

Research article

## Does Trade Openness Cause Deforestation? A Case Study from Indonesia

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**Abstract:** Forests are unique resources and environments because, in general, they provide many benefits. Changing the function of forest areas to other functions is inseparable from economic development. As a developing country, Indonesia's economy is still dependent on natural resources to support its development. Economic integration through trade openness plays a vital role in economic growth. Policies that enhance the country's ability to trade will help the economy to develop. The more open the trade regime will make the country specialize in semi-finished input products, its competitive advantage. However, economic integration also creates negative externalities in the form of increased deforestation. This study explores the effect of trade openness on deforestation using a panel data method in 20 provinces in Indonesia from 2008-2018. Not many studies have focused on trade openness, large plantations, and social interactions as the driving forces behind deforestation in Indonesia. From the estimation results of the model, it is known that trade openness, economic growth, and activities of logging and forest conversion each contribute to changes in forest cover. If the commodity price rises, it will impact decreasing forest cover. Also, increasing population and density have decreased forest cover because land outside the forest area is limited.

**Keywords:** trade openness, deforestation, forest cover, Indonesia

**JEL Classification:** C23; Q23; Q27; Q54

**Abstrak:** Hutan merupakan sumber daya dan lingkungan yang unik karena pada umumnya memberikan banyak manfaat. Perubahan fungsi kawasan hutan menjadi fungsi lain tidak terlepas dari pembangunan ekonomi. Sebagai negara berkembang, perekonomian Indonesia masih bergantung pada sumber daya alam untuk mendukung pembangunannya. Integrasi ekonomi melalui keterbukaan perdagangan memainkan peran penting dalam pertumbuhan ekonomi. Kebijakan yang meningkatkan kemampuan negara untuk berdagang akan membantu perekonomian berkembang. Rezim perdagangan yang lebih terbuka akan membuat negara tersebut mengkhususkan diri pada produk input setengah jadi, keunggulan kompetitifnya. Namun, integrasi ekonomi juga menciptakan eksternalitas negatif berupa peningkatan deforestasi. Studi ini mengeksplorasi pengaruh keterbukaan perdagangan terhadap deforestasi menggunakan metode data panel di 20 provinsi di Indonesia dari tahun 2008-2018. Tidak banyak penelitian yang berfokus pada keterbukaan perdagangan, perkebunan besar, dan interaksi sosial sebagai kekuatan pendorong di balik deforestasi di Indonesia. Dari hasil estimasi model diketahui bahwa keterbukaan perdagangan, pertumbuhan ekonomi, dan kegiatan penebangan dan konversi hutan masing-masing berkontribusi terhadap deforestasi. Jika harga komoditas naik, maka akan berdampak pada penurunan tutupan hutan. Selain itu, peningkatan populasi dan kepadatan penduduk menyebabkan penurunan tutupan hutan karena terbatasnya lahan di luar kawasan hutan.

**Kata Kunci:** keterbukaan perdagangan, deforestasi, tutupan hutan, Indonesia

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## **1. INTRODUCTION**

Trade openness and economic growth have a vital role in developing countries, such as Indonesia. By encouraging trade, developing countries can increase revenues, create jobs, transfer technology, improve company management, strengthen the competitiveness of domestic and private companies, which will ultimately help create sustainable economic growth (Amsden, 2001; Greenwald & Stiglitz, 2014; Martínez Licetti et al., 2018; Owusu-Antwi et al., 2013; Salazar-Xirinachs et al., 2014). Every country wants to improve the quality of life through economic growth (Gazzola & Querci, 2017). Todaro & Smith (2012) states that the term development has traditionally been defined as the capacity of a national economy initially in poor condition and has been static over a long time to create and sustain an increase in Gross Domestic Product (GDP).

According to Krugman et al. (2018), countries carry out international trade for two main reasons; each reason contributes gains from trade. First, countries trade because they are different from each other. Nations, like individuals, can benefit from their differences through an arrangement in which each party does something relatively better. Second, countries trade with one another, intending to achieve economies of scale in production. If each country only produces a certain number of goods, they can produce these goods on a larger scale and are therefore more efficient than if the country is trying to produce all kinds of goods. In the real world, international trade patterns reflect both motives.

The performance of an economy cannot be separated from the globalization process (Al-Rodhan & Stoudmann, 2006; Otter & Wetherly, 2014). However, the world economy is currently proliferating because trade openness linking production to one another is a product of globalization, resulting in tighter competition among countries in the world. Economic linkages between countries in the world have reduced trade barriers and increased foreign investment (Surugiu & Surugiu, 2015). Many countries have liberalized trade by removing trade barriers and reducing government subsidies to exploit the potential of globalization (Milner & Kubota, 2005). Trade openness is a vital competitiveness indicator (Pilinkiene, 2016), in which a country that implements a trade openness policy consistently tends to have a high level of economic growth compared to a more closed country (Kustanto, 2020). The literature states that the level of trade openness can be interpreted as a measure of trade flows and a measure of trade restrictions (Gräbner et al., 2021; Were, 2015). Hypothetically, high trade openness indicates the activeness of a country, which will ultimately support economic growth. Furthermore, the correct interpretation of trade openness can be linked to economic growth.

Trade is an essential issue for member countries of the World Trade Organization (WTO) (Partiti, 2020). The WTO has developed a policy framework to assist member countries in formulating and implementing these policies related to environmental issues. The impact of economic globalization has driven the economic development of countries or regions lagging and impacts the ecological environment of the country or region, such as forest degradation (Wang et al., 2019). Debate on the positive and negative effects of globalization continues today (Hecht & Saatchi, 2007; Lawrence et al., 1996; National Academy of Engineering, 1994; Oladipo, 2015; Osland et al., 2002; Socolow et al., 1994). Trade openness can positively impact the economy because it removes market distortions that are reflected in commodity prices (Kustanto, 2020). Trade openness also harms economic growth and quality of the environment in the short term and the long term; trade openness will harm economic growth if it is proxied by the ratio of export imports to GDP and the ratio of exports to GDP; however, it has a positive and significant effect if it is proxied by the ratio of imports to GDP (Belloumi & Alshehry, 2020).

Trade openness and economic growth will increase the use and utilization of natural resources (Hamdi & Sbia, 2013; Mohamed, 2020; Vespignani et al., 2019). The use and utilization of natural resources currently prioritize economic benefits and have not been adequately paid attention to as living resources (Falkner, 2013). As a source of human life, the use of which causes a decrease in the quality of natural resources and the environment directly or indirectly affects the quality of human life. The decline in environmental quality is characterized by increased air pollution (Jiang et al., 2020). Air pollution is characterized by increased carbon dioxide (CO<sub>2</sub>) emissions. The Ministry of

Environment (2009) states that the main sources of greenhouse gas emissions are paddy fields (69%) and livestock (28%).

Carbon emissions are a major driving factor in the occurrence of global climate change (Fehlenberg et al., 2017; Peters et al., 2012; Taubert et al., 2018; Werf et al., 2009). Carbon sequestration in forests is an important carbon sink, so improving land use management is very important to reduce greenhouse gases in the atmosphere. Forest preservation also plays a vital role in preserving a more extensive diversity of livelihood options and supporting extreme events such as floods and landslides (World Bank, 2010). Global climate change is a world issue that many countries now have concerns about (Najam et al., 2003). In line with the problem, the international community's attention on the subject is increasing. Avoiding deforestation is one part of reducing CO<sub>2</sub> emissions in the atmosphere, regulated through the natural absorption of soils and trees (Brack, 2019).

Globally, deforestation and forest area degradation continue to occur on a large scale, with log extraction being a significant cause (Dudley et al., 1995). It has a significant impact on biodiversity, ecosystem services, and the community and economic activities of local communities—the solution to the problem continues to be sought critically (Pirard et al., 2016). Deforestation in tropical forest areas has increased since the 1970s and has become an environmental problem worldwide (Davin & de Noblet-Ducoudre, 2010; Rudel, 2007). In the 21st century, deforestation has impacted climate change because deforestation and forest degradation are one of the primary sources of greenhouse gas emissions (IPCC, 2008; Werf et al., 2009). The United Nations promotes efforts to stop deforestation by including target 15.2 (under Goal 15) in the 2015-2030 Sustainable Development Goals (SDGs) agenda. Target 15.2 reads, "By 2020, promoting the implementation of sustainable management of all types of forests, halting deforestation, restoring degraded forests and substantially increasing afforestation and reforestation globally" (Nations, 2020).

Deforestation is removing natural forests by logging for timber or converting forest land to non-forest land. Intentional or natural forest fires can also cause it. Deforestation threatens the lives of humankind and other living species. The most significant contribution of climate change that is happening right now is caused by deforestation. The World Bank (2010) reports that net global deforestation, averaging 7.3 million hectares per year from 2000 to 2005, accounts for around 5.0 gigatons of CO<sub>2</sub> per year in emissions, or about a quarter of the global emissions reduction needed. According to the Intergovernmental Panel on Climate Change (IPCC) 2008 reports, emissions related to land-use change and deforestation account for around 17.4% of total greenhouse gas emissions, which are higher than world emissions through transportation and comparable to the industrial sector.

Indonesia is a vast country, allocating 120.6 million hectares or around 63% of its land area as forest areas (Ministry of Environment and Forestry, 2018). With this forest area, Indonesia is a country that has the third-largest forest in the world after Brazil and Zaire. Of course, this makes Indonesia one of the world's lungs in the context of the current global issue of climate change. Although forest resources in Indonesia are relatively abundant, there is no denying that forest resources in which timber has an economic function. Large-scale timber exploitation can cause forest degradation and deforestation (Kissinger et al., 2012). Also, the utilization of forest land due to population intervention is one of the factors causing high deforestation in Indonesia.

The extent of forest destruction in Indonesia has changed dynamically over time. The Forest Watch Indonesia (2019) reports several years of deforestation in his book entitled "Portrait of Indonesia's Forest State." In 2000 the rate of deforestation was 2 million hectares per year; in the 2000-2009 period, it was 1.5 million hectares per year and 1.1 million hectares per year in 2009-2013. The FWI again reports a State of the Forest Landscape for 2012-2017. The finding is that the rate of deforestation in this period is 1.47 million per year. Deforestation is a significant threat to the sustainability of forest resources. The causes of deforestation vary, but they are generally motivated by economic interests. Some of the activities that are suspected to be the cause of deforestation are the conversion of forest areas for development sectors such as plantations, transmigration, illegal logging and logging, land encroachment and occupation, and forest fires. Deforestation can be caused by many national, regional, and international forces to regulate interest rates, exchange

rates, power relations, capital accumulation, trade policies, and demographic changes, which ultimately impact the exploitation of forest resources. Trade openness, in theory, will benefit from an increase in GDP, but this can harm the environmental quality, in this case, the occurrence of deforestation. Deforestation in tropical forests is further exacerbated by forest area restructuring and decentralization, responsible for forest policy and management in many countries. Environmental problems cannot be separated from the trade openness of a country with other countries. Trade openness has been seen as an underlying cause through direct influence on deforestation.

Previous studies have shown no harm to trade openness on deforestation (Frankel & Rose, 2005; Galinato & Galinato, 2012; Van & Azomahou, 2007). However, adverse and significant effects of trade openness can be found in the method adopted was increased. This study explores the determinants of deforestation in Indonesia. While existing studies provide useful analysis of the effects of deforestation, no studies focus on trade openness, large plantations, and social interaction as the driving force behind deforestation in Indonesia.

A study conducted by Barbier (2001) studied the economics of forest land use and management, showing that the export-share of agricultural products proved to affect the expansion of agricultural land significantly. The higher the share of plantation land and export-share of agricultural products, the higher the percentage of agricultural land. The inverse relationship applies to the square of GDP per capita and cereal production. Agricultural development is a factor that determines land expansion, but institutional factors have a significant influence. Ferreira (2004) conducted a study that examined trade openness and institutional factors and their impact on deforestation. The proposed model predicts that the effect of trade openness on deforestation depends on the specific characteristics of each country. Using the general equilibrium model, the estimation results in this study indicate that trade openness affects deforestation that is getting lower in countries with high institutional quality, and vice versa, deforestation is getting higher in countries with lower institutional quality.

López & Galinato (2005) combine the elasticity of micro studies with estimates from cross-country analyses to identify structural relationships that explain deforestation in Brazil, Indonesia, Malaysia, and the Philippines. Broad economic factors such as trade openness and economic growth explain essential parts of variation in the three main factors of deforestation: poverty, agricultural expansion, and road development. Trade openness increases forest cover in Brazil and the Philippines but has no significant impact in Indonesia and Malaysia. In Indonesia and Malaysia, trade-in agricultural commodities that compete with forest land is through commodity export policies, while in Brazil, it is more directed at a mixture of import substitution. Moreover, the Philippines is more oriented towards the domestic market. An important channel through which trade policies affect forests in all four countries is agricultural expansion and economic growth, which has a negative and relatively significant impact on forest cover.

Tjandrakirana & Tambunan (2006) obtain an overview of the direct causes of changes in forest cover in Indonesia using panel data methods for 19 provinces from 1976 to 2000. The results of his study show a positive relationship between the speed of deforestation and forest cover. Logging and forest conversion activities contribute to changes in forest cover where forest conversion has a more significant impact on the speed of deforestation. Studies conducted by Grogan et al. (2019) and Warren-Thomas et al. (2018) also state that the expansion of rubber plantations is a driver of the revival of deforestation, carbon emissions, and biodiversity loss in Cambodia. This analysis shows that forest conversion is the leading cause of deforestation in Southeast Asia, Indonesia, and Cambodia.

Scrieci (2007) empirical study conducted a regression analysis based on panel data for fifty tropical countries during the 1980-1997 period. Preliminary findings in the study confirm the pattern of general causality of selected macroeconomic variables in influencing deforestation in tropical countries. Regression results show that the export price deflator, population, and GNP per capita show significant results, where the export price deflator and population have a positive relationship, whereas GNP per capita has a negative relationship. Boubacar (2012), in his study, analyzed the spatial determinants of deforestation in 24 Sub-Saharan African countries during the 1990-2004

period showing the general results of spatial TSLS that deforestation occurring in one country was positively correlated with deforestation occurring in neighboring countries. Tsurumi & Managi (2014) explore the effect of trade openness on deforestation using the latest data on annual deforestation rates for 142 countries from 1990 to 2003, treating trade and income as endogenous, and considering the adjustment process by applying a dynamic model. This study finds that increasing trade openness increases deforestation for non-OECD countries while slowing deforestation for OECD countries. Furthermore, the effects of capital-labor and environmental regulation may harm deforestation in developing countries, while the opposite is exact in developed countries. Faria & Almeida (2016) investigate how trade openness has influenced deforestation dynamics in Brazil's Amazon rainforest region at the municipalities' level. The data used include 734 municipalities from 2000-2010. The main findings of this study show that as openness to trade in the Amazon rainforest area increases, deforestation also increases. This study also found that the production of soybeans, sugar cane, cotton, and beef cattle, firewood and timber extraction, GDP per capita, and non-timber production had driven deforestation in the region. On the other hand, when the square of GDP rises, it reduces findings that support the Environmental Kuznets Curve (EKC) hypothesis.

Studies by Joshi & Beck (2017) compare OECD countries with non-OECD regions in Latin America, Asia, and Africa to determine how various factors such as economic growth, population, trade, urbanization, agricultural land conversion, and cereal yields impact at the rate of deforestation. The results show that OECD countries have N-shaped curves, while only Africa has a revenue-based EKC pattern. Population growth creates more deforestation, as does the conversion to agricultural land. More trade openness and greater urbanization impact the region differently, but only OECD countries have less deforestation because of better cereal yields. A study conducted by Ogundari et al. (2017) on reviewing the EKC in Sub-Saharan African countries shows that agriculture and trade openness is positively related to both environmental change indicators, population growth is positively related to the rate of deforestation, and economic growth is negatively associated with greenhouse emissions from agricultural activities. Current projections are that Sub-Sahara African countries will suffer the most from climate change and other developing countries.

The study conducted by Abman & Lundberg, (2020) provides new global evidence about the relationship between trade liberalization and deforestation. Using a study of events around the entry into force of regional trade agreements (RTA) on panel dataset from 189 countries from 2001-2012, found a significant increase in deforestation for three years after the enactment of RTA, which coincided with an increase in agricultural land conversion. The results of deforestation and agricultural land expansion are driven by developing countries in the tropics, showing that trade liberalization not only increases net deforestation but can also turn deforestation into an ecologically sensitive location.

Based on the empirical study described information, the framework of this study based on the conclusions of Kaimowitz & Angelsen (1998) states that agricultural expansion is the primary source of deforestation. In Indonesia, deforestation has been triggered mainly by large-scale agricultural industries. The conversion of forests into oil palm plantations is the most significant contribution to deforestation. The community for gardening and farming is influenced, among other things, by the intensity of trade that occurs on a domestic and international scale. An increase in exports means an increase in the amount of production, economies of scale, and increasing the country's foreign exchange. In contrast, import activities increase domestic activities; both industries utilize imported raw materials or sell imported goods to domestic consumers.

This empirical study contributes to the existence of the literature in several ways. First, this study contributes to the current debate about trade openness being a direct cause of deforestation. Second, to find out the factors that have the most influence on changes in forest cover due to trade openness, logging, or forest conversion to use their area outside the forestry sector. Third, provide alternative follow-up actions that need to be done to prevent deforestation, threatening the depletion of forest resources. So, it is hoped that this study can guide policymakers to reduce or even stop deforestation.

## 2. RESEARCH METHODS

### 2.1. Data

The data used in this study are secondary time-series data for 11 years, 2008-2018, and cross-section study areas, namely 20 provinces in Indonesia. Data used in this study were obtained from the Central Bureau of Statistics, Ministry of Agriculture, Ministry of Environment and Forestry, Ministry of Trade. This study does not include Java Island as a study area because the forest area in Java is small, and there is no natural forest management permit. This study aims to determine whether deforestation is affected by trade openness in Indonesia, deforestation, the conversion of forests to agricultural land, and the social interactions, so a model is formed to explain changes in the forest cover area.

### 2.2. Research Model

No agreement in the theory of deforestation indicates how to explain macroeconomic level variables in an empirical model. Perfect labor market assumptions impact production decisions that can be separated from household labor consumption and supply (Angelsen et al., 1998). Thus, the decision to produce for land expansion from a maximization of household utility can be analyzed with the problem of profit maximization, namely:

$$X = p \cdot A \cdot f(L, H, F) - q \cdot f - w[L + h(H)] \quad (1)$$

Where: the notation X is the production per unit of land expansion. A is the level of technology, L is labor input, H is the total area of land, F is fertilizer input, p and q are output price and fertilizer price, w is wage level, and h(H) is the cost of land clearing. Labor is used here to clear land.

This study uses a market theory approach at the farm household level to be used as the basis of the relationship between deforestation and agents' behavior for deforestation. The leading causes that can be indicated as the causes of deforestation, namely the cutting and conversion of forests into agricultural land. This study uses these approaches. Changes in deforestation in Indonesia in this study can be divided into two fundamental causes, namely (1) due to deforestation, can occur due to the management of concessions by natural forest management permit/industrial plantations forest, timber industry and illegal logging activities; and (2) as a result of forest conversion, it can occur due to conversion as a spontaneous or local transmigration area, the encroachment of forest areas due to population growth, conversion to community plantations or the shifting of agricultural fields.

The price of logs influences the direct cause of changes in forest cover due to deforestation, the amount of natural forest management permits, the area of natural forest management permits, the need for raw material for industrial plantations forest. If the area is used for other uses outside the forestry sector, changes in forest cover are believed to be influenced by the prices of oil palm, rubber, coffee producers, population, density, GRDP per capita, and institutions. The selection of independent variables for the model in this study is the development of the independent variables that have been analyzed empirically by Faria & Almeida (2016). The empirical linear regression equation model that is compiled is as follows:

$$\begin{aligned} FOREST_{it} = & \beta_0 + \beta_1 TRADE_{it} + \beta_2 GRDP_{it} + \beta_3 GRDP_{it}^2 + \beta_4 \ln RUBBER_{it} + \beta_5 \ln COFFEE_{it} + \\ & \beta_6 \ln COCONUT_{it} + \beta_7 \ln PALM_{it} + \beta_8 \ln FOREST_{it} + \beta_9 INDUSTRIAL_{it} + \\ & \beta_{10} \ln POPULATION_{it} + \beta_{11} DENSITY_{it} + \beta_{12} \ln PRICE_{it} + \\ & \beta_{13} INSTITUTIONS_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

where: the forest is notified as forest cover area. Trade is trade openness. GRDP is GRDP per capita at 2010 constant market prices. GRDP2 is squared of GRDP per capita at 2010 constant market prices. Rubber (in natural logarithm) is the area of the rubber plantations. Coffee (in natural

logarithm) is the area of coffee plantations. Coconut (in natural logarithm) is the area of coconut plantations. Palm (in natural logarithm) is the area of palm oil plantations. Forest (in natural logarithm) is a natural forest management permit. Industrial is the industrial plantations forest. The population is the number of population growth. Density is population density. Price is the price of logs. Institutions are an index of democracy seem from the aspect of democratic institutions.

The model used in this study is a panel data regression model. The panel data has a  $T > 1$  and a cross-section  $N > 1$ . According to Baltagi (2015), panel data combines time series and cross-section data, which has observations in one unit of analysis at a certain point in time. A unique feature of time series data is a numerical sequence in which the interval between observations on several variables is constant and fixed. Meanwhile, cross-section data is a unit of analysis with observations on several variables at a certain point.

Panel data has three estimation approaches: least squares, fixed-effect model (FEM), and random effect model (REM). The first approach combines all time-series and cross-section data and then estimates the model using the OLS method. The second approach considers the possibility that we are dealing with the problem that the omitted variable may bring about changes in the time-series or cross-sectional intercept. Models with fixed effects add a dummy variable to allow for changes in this intercept. The third approach improves the efficiency of the least square process by taking into account errors from cross-section and time series. The REM is a variation of the generalized least squares estimate. The panel data model selection requires several tests, namely the Chow, Lagrange Multiplier, and Hausman.

### 3. RESULTS AND DISCUSSION

#### 3.1. Descriptive Statistics

This study uses forest cover as the dependent variable, a proxy of deforestation. While the independent variables to explain the factors causing deforestation are used trade openness, economic growth, natural forest management permits, industrial forest plantations, oil palm plantations, coconut plantations, rubber plantations, coffee plantations, log prices, population growth, density, and institutions that have been emphasized in previous studies as a fundamental cause of deforestation. This study was conducted on provinces in Indonesia without including Java Island because the forest area in Java Island is minimal. This study was conducted in 20 provinces for 11 years. In summary, the descriptive analysis of the variables used in this study can be seen in Table 1.

**Table 1.** Descriptive Statistics of Main Variables, 2010-2018

Variables	Obs.	Mean	Median	Max	Min	Std. Dev.
Forest	220	6561.202	3910.4	29368.5	711.7	7061.192
Trade	220	23.87778	18.38212	110.0622	0.352277	21.83583
GDRP	220	51386.65	38611.52	165651.9	17092.99	37186.27
GDRP <sup>2</sup>	220	4.00E+09	1.49E+09	2.74E+10	2.92E+08	6.60E+09
lnRubber	220	11.37264	12.14189	13.63275	7.32449	1.941549
lnCoffee	220	9.36946	9.14798	12.42725	7.064759	1.519827
lnCoconut	220	11.3386	11.48825	13.16208	9.987001	0.820636
lnOilPalm	220	13.07722	13.48742	16.148	9.444463	1.378525
lnForest	220	13.07972	12.74724	15.48169	10.93311	1.45038
Industrial	220	568682.5	378863.5	1740640	1988	502743.5
lnPopulation	220	15.25632	15.2172	16.47312	14.30311	0.521836
Density	220	67.95613	66.5	193.24	9.95	49.91644
lnPrice	220	4.24E+08	80116680	3.05E+09	3938161	7.67E+08
Institutions	220	70.30597	68.815	92.72	50.87	10.40571

Source: Authors' calculations

The deforestation variable has a maximum value of 29368.5 and a minimum value of 711.7, which is quite different; this can also be seen from the relatively large standard deviation value of 7061,192. Forest cover has a maximum and a minimum value that is quite different, and this can also be seen from the value of a relatively large standard deviation. This significant difference in forest cover is likely due to the different causes of deforestation in each region. While the trade openness variable has a maximum value of 110.0622 and has a minimum value, and the standard deviation has a considerable difference, this shows that trade openness between provinces is much different. For GRDP per capita, the maximum and minimum values are very different, and also, the large standard deviations indicate differences in each province.

Agricultural land expansion, namely rubber plantation area, coconut plantation area, and coffee plantation area, have different maximum and minimum values. The area of oil palm plantations is the most extensive plantation area in Indonesia compared to rubber, coconut, and coffee. The forest land concession variable, the area of industrial forest plantations and natural forest management permits, has a different maximum and minimum value, which can be seen from the standard deviation values because not all provinces have industrial forest plantations and natural forest management permits. Population and density have vastly different maximum and minimum values; this shows that the population in several provinces in Indonesia is different, and the distribution is not evenly distributed. For the democracy index, seen from the aspect of democratic institutions, the maximum value is 92.72, and the minimum value is 50.87, while the standard deviation has a value of 10.40571. The process of changing the leading institutions of democracy both at the horizontal (checks and balances) and vertical (decentralization) levels still leaves significant political problems and institutional legality.

### *3.2. Empirical Analysis*

The next step is to carry out Hausman testing to ensure more accurate estimation methods to be used in the model is a random effect, while is a FEM The test results show that the data used in the model has a p-value = 0.000, then the hypothesis is null; there is no problem of specification (the REM is appropriate) is rejected (Table 2). The results of the Hausman test states that the deforestation model in this study is better estimated using FEM. Estimating the model with FEM rather than REM and the cross-sections selected in this study were not taken randomly. In FEM, intercepts between individuals are different, but these intercepts do not vary over time or time-invariant. Then in FEM, it is also assumed that there is a correlation between cross-section errors and independent variables. FEM does not require the assumption of a model-free from serial correlation so that the autocorrelation test can be ignored (Baltagi, 2015). As for the heteroskedasticity assumption test, since the data used are cross-section data, heteroskedasticity is indeed suspected. To eliminate the effect of heteroskedasticity, the estimator used is Generalized Least Squares (GLS), using weighting: cross-section weight for all variables. Thus, the estimated model is expected to be free from heteroscedasticity.

Estimation in this study is by regressing the independent variable on the dependent variable using FEM. Furthermore, to produce estimations that are Best Linear Unlimited Estimator (BLUE) models must be free from violations of classical assumptions, including heteroscedasticity, autocorrelation, and multicollinearity. The problem of heteroscedasticity in this study using the GLS method. The estimation results using GLS show the model with a high enough number. Based on the results of Table 2 estimates, it is known that the model has an of 80%, this value indicates that the model in this study can explain the variation of deforestation by 80% while the role of other variables in explaining the independent variable is 20 percent (Table 2).

### *3.3. Discussions*

Based on the estimation results of the model, trade openness has a negative and significant effect on forest cover. By the initial hypothesis, trade openness affects forest cover with a negative relationship. Every increase in trade openness by one unit will reduce forest cover by 80.2 hectares, *ceteris paribus*. A negative relationship to deforestation shows the more open trade of provinces.



The deforestation rate in that province will increase in line with this study conducted by Abman & Lundberg (2020); Austin et al. (2019); Barbier (2001); Faria & Almeida (2016); Ferreira (2004); Joshi & Beck (2017); López & Galinato (2005); Scriciu (2007) concludes that increasingly open international trade has been associated with increasingly high deforestation in developing countries. Export activity is an essential factor in a country's economy, making developing countries export-oriented to encourage increased state revenue. Generally, exported goods are raw goods such as wood, agricultural and plantation products, and natural minerals. Indonesia is one of the countries that, until now, still rely on natural resources to increase the country's income.

GRDP per capita is negative and significantly correlated to forest cover in Indonesia. The results of this study are in line with Abman & Lundberg (2020); Faria & Almeida (2016); Ferreira (2004); Joshi & Beck (2017); López & Galinato (2005); Ogundari et al. (2017); Scriciu (2007); Tjandrakirana & Tambunan (2006); Tsurumi & Managi (2014); Van & Azomahou (2007) states that economic growth has a significant effect with a negative relationship on the area of forest cover. In the initial stages of the economic development of a country, the need for economic growth and increased income causes demand for logging and clearing of forest land for agricultural and plantation activities. It means that if the economic target or income is highest, the exploitation of natural resources will be higher.

Squared GDRP per capita has a positive and significant correlation to forest cover. In line with studies Abman & Lundberg (2020); Faria & Almeida (2016); Ferreira (2004); Ogundari et al. (2017); Tsurumi & Managi (2014); Van & Azomahou (2007) states that higher levels of income cause changes in the composition of demand for goods and services, as well as an increase in demand for a better environment. Pressure on deforestation due to increased incomes can be reduced because agricultural production becomes intensive, demand for the service sector in the economy, and demand for products and services increase, making forest land more valuable. The estimated GDRP per capita and squared GDRP per capita follow the trend of the EKC hypothesis, which postulates that economic growth and environmental degradation follow the U-shaped curve. However, because the environmental degradation variable is proxied by deforestation, the EKC hypothesis in this study is that the curves formed are not U-shaped inverted.

**Table 2.** Estimation Result of FEM with Generalized Least Squares

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-2581141***	809898.7	-3.187	0.003
Trade	-80.265***	77.926	-3.030	0.009
GDRP	-0.614**	0.359	-2.712	0.055
GDRP <sup>2</sup>	1.44E-06*	1.35E-06	2.066	0.063
lnRubber	-13786.25***	8195.952	-3.682	0.001
lnCoffee	10742.99*	5634.909	3.907	0.065
lnCoconut	2783.337	2142.021	1.299	0.202
lnOilPalm	-1262.172**	1567.777	-2.805	0.026
lnForest	-6558.454	4537.814	1.445	0.157
Industrial	-0.018170**	0.008	-2.282	0.028
lnPopulation	167209.4***	53559.54	3.122	0.004
Density	-148.865*	213.949	-4.696	0.061
lnPrice	-2248.969***	865.719	-2.598	0.014
Institutions	-13.644	63.0319	-0.216	0.829
Number of Obs.	220			
R-squared	0.809			
F-statistic	11.123			
Hausman test	39.069***			

**Note:** Dependent variable is deforestation. \*, \*\*, and \*\*\* indicate significance at 10%, 5%, 1%, respectively

**Source:** Author's calculation

The area of rubber plantations shows negative and significantly correlated to forest cover. The results of this study are in line with Grogan et al. (2019); Meijide et al. (2018); Tjandrakirana & Tambunan (2006); Warren-Thomas et al., (2018) that the expansion of rubber plantations is a significant driver of forest cover. Indonesia is the second-largest rubber-producing country in the world. Rubber plantations are plantations that small-scale farmers mostly plant, and smallholders open up plantations to supplement their income or build small-scale plantations for commodities of high economic value. In the last few decades, the production of smallholder plantations has expanded, with extensive rubber plantations often being planted on forested land that is on agricultural land, causing deforestation.

The area of coffee plantations shows significant results in a positive direction towards forest cover. This study's results do not follow the initial hypothesis that an increase in the area of coffee plantations will increase deforestation. According to Tjandrakirana & Tambunan (2006), the area of agricultural land can cause an increase in deforestation of 0.05-0.31 hectares per year. The conversion of forest land into coffee farming has become a concern because it is feared that it can severely impact the destruction of forest functions, decreasing soil productivity in particular and land degradation in general.

The area of coconut plantations shows a positive and insignificantly correlation to forest cover. The results of the coconut plantations are less profitable compared to other plantation and agricultural commodities, so the forests that are cleared as coconut plantations are shifted to oil palm plantations which have an impact on deforestation (Miyamoto et al., 2014; Parid et al., 2013). Coconut plantations have developed as smallholder plantations because of some of the coconut plantations in Indonesia. The condition of the coconut plantations is that they have narrow land and improvised maintenance or none at all, not on a commercial scale and traditionally managed. The coconut processing industry is less developed so it cannot compete with oil palm. Therefore, the area of coconut plantations has a reasonably large area but not in the forest area, and the growth of coconut plantations is not as fast as oil palm plantations.

The area of oil palm plantations has a negative and significant effect on forest cover. The result in this study is in line with Austin et al. (2019); Meijide et al. (2018); Miyamoto (2020); Miyamoto et al. (2014); Omran & Schwarz-Herion (2020); Tjandrakirana & Tambunan (2006) studies show that the area of oil palm plantations negatively impacts forest cover. Oil palm plantations are included in the permanent crop category, where these plantations have a long planting period, and oil palm trees have high productivity compared to other oil producers.

Palm oil production has surged in several developing countries because palm oil is relatively cheap to plant. High demand and rising prices for palm oil production, including Indonesia, are investing heavily in oil palm plantations. Therefore, increasing the area of oil palm plantations will expand the area of forest cover. Palm oil has a positive impact on the Indonesian economy by making the mainstay of the country's foreign exchange earnings through crude palm oil export, which tends to increase from year to year. The results of the palm oil industry are not only vegetable oil but are also used for the food, soap, cosmetics, and cosmetics industries that can be developed into a renewable energy source for biodiesel.

However, environmentalists argue that oil palm does absorb carbon as they grow. The process of deforestation to establish a plantation releases more carbon than would be produced by planted oil palm. So that oil palm plantations will grow faster and seize higher carbon in a matter of years compared to natural forests that continue to regenerate. In the end, the area of oil palm plantations will still store less carbon than the original forest plants. The vast development of oil palm plantations has had a significant impact on the environment, including decreasing the availability of clean water. Ecologically, oil palm plantations are the plants that need the most water in their growth processes. Oil palm plantations are plantations that are applied to monoculture on land. Changes in land use from natural forests to monoculture plantations such as oil palm plantations will change the system and balance of water availability and water needs in the region.

The natural forest management permit area shows a negative and not significant effect on forest cover in Indonesia. The results of this study are in line with Fisher et al. (2011); Gaveau et al. (2012); Gaveau et al. (2013); Indarto et al. (2015); Meijaard & Sheil (2007); Tjandrakirana &

Tambunan (2006) raising questions about the effectiveness of policies the current forest moratorium and the forest tariff policy towards mitigating deforestation. As the rate of deforestation and the increasing volume of timber from illegal logging and the number of natural forest management permits tend to decrease, the area of forest damaged by illegal logging continues to increase, and there is no clear information about the area of forest affected by logging activities.

The area of industrial plantations forest has a negative and significant effect on forest cover in Indonesia. Consistent with the initial hypothesis that the more extensive industrial plantations forest will cause a decrease in the area of forest cover. The development of new industrial plantations can cause deforestation by replacing natural forests or avoiding them by using previously cleared areas (Gaveau et al., 2016). Initially, the development of industrial plantations forest aimed at providing new wood from natural forests, rehabilitating degraded land, and conserving nature. From the standpoint of environmental support, the development of industrial plantations forest can be seen as "deforestation", whereas, from government and industry, this is seen as "reforestation" (Sunderlin & Resosudarmo, 1997). The development of industrial plantations forest, although reportedly intended to protect natural forests, may play a role in forest destruction because if supplies from industrial plantations forest are not available, pressure on natural forests may increase (Belcher & Gennino, 1993; WALHI, 1992).

The industrial plantations forest has been, and continues to be developed, to meet increasing global demand for wood products (McEwan et al., 2020). In Indonesia, the industrial plantations forest program is based on the Regulation of the Minister of Environment and Forestry Number P.62/MENLHK/SETJEN/KUM.1/10/2019 about the construction of industrial plantations forest. However, in reality, the rehabilitation that was carried out was less successful, and investors made the industrial plantations forest only want a timber utilization permit and a rehabilitation fund loan. So that the industrial plantations forest program is not greening the former natural forest into plantations but instead most only clear the remaining natural forests managed by natural forest management permits. As a result, the more extensive industrial plantations forest will reduce forest cover.

Population density has a negative and significant effect on forest cover. The estimation results in this study are in line with Abman & Lundberg (2020); Darmawan et al. (2015); Fraser (1998); Margono & Turubanova (2012); Mather & Needle (2000); Romijn et al. (2013); Ryan et al. (2017); Tjandrakirana & Tambunan (2006) states that population growth and density are fundamental explanations of the problem of deforestation. In Southeast Asia and the humid tropics, there is generally a specific sequence of activities in which forests are first cleared by the logging industry and subsequently sought for agriculture. Rapid population growth causes the need for new land, both for shelter and economic activities, to increase, and forest areas are also the primary target. However, the notion that the population is the leading cause of reduced forest cover is not entirely true.

Global logs prices show a negative and significant effect on forest cover in Indonesia. The high world price of logs will cause a reduction in forest cover area (Kissinger et al., 2012; Tjandrakirana & Tambunan, 2006). The world price of logs greatly influences the price of domestic logs because Indonesia adheres to an open economic system so that if the price of global round wood increases, the price of domestic logs will also increase. However, the impact of various government policies also greatly influenced the instability of domestic timber prices. Cheap domestic logs prices resulted from the enactment of the logs export ban policy and the resultant various other policies imposed by the government in conjunction with and after the enactment of the log export ban in the 1980s, which caused timber smuggling to become even more significant. Because the profits derived from the sale of smuggled timber are huge, resulting in a vast difference between the price of domestic logs and international logs prices.

The role of institutions shows negative and insignificant results on forest cover in Indonesia. High rates of deforestation in developing countries are related to weak institutions, which have driven abuse of land cover (Bohn & Deacon, 2000; Boubacar, 2012; Ferreira, 2004; Mendelsohn, 1994). Barbier (2002) argues that the existence of formal and informal institutions protects access

and guarantees optimal use of open access such as forests. The political structure of power is closely related to natural resources is very closely related to the composition in the legislative and executive (patronage). The legislative structure contributes significantly to the executive's control and use of natural resources.

Deforestation in several provinces in Indonesia is mostly caused by licenses in the forestry and plantation sectors. The most crucial issue of forest governance in various provinces in Indonesia is the overlapping issue of forestry, plantation, and mining licenses. This problem should be the main thing for local governments related to licensing and map sources issued. In this case, the Department of Environment and Forestry, the regional government, can ensure that permits issued do not overlap. The local government did not recognize the issue of community forest management rights during this process, and the problem of improving environmental problems was not a top priority for the management of forest governance by companies in the forestry, plantation, and mining sectors.

The equation model's estimation results show the link between forest cover in Indonesia during the period 2008-2018 with trade openness and economic growth. With a negative relationship to the area of forest cover, it shows that the more open trade in a region, the deforestation rate in the area will increase. As a developing country, Indonesia still relies on natural resources to increase its income. Export orientation policy on raw materials such as wood, agricultural and plantation products, natural minerals, and others was carried out to encourage increased foreign exchange. These activities led to the opening of trade in Indonesia, which in the end, agriculture and plantation activities competed with the area of forest cover, causing higher deforestation. Many environmental economists argue that a country with an open economic system will further strengthen economic growth compared to countries with a closed economic system. However, it also needs to be understood that trade openness will only positively impact a country's population has adequate quality human resources in education and skills.

From the estimation results of the model, it is known that the activities of deforestation and debt conversion each contribute to changes in forest cover. However, forest conversion activities are more influential on changes in forest cover—evidenced by the significant coefficients produced by each independent variable. This analysis provides the impression that forest conversion activities are the leading cause of deforestation in Indonesia. It is indicated by trade openness, economic growth, rubber plantations, oil palm plantations, and industrial forest permits. If the price of the commodity rises, it will impact decreasing forest cover. Also, increasing population and density have resulted in a decrease in forest cover because land outside the forest area is increasingly limited, while the need for agricultural land and settlements is increasingly pressing. It has led to the expansion of land to the forest area.

Natural forest management permits have a not significant effect on a positive relationship. If natural forest management permits are reduced, the area of forest cover will be reduced as the rate of deforestation and the increase in the volume of timber resulting from illegal logging by logging companies will decrease. It can be concluded that the reduced area of natural forest management permits goes hand in hand with the reduction in forest cover. Although the area of natural forest management companies permits has decreased, the area of damaged forest areas continues to increase due to illegal logging and forest fires. The area of oil palm plantations and rubber plantations significantly influences the direction of the negative relationship. Plantation development on forest land is twice as attractive as getting a timber utilization permit. A company can clear the area and sell the wood to the wood processing industry.

The price of logs has a significant effect on forest cover in Indonesia. Domestic and international wood price differences occur with the increase in world logs prices. In the end, it will have an impact on increasing deforestation. Population growth and density have a significant effect on forest cover. Rapid population growth causes the need for new land, both for shelter and economic activities, to increase, and forest areas are also the primary target. However, the notion that the population is the leading cause of reduced forest cover is not entirely true. The role of institutions has a negative and not significant effect on forest cover. Influencing factors are various formal regulations and the role of formal and informal institutions that affect forest governance, including the relations of

formal and informal actors in the policymaking process. The strategic issues on forest governance, such as spatial planning, spatial policy process, licensing, and budgeting, if not implemented correctly, will be a gap by the actors to use the forest by violating the rules.

The intensity of trade openness will increase for a commodity because of the high demand. Therefore, it can be assumed that, if *ceteris paribus*, the existence of trade openness will reduce trade barriers, increase demand for plantation and agricultural commodities. Increased export activities require the role of commodities, which means that it requires land as capital. The need for land triggers the conversion of forest land to plantation and agricultural land, which in other words, will contribute to increased deforestation in Indonesia. So, it can be concluded that an increase in exports and imports will increase trade openness, which will impact deforestation directly through the area of production land.

#### **4. CONCLUSIONS**

Deforestation has become an international issue, especially in countries with vast tropical forests. The concern raised is related to the greenhouse effect because forests are the earth's lungs. Countries that implement forest use are now under international pressure to take steps to slow the rate of deforestation. Indonesia is one of them. From the estimation results of the model, it is known that trade openness, economic growth, and activities of logging and forest conversion each contribute to changes in forest cover. If the price of the commodity rises, it will impact decreasing forest cover. Increasing population and density have resulted in decreased forest cover because land outside the forest area is increasingly limited. The need for agricultural land and settlements is increasingly pressing so it has led to the expansion of land to the forest area.

Based on the estimation results obtained, suggestions can be submitted for policymaking to achieve sustainable forest development and Indonesia's forest sustainability interests: (i) implementing international trade, it is necessary to pay attention to environmental aspects as a counterweight to the externalities generated by trading activities against deforestation; (ii) the performance of environmentally friendly products needs to be improved to protect forests from over-exploitation; (iii) the development of plantations in weak areas, not in conversion forest areas and the use of weak areas for plantations will result in relatively lower costs of environmental damage; and (iv) the government must also be severe and strongly commit to the REDD+ program as a new opportunity to address the prolonged threat to forests.

The limitation in this study is that the data used is panel data for 11 years in 20 provinces in Indonesia, with a relatively large number of variables, so there is a possibility of estimating inefficient models. This study uses the dependent variable of forest cover to approach deforestation. Due to the unavailability of annual data on deforestation, to get annual forest cover data extrapolated from one point of time to a particular time associated with forest cover. Estimation of deforestation due to inferential trade openness needs to be developed with a better model, especially in selecting independent variables.

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