action Plan in 2003. As a result, in 2013, they established the EUTR (EU Timber Regulation), which has the policy effect of prohibiting the import of illegal timber from the demand side. In terms of supply, they are promoting VPAs (Voluntary Partnership Agreements) to encourage legal timber production and export in timber-producing countries. In this context, this study tried to analyze the policy effect of the EU′s timber legal requirements for preventing the trade in illegal timber and achieving sustainable forest management. The results are as follows:

The EU, which is subjected to the EUTR, a system that prohibits trade in illegal timber, was analyzed to have decreased the import volume of tropical timber in the range of –0.56% to –0.13% compared to the control group of countries. This result was the same as the previous prediction of a decrease in tropical timber imports from the EU. Additionally, these results were the same as previous studies [15,16,39]. However, existing research analyzing the impact of EUTR on changes in trade volume is minimal.

The limitations of this study are as follows: First, from a methodological perspective, a test of parallel trends is necessary. This requires comparison with countries or economic communities with similar economic situations to the EU, but such comparable groups are not easy to find.

Although legal requirements for timber have been introduced in the United States (2008), the EU (2013), Indonesia (2016), Australia (2017), Japan (2018), the Republic of Korea, and China (2019), this study is limited to analyzing the effects of this policy implemented only in the EU. The lack of sufficient time series data for countries other than the US and EU hinders the analysis of the worldwide effects of this policy. If sufficient data are accumulated in the future, it will be possible to conduct a quantitative analysis that simultaneously considers the effects over the cross-countries. This topic will also be a valuable analysis subject for future research.

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