Revisiting the trade restrictions-industrialisation nexus in developing countries: the case of log export ban and wood processing

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Preliminary version

Abstract

Many developing countries impose restrictions on the export of logs primarily to promote local wood processing. This study focuses on the Log Export Ban (LEB) policy and investigates if this policy impacts both the production and exports of two processed wood, i.e., sawnwood (first stage of processing) and veneer (second stage of processing). We implement the propensity score matching method to assess the average treatment effect on the treated (ATT) of the LEB policy in 101 developing countries. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 4 percents) compared to veneer (about 1 percent). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 10 percents) while we do not find any significant results on the exports of veneer. In addition, we investigate the heterogeneity in treatment effects using control function with some institutional variables such as the level of corruption, the quality of law and order as well as the bureaucracy quality. The results found are comparable to the ATTs results. Also, to avoid endogeneity issue, we apply the two-step GMM estimation model that confirms the ATTs results. Taking together, these results suggest than the LEB policy has mainly contributed to improve the first stage of wood processing rather than the second stage.

JEL classification: C21, F13, O14, Q23.

Keywords: Log export ban, Wood processing, Developing countries, Propensity score matching.

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1 Introduction

Free trade suggests that each country is expected to export the products in which the country has a comparative advantage. The roots of its advantage are numerous (natural resource endowments, commercial or industrial policies, etc.). As a consequence, international trade relies on differences between countries (Dodzin and Vamvakidis, 2004). This implies that countries can not take advantage of international trade in the same way. Some sectors of production grow faster that other sectors. Countries in the slow growing sectors will thus grow slower than countries with a a comparative advantage in the fast growing sectors. As a result, international trade can be a losing game for some countries and a winning game for other countries. This issue has been the key stone of theories supporting trade protection (e.g. the infant industry theory) and the promotion of trade protection policies (e.g. import substitution policies). This issue is particular relevant in developing countries in the 1970s and 1980s where specialization in agriculture, considered as the slow growing sector, was dissuaded in favor of the industrial sector. Thus, industrialization becomes the strategy to leave the slow growing sector to the fast growing sector in order to achieve sustained economic growth (Mukherjee, 2012).

Moreover, the pattern and process of industrialization in developing countries have been shaped by different trade policies (Dodzin and Vamvakidis, 2004; Mukherjee, 2012). One strategy is the export oriented industrialization (EOI) also known as export-led growth. This strategy is based on the postulate that the export growth is the engine of economic growth by improving allocation of resources within the entire economy through an increase of physical and human capital (thanks to economies of scale for instance) and also a technological improvement in response to foreign competition (Balassa et al., 1971; Medina-Smith, 2001; Amoah et al., 2009). The export-led growth strategy adopted in many countries has been implemented with the promotion of trade protection measures on raw materials to conform with industrialization purposes. Raw material exports are the main source of revenues for many developing countries. However, the industrialization strategy leads to process these inputs to get more value-added and export incomes. So, the governments put in place some restrictions on export of raw materials to create a large availability of these goods for local industry and the production of processed goods. These restrictions on primary goods concern countries endowed in natural resources such as forest resources or agricultural raw materials. The case of forestry in developing countries is particularly relevant. In many forest-rich countries (Ghana, Gabon, etc.), several governments decided to develop their industry through the promotion of the processing relating to primary, secondary and tertiary wood products for export.

As a consequence, these countries adopted restrictions on raw logs from quotas and tax on exports to strict export ban[1]. The wisdom behind the log export ban (LEB) policy is both to promote local processing (with employment benefits) (Amoah et al., 2009; van Kooten, 2014) and to encourage a more sustainable management of forests (Resosudarmo and Yusuf,

[1] Schulz (2020) shows that wood was in 2011 the most export restrictions commodity in Africa.

2006). However, the implementation of the LEB policy has not been uniform in all developing countries. Some countries have implemented the LEB policy for more than two decades while others countries have decided to remove it or have been enacted it recently. Thus, what is the real effect of the LEB policy on the wood industrialization of country adopters? What is the effect of the LEB policy on trade opportunities in terms of processed wood exports? The purpose of this study is twofold: (1) to assess the impact of the LEB policy on the dynamic of processed timber production growth (resources-based industrialization) and (2) to assess the impact of the LEB policy on trade opportunities, specifically in terms of processed wood export dynamics.

All former studies on the impacts of the LEB policy are country specific and focus on the price analysis and the removing effect of the LEB policy (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). Therefore, our contribution to the literature is twofold. First, we estimate the impact of the LEB policy at macro-level using panel data for 101 developing countries between 1999 to 2019. Second, we analyze the impact of the LEB policy by focusing on the volume of first and second level of processed wood production rather than price. Furthermore, as defined by the LEB purpose of export increases, our study focuses on the effect of the LEB policy on the dynamic of processed wood exports.

We implement the propensity score matching to estimate the average treatment effect on the treated (ATT) of the LEB policy. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 4 percents) compared to veneer (about 1 percent). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 10 percents) while we do not find any significant results on the exports of veneer. Moreover, we study the heterogeneity in treatment effects of the LEB policy using control function. More precisely, we examine if countries which meet the preconditions of LEB adoption record better performance in processed wood production and export. We also analyze if the time length since the adoption of the LEB policy and the quality of institutions (the level of corruption, the quality of law and order as well as the bureaucracy quality) can play on the effect of LEB adoption on processed wood production and export. The results found are comparable to the ATTs results regarding the additive effect of the LEB dummy variable. Moreover, we find several differential effects of the LEB policy mainly according to institutional variables. For instance, we find a positive effect of the interaction term between the LEB dummy and corruption on sawnwood production. This result can be related to the fact that the LEB policy tends to encourage the development of upstream logging activities to meet the increase of the demand of downstream wood activities created by the LEB policy. Given that upstream logging activities are often informal and illegal, high corruption can thus contribute to raise these kind of activities and then, stimulate sawnwood production. Also, to deal with endogeneity issue, we apply the two-step GMM estimation model and the estimation results confirm the ATTs. Taking together, our results suggest than the LEB policy influence more the first stage of wood processing rather than the

second stage. As a consequence, the development of the second stage like the production and the export of veneer needs more than the interdiction of logs. Highly processed woods require more skilled labor and more technically advanced machines which need more complex industrial and employment policies than the LEB policy.

The remainder of the paper is structured as follows. Section 2 discusses the theoretical effects of the LEB policy. Section 3 describes the econometric framework and data, and gives descriptive statistics. Section 4 presents and discusses the main results of the study and Section 5 shows the robustness checks. Section 7 concludes with remarks concerning policy and future research.

2 Background

The LEB policy has many implications in terms of forest management and deforestation but also for the wood sector itself and the entire economy in terms of employment, balance of payment, fiscal revenues and industrialisation of the wood industry (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). In this paper, we focus only on the industrialization of the processed wood sector since the LEB policy was imposed primarily with the objective of promoting this sector.

The theoretical gains of the LEB policy in terms of resource-based industrialisation such as the processed wood industry are not obvious. While trade economists are almost all agreed that log export bans and restrictions should have detrimental effects on the overall economic efficiency of an economy, the impact of a such policy only on the concerned sector is fuzzy (Resosudarmo and Yusuf, 2006).

On the one hand, we can advocate that the LEB policy will have a net positive effect on wood industry. Even though there is a dead-loss due to the ban on log exports in the logging industry, there can be a welfare gain by producing processed wood products far larger than the welfare loss in logging industry (von Amsberg, 1998; Dudley, 2004; Resosudarmo and Yusuf, 2006). Thanks to the ban of exporting logs, the domestic processing industry has not to compete with foreign processors for access to the local timber supply, which is typically cheap in the case of developing countries. Processing industries can thus expand their scale thanks to the low cost of lags as a raw material. This expansion can then call for new investments in the processing industry. As a consequence, the incoming new capital will increase the capital-labor ratio and then the marginal productivity of employment. Efficiency should therefore improve in the wood-processing industry that can then be able to compete on the international market by exporting higher-value processed wood. We thus expect a positive effect of the LEB policy both on the production and the exportation of processed wood products. Some empirical studies support such an argument at country level. For instance, Amoah et al. (2009) found that the LEB policy increased the production of processed wood products (sawnwood, veneer and plywood) in Ghana. In Indonesia, Resosudarmo and Yusuf (2006) used a computable general

equilibrium model to predict the anticipated impact of implementing the LEB policy on the national economy and on household incomes for various socioeconomic groups. Regarding only the wood sector, they showed that the LEB policy in long run may have benefits for the wood processing industry.

On the other hand, although the dead-loss in logging industry can be compensated by the promotion of the downstream wood processing industries, the net gain in welfare for the wood industry can be negative. If the processing capacity can increase during the first time of the LEB policy, it can be established at the expense of the economy because countries can pay an economic price in the form of subsidy and inefficiency. An important pitfall occurring after the implementation of the LEB policy is a significant reduction of the price of logs in the exporting country (von Amsberg, 1998). For instance, following a log export ban in Costa Rica, domestic log prices have fallen to 20-60 percent of international price levels (Kishor and Constantino, 1993). This fall could lead to inefficient and wasteful logging and processing techniques (Barbier and Rauscher, 1994). Most empirical studies support such an argument. For instance, Boscolo and Vincent (2000) found a similar result after the implementation of the LEB policy in Indonesia, Philippines and Malaysia. They argued that the development of processing capacity was implemented at high economic cost in the form of subsidization and inefficiency. They found that for every cubic meter of plywood produced, for instance, 15 to 20 percent more trees had to be cut than it would have been the case if the logs had been processed by more efficient milling plants in Asian countries.

Despite the controversial theoretical debate and no empirical consensus on the efficiency of the LEB policy, many countries still implement them. The goal of this study is to provide an estimation of the impact of this policy on wood processing industry by comparing more than one hundred developing countries experiencing or not this policy.

3 Econometric framework and data

3.1 Econometric framework

The purpose of our study is to estimate the impact of the LEB policy on industrialization and export of wood processing industry (sawnwood and veneer). The LEB adoption i thus the treatment variable. The countries implementing the LEB policy are the treated group and the countries which do not apply the policy are the control group. To estimate the causal effect of the LEB policy, we implement a propensity score matching (PSM) strategy that allows us to study the Average Treatment Effect on the Treated (ATT). The ATT estimation is based on the following equation:

$$ATT = E[(Y_{i1} - Y_{i0})|LEB = 1] = E[Y_{i1}|LEB = 1] - E[Y_{i0}|LEB = 1], \quad (1)$$

where LEB is the log export ban adoption dummy variable in country i. Y_{i1} is the outcome

representing either the production or the exportation of vener or sawnwood of the country that has applied the LEB policy and Y_{i0} is the same outcome of the country that had not applied the LEB policy. In this approach, the outcome Y_{i0} is not observable, i.e the outcome of the LEB adopter country if it had not adopted the LEB policy. We can estimate the ATT to compare the LEB adopters with the non-LEB adopters if the choice of LEB adoption is random. However, the choice of LEB adoption or not may be favoured by some observable factors that also affect the outcomes. So, to compare the mean value of outcomes between the two groups can lead to the selection on observables. To deal with the selection on observables problem, the propensity score matching methods can be implemented. Based on the observables characteristics, the PSM allows to compare the LEB adopters and the non-LEB adopters. According to unconfoundedness assumption, the differences in outcomes between the LEB adopters and the non-LEB adopters with the same values for covariates are attributable to the treatment. This assumption expressed by $(Y_0, Y_1 \perp LEB|X)$ means that conditional on the vector of observable factors which are not affected by the treatment, the outcome are independent of the treatment. Under this assumption, the ATT expression became:

$$ATT = E[(Y_{i1}|LEB = 1, X_i)] - E[(Y_{i0}|LEB = 0, X_i)], \tag{2}$$

where we have replaced the $E[Y_{i0}|LEB = 1]$ with $E[(Y_{i0}|LEB = 0, X_i)]$

Thus, all matching strategy consist in matching the treated units and comparison units with the same values of X. However, given the high dimensional of covariates X, it is difficult to implement a matching on X. Rosenbaum and Rubin (1983) suggest to implement the matching based on the propensity score of our two groups. The propensity score $p(X) = E[LEB|X_i] = Pr(LEB = 1|X_i)$ is the probability for an individual to adopt the LEB policy given his observed covariates X.

There is another assumption which is important for PSM application. It is the common support assumption $(p(X) < 1)$. Thus, we can rewrite the ATT:

$$ATT = E[(Y_{i1}|LEB = 1, p(X_i)] - E[(Y_{i0}|LEB = 0, p(X_i)] \tag{3}$$

To estimate the ATT using the propensity score matching, we choose four types of matching identified in the literature. We first begin with the nearest neighbors matching based on the matching with the closest PS and we choose the three types of nearest matching (n=1, n=2 and n=3). Second, we use the radius matching (Dehejia and Wahba, 2002) which is based on the PS matching of treated and non-treated located at a certain distance. We retain three radius focused on a small, a medium and a wide radius (respectively for r=0.005, r=0.01, r=0.05). Third, we implement the kernel matching which matches each treated with the distribution of untreated in the common support, with weights that are inversely proportional with the distance from PS of each treated (Heckman et al., 1997). Finally, we use the local linear regression which is comparable to kernel matching with the difference that this last method

considers a linear term in weighting function (Heckman et al., 1997).

In addition, we complete the propensity score matching analysis in two ways. On one hand, we explore potential differential effects of the LEB policy with the control function regression approach (Wooldridge, 2015). More precisely, we examine several potential heterogeneity in treatment effects: (1) the LEB adoption preconditions meeting, (2) the time length since the adoption of the LEB policy and (3) the quality of institutions (corruption, law and order and bureaucracy quality)[2]. On the other hand, we deal with endogeneity of the LEB policy with a panel two-step system GMM estimation (Blundell and Bond, 1998) with Windmeijer (2005) small sample correction in order to take account the potential endogeneity caused by simultaneous bias.

3.2 Data and descriptive statistics

3.2.1 Data

Our study covers 101 developing countries from 1990 to 2019. The data on processed wood (sawnwood and veneer) are downloaded on the International Tropical Timber Organization (ITTO)[3].

Sawnwood is the first processing level of wood and consists in producing either by longitudinal sawing or by a profiling process and whose thickness exceeds six mm. Veneer is considered as the second processing level of wood and is made from thin sheets of wood of uniform thickness, not exceeding six mm. It is worth noting that the sawnwood is not the previous level of veneer. As a consequence, the volume of log used for sawnwood production is independent to the volume of log used for veneer production. In our study, we focus on the effect of the LEB policy on both production and export of processed wood. Regarding production, we use the ratio of sawnwood (veneer) production on roundwood production which is the main input of processed wood. In this approach, we thus standardise the measure of sawnwood (veneer) production to capture the real growth of processed wood rather than the volume increase that can hide some disparities of the countries performances in terms of roundwood use. Regarding export, we use the ratio of sawnwood (veneer) export on the sawnwood (veneer) production. The underlying motivation is to capture one of the main goals of the LEB policy that is to increase the share of exported production of processed wood.

Information regarding the LEB policy comes from Forest Product Export Restriction (FPER) database[4]. For each country and each year, the LEB treatment variable equals to 1 when the LEB policy is implemented and 0 if the LEB policy is not implemented or if the LEB has been removed. In our study, they are 43 LEB adopters and 58 non-adopters mapping in Figure 1 and reporting in Table A2 in the Appendix.

[2] All these variables are defined in Table A1 in the Appendix.

[3] https://www.itto.int/biennal_review/

[4] We exclude the countries which banned logging because this ban aimed only at fighting against deforestation.

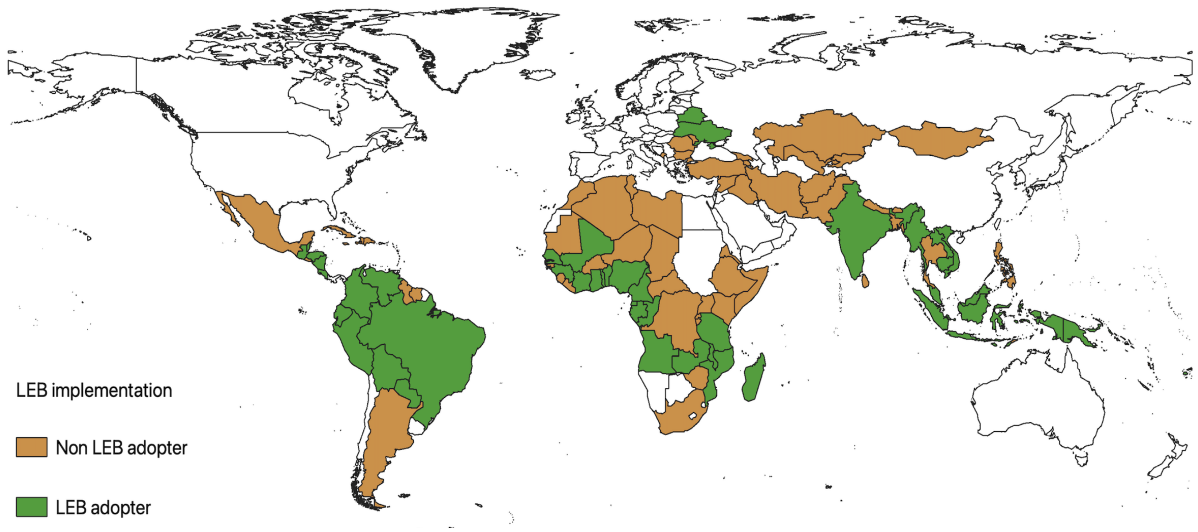


Figure 1: Sample used in this study: adopters and non adopters LEB

The other covariates come from various sources. Macroeconomic data come from the World Bank Indicators (i.e. GDP per capita, labor force, agricultural and manufacturing GDP, FDI inflows, exchange rate and inflation). Variables related to the quality of institutions come from the International Country Risk Guide (ICRG) (i.e., the quality of government, corruption, the quality of law and order, and the quality of the bureaucracy). Finally, processed log price come from the International Tropical Timber Organization (ITTO). Table A1 gives a complete description of the variables and their sources.

3.2.2 Descriptive statistics

As a first step before the estimation method, we plot in Figure 2 the mean of sawnwood and veneer production measured as the ratio of each processed wood production to log production, and the mean of sawnwood and veneer exportation measured as the ratio of each processed wood exports to total production of each processed woods five years before and five years after the LEB adoption.

In the left-top graph related to sawnwood production, more than the half of countries adopters have performed at least as well as they did before the adoption of the reform. However, the countries located in the left-bottom of the graph seem to be stuck at early stages of wood processing. The LEB adoption clearly did not help them to pursue development of sawnwood industry.

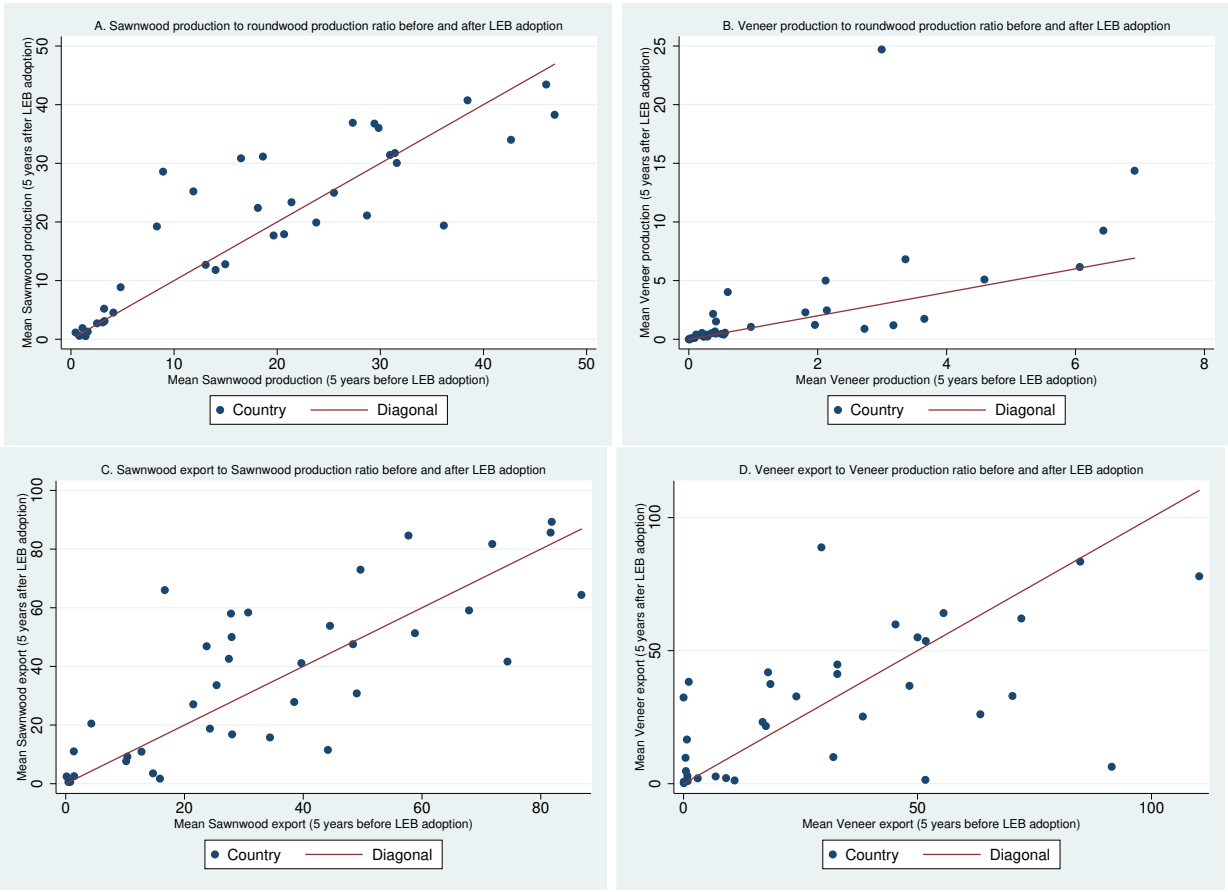
The right-top graph is related to veneer production. It is worth noting that there are more countries producing more veneer compared to log production after the LEB than before. However, the veneer production is distinctly less important than the sawnwood production. This result can suggest that the sawnwood producer countries did not significantly begin the second level of processing. Moreover, there are many countries in the left-bottom of the graph.

Despite the adoption of the LEB policy, they did not implement the development of veneer industry.

In the two bottom graphs are related to exports of processed wood. The most countries seem to have increased the share of processed wood exported after the LEB adoption although many countries did not.

The impact of the LEB policy on both processed wood production and exportation remains an empirical issue, to which we now turn.

Figure 2: Processed wood production and exportation before and after LEB adoption



Source: authors' calculation

4 Results

4.1 First stage: estimation of propensity scores

We use a probit model to estimate the propensity score of the LEB adoption. Recall that in the second stage, we will estimate the ATT of the LEB policy on four different outcome variables: the production of sawnwood, the production of veneer, the exportation of sawnwood and the exportation of veneer. Then, we do not use the same variables to explain the probability to

implement the LEB policy in the first stage. More precisely, we use three variables common to the four models (the real GDP per capita, the industry GDP and a measure of the quality of the governance) and several specific variables related to macroeconomic conditions and wood industry. Table 1 reports the estimation results for the sawnwood and veneer production in columns 1 and 2 respectively, and the sawnwood and veneer exportations in columns 3 and 4 respectively.

Regarding the GDP per capita and manufacturing value added, they are expected to have a negative effect on the probability to adopt the LEB policy. Indeed, the countries that achieved some high level of industrial development and GDP per capita should not need the LEB policy to push up the industrialization of the wood industry. The presence of a developed industry sector can help the transfer of useful technology to the wood sector to help its industrialization. Also, high GDP per capita is often associated to a well developed domestic market that is useful for the industrialization of the wood sector. Manufacturing value added has the expected negative sign on the probability to adopt the LEB policy.

Regarding the quality of the governance, we use an aggregated governance index provided by ICRG. This variables takes into account both the level of corruption, the quality of the bureaucracy, the quality of the legal system and the strength of the popular observance of the law. We assume a negative effect of this variable on the probability to adopt the LEB policy. If a government had the capacities of government to apply and comply to rule and law and fight the corruption, it would have not been not necessary to ban the exportation of logs. We find the expected negative effect of the quality of the governance in all specifications.

We then add several control variables in the two first specifications related to the production. First, we use the level of roundwood export to explain the LEB adoption. We find the expected positive effect given that the goal of the LEB policy is to ban the log export to shift it to domestic processed woods. Thus, the increase of high level of roundwood export encourage the LEB adoption. Second, we also control for the labor force. Given that the LEB policy has the goal to develop the national production of processed wood, more labor force in the economy should encourage the implementation of the policy. We find this expected positive effects. Third, we add the agricultural GDP by assuming a negative effect on LEB adoption. A more developed agricultural sectors can discourage the adoption of the LEB policy because the country has less incentive to develop its wood industry. Our results confirm the expected negative effect. Fourth, we use foreign direct investments (FDI) and we assume a positive effect. FDI is often oriented toward high value added sectors. For forest endowed countries, the presence of FDI in the economy should incite to develop the production of processed woods to attract more FDI in the forestry sector. As a consequence, the country implements the LEB policy to help the emergence of the processed woods sectors. Also, we can assume that in forest-rich countries FDI are already located in the wood industry. Given that these investments look for more efficiency in production and higher revenues, the country can be incited to ban log exports to help the forestry sectors to growth. Our results confirm the positive effect of FDI

on LEB adoption.

Moreover, in the two last specifications related to wood exports, we add three other variables. First, we add the level of international trade. The expected effect of trade on LEB adoption is not straightforward. On one hand, countries experiencing more international trade should be less incited to implement a policy aiming at dampening international trade. On the other hand, more opened economies can be incited to develop the production and then the exportation of more processed goods. As a consequence, international trade should increase the probability to adopt the LEB policy. Our results confirm a positive effect of international trade on LEB policy. Second, we add the exchange rate and find a negative effect on the LEB dummy. Third, we use the level of inflation. The evolution of domestic prices acts on trade and industrialization policy. More inflation implies an increase of production costs for wood industry and a fall of its competitiveness in international market. In this context, the adoption of LEB policy can be implemented to shift national log production from international market to domestics markets. So the effect of inflation is positive on LEB adoption. On the contrary, we can assume that inflation can reduce the incentive to implement the LEB policy. In fact, if wood industry loses in competitiveness because of inflation, government could not be incited to promote a more expansive processed wood production. Our results suggest that inflation has a negative effect on LEB adoption.

Lastly, we add two variables specific to sawnwood and veneer respectively: export price and import. In columns 1 and 3 (2 and 4), we add the sanwwood (veneer) export price. We assume that the export price of processed woods should increase the incentives to adopt the LEB policy. The increase of processed wood production and exportation thanks to the LEB policy will then increase revenues generated by the wood industry thanks to an increase of processed wood export prices. We find a positive and significant effect of sawnwood price and LEB adoption while the effect is negative and significant for veneer. We explain this result by the fact that most of developing countries are first incited to adopt the LEB policy to develop the first step of processing, i.e. sawnwood. Finally, we control for the level of processed wood imports. We find a negative effect of this variable on the probability to adopt the LEB policy. This result can be explained by the availability of imported processed woods in the country that do not incite to develop the national production of processed woods.

4.2 Second stage: the matching results

The ATT of LEB adoption on the outcomes variables are presented in Table 2. For each outcome variable, we estimate several ATT according to four types of matching, i.e. nearest neighbor (cols. 1 to 3), radius matching (cols. 4 to 6), local linear regression matching (col. 7) and kernel matching (col.8). Before presenting the estimation results of the ATT, we discuss the results of several diagnostic tests used to to assess the quality of the matching estimation. Firstly, we test whether our two groups are comparable by using the pseudo-R^2. The pseudo-R^2

Table 1: Propensity score estimation results

Log Export Ban	[1]	[2]	[3]	[4]
Log GDP per capita	-0.1731***	-0.1526***	0.2352***	0.1472***
	(0.0531)	(0.0559)	(0.0401)	(0.0434)
Manufacturing GDP	-0.0168***	-0.0222***	0.0041	-0.0147**
	(0.0061)	(0.0065)	(0.0059)	(0.0067)
Quality of government	-1.0114***	-1.4078***	-0.9078***	-1.7907***
	(0.2920)	(0.3113)	(0.3053)	(0.3375)
Log roundwood export	0.1312***	0.0966***		
	(0.0095)	(0.0105)		
Log Labor force	0.0702***	0.0530**		
	(0.0234)	(0.0249)		
Agricultural GDP	-0.0286***	-0.0245***		
	(0.0047)	(0.0051)		
FDI inflows	0.0089*	0.0435***		
	(0.0053)	(0.0089)		
Internation trade			0.0044***	0.0048***
			(0.0009)	(0.0010)
Log exchange rate			0.0421***	0.0469***
			(0.0136)	(0.0143)
Inflation			-0.0053***	-0.0051***
			(0.0016)	(0.0015)
Log sawnwood price	0.3987***		0.2867***	
	(0.0553)		(0.0559)	
Log veneer price		-0.0975**		-0.0871**
		(0.0380)		(0.0393)
Log sawnwood import			-0.0797***	
			(0.0121)	
Log veneer import				-0.0362**
				(0.0151)
Constant	-2.6537***	0.9763	-3.2320***	0.0146
	(0.7223)	(0.6936)	(0.4873)	(0.4237)
Observations	1,862	1,551	1,609	1,357
Pseudo-R2	0.15	0.10	0.07	0.07

Note: the dependent variable is LEB adoption (dummy variable). Columns 1 and 2 refer respectively to the production of sawnwood and veneer while columns 3 and 4 refer respectively to the exportation of sawnwood and veneer. *** p<0.01, ** p<0.05, * p<0.1

shows how well the vector of X covariates explains the probability of LEB adoption and thus provides balanced scores (Sianesi, 2004). For Caliendo and Kopeinig (2008), the good model performance should be associated to a fairly low value of pseudo-R^2 and near to zero. In the Table 2, the pseudo-R^2 are lower than 0.016 showing that our matching provides balanced scores and confirming the comparability hypothesis. Secondly, we continue with matching quality by testing the conditional independence assumption regarding both observables and unobservables. As related by Caliendo and Kopeinig (2008), if there are unobserved covariates which affect the assignment to treatment and the outcome variable simultaneously, a hidden bias might arise. On the observable side, we use the Rosenbaum (2002) bounds sensitivity test statistics to check for possible hidden bias due to unobserved variables that could affect the effect of LEB adoption on the outcomes variables. Table 2 reports the critical values of the Rosenbaum bounds test between 1.6 and 1.8 for sawnwood production, 1.2 and 1.6 for veneer production, 1.4 and 1.8 for sawnwood export and 1 and 1.3 for veneer export. These results are comparable to others studies (Balima et al., 2016; Caliendo and Künn, 2011; DiPrete and Gangl, 2004; Jacolin et al., 2019) and suggest that the estimation results of the ATT of LEB adoption are robust even in the presence of unobserved heterogeneity. Thirdly, regarding observables covariates, we run the standardized bias test which evaluates the marginal distance distributions of our control variables. This test reveals in most specifications that there are no statistical difference between LEB adopters and LEB non-adopters after matching except for some specifications.

Regarding the estimation results of the ATT on LEB adoption in Table 2, we find a positive and statistically significant at 1% for all matching methods on both the sawnwood and veneer production. For sawnwood production, the magnitude of the effect of LEB adoption is from about 4.12 percentage points (with the largest radius matching) to about 4.60 percentage points (with the 3-nearest neighbor). Regarding the veneer production, the ATT is ranged from about 1.18 percentage points (with the 1-nearest neighbor) to about 1.30 percentage points (with the middle radius matching). Our results show a much higher effect of LEB adoption on the sawnwood production than veneer production. This result is expected because the production of sawnwood is the first stage of the production of processed wood. Put differently, it is easier for a country banning log export and wishing to industrialize its wood industry to develop first the production of sawnwood. Regarding the exports of wood processed, we find a positive and significant (at 1%) for all specifications of sawnwood exports while we do not find any significant results for veneer exports. On average, the LEB adopters countries experience higher sawnwood export from about 9.30 percentage points (with the smallest radius matching) to 10.27 percentage points (for 1-nearest neighbor). We do rely these results to the previous explanation regarding the preference to sawnwood rather than veneer. Indeed, the timber industry in most developing countries is always in the early stages and has to invest in the first level of processing like sawnwood. As a consequence, the production level of more processed woods like veneer cannot compensate the need for domestic consumption. Therefore, the LEB policy increase the production of veneer (but lower than the production of sawnwood as found)

but this production is first of all oriented to the domestic market instead of to the international market.

Table 2: The impact of the LEB policy on outcomes variables: the matching results

Treatment var: LEB	**1-Nearest Neighbor**	**2-Nearest Neighbor**	**3-Nearest Neighbor**	**Raduis Matching**			**Local Linear Regression**	**Kernel**
	Matching	**Matching**	**Matching**	**r=0.005**	**r=0.01**	**r=0.05**	**Matching**	**Matching**
Dependent variable: Sawnwood production								
ATT	4.3521***	4.1682***	4.5844***	4.1369***	4.1688***	4.1182***	4.3988***	4.1585***
	(1.1492)	(0.9906)	(0.9883)	(0.7883)	(0.7501)	(0.7059)	(0.7204)	(0.7568)
Obs/Treated obs	1862/626	1862/626	1862/626	1862/626	1862/626	1862/626	1862/626	1862/626
Pseudo-R2	0.010	0.016	0;013	0.008	0.007	0.006	0.010	0.006
Standard. bias (p-value)	0.031	0.000	0.005	0.076	0.166	0.245	0.031	0.240
Rosenbaum bounds test	1.6	1.6	1.7	1.6	1.7	1.7	1.8	1.7
Dependent variable: Veneer production								
ATT	1.1818***	1.2183***	1.2272***	1.2833***	1.2925***	1.2576***	1.2617***	1.2629***
	(0.1852)	(0.1910)	(0.1769)	(0.1883)	(0.1746)	(0.1763)	(0.1681)	(0.1604)
Obs/Treated obs	1551/596	1551/596	1551/596	1551/596	1551/596	1551/596	1551/596	1551/596
Pseudo-R2	0.008	0.006	0.005	0.006	0.005	0.004	0.008	0.004
Standard. bias (p-value)	0.129	0.309	0.344	0.331	0.355	0.546	0.129	0.556
Rosenbaum bounds test	1.6	1.4	1.3	1.2	1.2	1.2	1.2	1.2
Dependent variable: Sawnwood export								
ATT	10.2684***	10.0019***	9.7537***	9.2975***	9.5246***	9.6826***	9.3478***	9.7043***
	(2.5650)	(2.3331)	(2.0059)	(1.8624)	(1.7162)	(1.6110)	(1.6502)	(1.5958)
Obs/Treated obs	1594/598	1594/598	1594/598	1594/598	1594/598	1594/598	1594/598	1594/598
Pseudo-R2	0.011	0.006	0.005	0.005	0.006	0.004	0.011	0.005
Standard. bias (p-value)	0.021	0.289	0.456	0.364	0.253	0.496	0.021	0.473
Rosenbaum bounds test	1.8	1.6	1.6	1.4	1.5	1.5	1.4	1.5
Dependent variable: Veneer export								
ATT	0.1936	-0.4252	0.0161	0.0998	0.6873	2.0403	1.7440	1.9262
	(2.7957)	(2.5151)	(2.4272)	(2.1811)	(2.1496)	(1.8229)	(1.8204)	(1.9447)
Obs/Treated obs	1239/545	1239/545	1239/545	1239/545	1239/545	1239/545	1239/545	1239/545
Pseudo-R2	0.007	0.010	0.009	0.009	0.008	0.007	0.007	0.007
Standard. bias (p-value)	0.245	0.054	0.073	0.112	0.124	0.241	0.245	0.236
Rosenbaum bounds test	1.3	1	1	1	1	1	1	1

Note: standard errors in brackets. *** significance level at 1%, ** significance level at 5%, and * significance level at 10%. Bootstrap replications=500.

5 Robustness checks

5.1 Exploring heterogeneity in treatment effects

Regarding the significant heterogeneity in economic conditions and institutional structure in developing countries (Acemoglu et al., 2019; Easterly, 2002; Lin and Ye, 2009) and as suggested by Lin and Ye (2009), we explore potential differential effects of the LEB policy.

Following Lin and Ye (2009) and Combes et al. (2019), we use the control function regression approach to test potential sources of heterogeneity[5]. We first start by examining if countries which meet the preconditions of LEB adoption record better performance in processed wood production and export. We then analyze if the time length since the adoption of the LEB policy and the quality of institutions can play on the effect of LEB adoption on processed wood production and export.

Estimation results based on control function approach are reported in Tables 3 and 4 for sawnwood and veneer production respectively, and in Tables 5 and 6 for sawnwood and veneer exports respectively . In each column, we run the OLS regression of processed wood production or export on the LEB adoption dummy variable within the common support. The estimated coefficients of the LEB dummy show the mean difference between LEB adopters and LEB non-adopters countries.

The first column in Tables 3, 4, 5 and 6 reports the coefficient of the LEB dummy without any control variables. We find a positive and significant effect of LEB in the four tables showing that the LEB adopters produce and export more processed wood than non LEB adopters. In column 2, we add the propensity scores from our baseline probit model (Table 1) to respect the common support as a control function. We find a significant coefficient of the propensity score showing self-selectivity in the models related to sawnwood production, sawnwood export and veneer export unlike the model related to veneer production. After controlling for the propensity score, the estimated coefficient of LEB in the models of sawnwood production and export remains positive and significant, and becomes closer to the estimated ATT producing from various matching results in Table 2. For sawnwood production, the LEB coefficient goes from about 1.47 to 3.39 in Table 3. For sawnwood export in Table 5, the LEB coefficient moves from about 10.67 to 9.01. Regarding veneer, the estimated effect of LEB on veneer production remains significant and is around 1.25, also comparable to the ATTs estimation presented in Table 2. However, the LEB coefficient becomes non significant for veneer export in Table 6 and is also comparable to the ATTs estimation presented in Table 2.

We now turn to the heterogeneity analysis of the treatment effect and begin with processed wood production. In column 3, we add the interaction between the LEB dummy and the difference between the estimated propensity score and its sample average. With the addition of this interaction variable, the coefficient of the LEB dummy measures the ATT at mean

[5]See Wooldridge (2015) for more details on control function.

propensity score. The LEB dummy is still found to have a positive and statistically significant effect. Regarding the coefficient of the interaction term, we find a negative and significant effect in the sawnwood production model in Table 3. This result suggests the presence of heterogeneity. More precisely, this results means that the LEB policy is less effective in countries that meet the preconditions of LEB adoption (i.e. higher estimated propensity score). However, we find a negative and non statistically significant effect of the interaction term in the veneer production model in Table 4. This result shows no evidence of additional effect on veneer production concerning the LEB adoption preconditions meeting. In column 4, we add an interaction between the LEB dummy and the time since the LEB policy has been adopted. We do not find evidence of this variable. Furthermore, we explore the heterogeneity of the treatment effect with the quality of institutions. In column 5, we add the corruption level and its interaction term with the LEB dummy. While the positive effect of the additive coefficient suggests that corruption reduces sawnwood production in Table 3, we do find a positive effect of the interaction term. Therefore, an increase of corruption influences positively the sawnwood production in LEB adopter countries. This result can be related to the fact that the LEB policy tends to encourage the development of upstream logging activities where informal and illegal activities are more common. As a consequence corruption can push forward these illegal and informal logging activities to meet the increase of the demand of downstream wood activities. However, we do not find significant results regarding corruption in the veneer production model of Table 4. In columns 6 and 7, we add respectively the quality of law and order, and the quality of bureaucracy. We find that these two institutional variables have a negative effect on both sawnwood and veneer production in LEB adopter countries. These results are related to the fact that a better quality of law and order as well as bureaucracy allows to fight against illegal miller and logger what can reduce downstream wood production. Also, the LEB policy is often followed by the creation of special economic zone with restrictive conditions applied to logging activities. These conditions exclude a lot of millers and loggers what then lead to a decrease of logging production and finally to a fall of processed wood production.

In the same vein, we do the same heterogeneity analysis of the treatment effect on processed wood exports. Table 5 and Table 6 report the results for sawnwood and veneer export respectively. In column 3, the interaction term is not significant in both tables showing no evidence for the precondition meeting of LEB adoption on processed wood export. However, the effect of the LEB dummy still remains positive and significant regarding the sawnwood export and non significant for the veneer export. In column 4, we add the interaction term between the LEB dummy and the time since the introduction of the LEB policy. Unlike the previous results related to production, we now find a negative and significant effect of this interaction term while the additive effect the LEB dummy is positive and significant both for sawnwood and veneer exports. Thus, at the beginning of the introduction of the LEB, the policy contributes to increase processed wood exports while its contribution turns to be negative with time. We assume that these results can be related to a lack of infrastructure used by exporters. Just

Table 3: Heterogeneity analysis of the effect of LEB adoption on Sawnwood production

Sawnwood production	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	1.4685**	3.6911***	4.3347***	3.3983***	-2.2353	8.0918***	7.8057***
	(0.6654)	(0.8282)	(0.8655)	(1.2212)	(2.4009)	(2.4519)	(1.7792)
PS		-9.1845***	-5.7037**	-9.3057***	-9.4777***	-9.4781***	-8.5873***
		(1.9973)	(2.4256)	(2.0320)	(2.0536)	(2.0626)	(2.0177)
LEB*(PS-$\overline{PS}$)			-10.7468**				
			(4.2620)				
LEB*Time				0.0269			
				(0.0825)			
Corruption					-0.9769*		
					(0.5151)		
LEB*Corruption					2.6544***		
					(0.9998)		
Law_order						0.0218	
						(0.4109)	
LEB*Law_order						-1.5183*	
						(0.8001)	
Bureau_quality							2.6948***
							(0.5003)
LEB*Bureau_quality							-2.4671***
							(0.9491)
Constant	19.8526***	22.1006***	21.1375***	22.1342***	24.4404***	22.0989***	17.3456***
	(0.3387)	(0.7031)	(0.7993)	(0.7108)	(1.4662)	(1.5529)	(1.1299)
Observations	3,041	1,862	1,862	1,862	1,856	1,856	1,856
R2	0.002	0.015	0.019	0.015	0.019	0.018	0.031

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Heterogeneity analysis of the effect of LEB adoption on Veneer production

Veneer production	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	1.2054***	1.2495***	1.2495***	1.1054***	0.6381	1.9109***	2.2141***
	(0.1229)	(0.1444)	(0.1478)	(0.2156)	(0.4271)	(0.4440)	(0.3302)
PS		-0.5272	-0.5275	-0.5705	-0.5892	-0.6763	-0.2243
		(0.4050)	(0.4947)	(0.4079)	(0.4393)	(0.4302)	(0.4303)
LEB*(PS-$\overline{PS}$)			0.0009				
			(0.8620)				
LEB*Time				0.0127			
				(0.0141)			
Corruption					-0.1300		
					(0.1021)		
LEB*Corruption					0.2673		
					(0.1766)		
Law_order						-0.0915	
						(0.0821)	
LEB*Law_order						-0.2382*	
						(0.1442)	
Bureau_quality							0.3757***
							(0.1014)
LEB*Bureau_quality							-0.5775***
							(0.1744)
Constant	1.1389***	1.2218***	1.2219***	1.2362***	1.5555***	1.5670***	0.4515*
	(0.0626)	(0.1584)	(0.1844)	(0.1593)	(0.3297)	(0.3438)	(0.2696)
Observations	3,041	1,551	1,551	1,551	1,545	1,545	1,545
R2	0.031	0.048	0.048	0.049	0.049	0.053	0.058

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

after the introduction of the LEB policy, processed wood exports increase thanks to seaport infrastructures available in the country. However, after a while, seaports become congested following the increase of processed wood exports. As a consequence, because of a lack of new infrastructure to meet the demand of exporters, these latter have to reduce their activities. Finally, we check the heterogeneity in treatment effect on sawnwood and veneer export following the same institutional variables as defined above. We find no evidence of an effect of corruption. However, we find a positive effect of the interaction term between the LEB dummy and both the quality of law and order, and the quality of the bureaucracy in both the sawnwood and veneer export models. In many developing countries where the LEB policy has been implemented, tax is collected at seaport level defined as the timber trade check point. Thus, a higher level of law and order as well as a better bureaucracy quality can drop the time to comply with export procedures and checking and so, in turn, facilitate the transit in the seaport. Also, many European countries for instance require the legal source and impose norms for their wooden imported goods. So, better quality of law and bureaucracy can help exporters of processed woods to sell their products to these countries. At the same time, the additive effect of the LEB dummy is significantly negative on veneer exports when interaction with the quality of law and order (col. 6) or with bureaucracy quality (col.7) is controlled for. Moreover, the magnitude is particularly important. The LEB policy reduces veneer exports by 22.57 percent in column 6 and 13.13 percent in column 7. As a consequence, the LEB policy should not be introduced in countries with weak law and order or with deteriorated bureaucracy quality at the expense of reducing the exports of veneer. Regarding sawnwood, the additive effect of the LEB dummy is not significant both in columns 6 and 7.

Table 5: Heterogeneity analysis of the effect of LEB adoption on Sawnwood export

Sawnwood export	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	10.6771***	9.0095***	9.1154***	19.5546***	9.9315**	-6.2902	5.2864
	(1.2471)	(1.4880)	(1.5158)	(2.2564)	(4.5642)	(4.5977)	(3.3097)
PS		25.3941***	26.6580***	28.7186***	24.4949***	27.4845***	23.0212***
		(4.9716)	(6.0393)	(4.9443)	(5.0907)	(5.0703)	(5.0961)
LEB*(PS-$\overline{PS}$)			-3.9253				
			(10.6433)				
LEB*Time				-0.9327***			
				(0.1513)			
Corruption					-0.6192		
					(1.0982)		
LEB*Corruption					-0.2694		
					(1.9137)		
Law_order						-0.6530	
						(0.8088)	
LEB*Law_order						5.3348***	
						(1.4808)	
Bureau_quality							-2.6081**
							(1.0235)
LEB*Bureau_quality							2.4627
							(1.7790)
Constant	19.4568***	9.3712***	8.9419***	8.2420***	10.8216***	10.4158***	14.3488***
	(0.6410)	(1.8996)	(2.2282)	(1.8868)	(3.4424)	(3.4058)	(2.8100)
Observations	2,983	1,594	1,594	1,594	1,588	1,588	1,588
R2	0.024	0.053	0.053	0.075	0.056	0.064	0.059

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Heterogeneity analysis of the effect of LEB adoption on Veneer export

Veneer export	[1]	[2]	[3]	[4]	[5]	[6]	[7]
LEB	4.8246***	2.5981	2.5805	6.9775***	-3.1870	-22.5682***	-13.1340***
	(1.2693)	(1.6509)	(1.6712)	(2.4341)	(5.0161)	(5.1173)	(3.8645)
PS		29.9941***	29.7352***	31.7827***	31.4209***	33.6881***	22.1902***
		(5.3561)	(6.5474)	(5.3952)	(6.0505)	(5.5796)	(5.8693)
LEB*(PS-$\overline{PS}$)			0.7842				
			(11.3932)				
LEB*Time				-0.3842**			
				(0.1572)			
Corruption					-0.0786		
					(1.3588)		
LEB*Corruption					2.5594		
					(2.0547)		
Law_order						-0.6183	
						(1.0007)	
LEB*Law_order						8.7022***	
						(1.6241)	
Bureau_quality							-6.9265***
							(1.2827)
LEB*Bureau_quality							9.2875***
							(1.9966)
Constant	19.2716***	8.9144***	9.0166***	8.2084***	8.3862*	9.3340**	24.5020***
	(0.7338)	(2.3553)	(2.7852)	(2.3683)	(4.8047)	(4.5316)	(3.9266)
Observations	2,199	1,239	1,239	1,239	1,233	1,233	1,233
R2	0.007	0.034	0.034	0.039	0.035	0.063	0.059

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

5.2 Endogeneity issue

The estimation of the impact of the LEB policy on processed wood production or exports can be challenged by endogeneity due to reserve causality and simultaneous bias. To get a high level of processed wood, some governments could adopt strategies to improve timber industry. One strategy is the export substitution by protecting the infant industry. This strategy consists in replacing gradually the export of primary goods by processed value added goods. Thus, the purpose to increase the processed wood production and export can incite to adopt the LEB policy.

We then use a panel two-step system GMM estimation (Blundell and Bond, 1998) with Windmeijer (2005) small sample correction in order to take account the potential endogeneity caused by simultaneous bias. To deal with the proliferation of instruments problem, we restrict and collapse the instruments (Roodman, 2009). Table 7 provides the GMM estimation results. The p-values at 5% of AR(1) and AR(2) and the Hansen tests support the validity of our results. In each specification, the lagged dependent variable is positive, significant at 1% and lower than 1 showing there are no fallacious regression. In columns 1, 2 and 3, the LEB dummy is still positive and significant showing the positive effect of the LEB policy on the sawnwood production, veneer production and sawnwood export. However, the column 4 regarding the veneer export shows that the LEB dummy is non significant. All results can thus be comparable to the ATTs.

Table 7: Panel two-step system GMM estimation results

	[1] Sawnwood production	[2] Veneer production	[3] Sawnwood export	[4] Veneer export
Sawnwood production $_{(-1)}$	0.8715***			
	(0.0317)			
Veneer production $_{(-1)}$		0.9576***		
		(0.0047)		
Sawnwood export $_{(-1)}$			0.3222***	
			(0.0294)	
Veneer export $_{(-1)}$				0.5919***
				(0.0345)
LEB	2.1033***	0.1549***	9.7803**	-1.9342
	(0.6558)	(0.0420)	(4.1037)	(2.0690)
Manufacturing, value added (% of GDP)	0.0346	0.0053***	-0.0049	0.1487
	(0.0272)	(0.0014)	(0.1605)	(0.1223)
Log GDP per capita (constant 2010 US$)	0.8414***	0.0610***	1.2370	0.7722
	(0.2690)	(0.0152)	(1.5099)	(1.0017)
Quality Of Government	3.3019	-0.5354***	62.8669***	40.9645***
	(4.3288)	(0.1564)	(19.7759)	(14.6184)
Log Roundwood export	-0.1416***	-0.0084***		
	(0.0485)	(0.0024)		
Agriculture, value added (% of GDP)	0.0489**	0.0048***		
	(0.0211)	(0.0015)		
FDI inflows (% of GDP)	0.0202**	-0.0005		
	(0.0088)	(0.0012)		
Log Laborforce	-0.0915	-0.0048		
	(0.1281)	(0.0102)		
Total trade (% of GDP)			0.0871***	0.0195
			(0.0268)	(0.0240)
Log Exchange rate			0.0550	-0.1256
			(0.4543)	(0.3276)
Inflation			-0.0046	0.0008
			(0.0037)	(0.0016)
Log Sawnwood price	-0.2308*		-6.1795***	
	(0.1336)		(1.1556)	
Log Veneer price		-0.0055		-5.4111***
		(0.0068)		(0.8773)
Log Sawnwood import			-1.4328***	
			(0.3081)	
Log Veneer import				-0.9275***
				(0.3585)
Constant	-3.6819	-0.1847	15.0452	24.0555**
	(3.2325)	(0.1922)	(14.3235)	(10.1669)
Observations	1821	1524	1561	1200
Groups	72	70	69	59
Instruments	40	40	40	40
AR1-pvalue	0.00	0.00	0.00	0.00
AR2-pvalue	0.62	0.65	0.09	0.18
Hansen-pvalue	0.61	0.45	0.26	0.53

Note: robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

6 Conclusion

The implementation of a international trade restriction policy such as the log export ban (LEB) gives rise the issue of its efficiency, that is to say, if its primary goals are fulfilled. These goals in the case of the LEB policy is to promote wood processing industry. This study aims at estimating the impact of the LEB policy on both production and exportation of processed wood. We focus on sawnwood and veneer which are respectively the first and second stages of wood processing.

We use the propensity score matching to assess the average treatment effect on the treated (ATT) of the LEB policy. We find a positive and significant effect of the LEB policy on both sawnwood and veneer production while the effect is stronger in the case of sawnwood (about 4 percents) compared to veneer (about 1 percent). Moreover, we also find a positive and significant effect on the exports of sawnwood (around 10 percents) while we do not find any significant results on the exports of veneer. In addition, we investigate the heterogeneity in treatment effects of the LEB policy using control function. We focus on several potential differential effects according to the LEB adoption preconditions meeting, the time length since the LEB adoption and (3) the quality of institutions (corruption, law and order and bureaucracy quality). The results found are comparable to the ATTs results while we find differential effects of the LEB policy mainly according to institutional quality. These latter results confirm the great importance of institutions in terms of policy efficiency. Also, to avoid the possible endogeneity issue, we apply the two-step GMM estimation model and the results confirm the ATTs.

Taking together, these results suggest than the LEB policy has mainly contributed to improve the first stage of wood processing rather than the second stage. As a consequence, the development of the second stage like veneer asks for more than the interdiction of non-processed wood. Veneer needs more skilled labor and more technically advanced machines which call for complex industrial and employment policies.

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A Appendix

Table A1: Variables definition

Variables	Definition	Source
Log Export Ban	Log export ban is the dummy variable taking 1 if country apply ban on log export and 0 if not	FPER*
Roundwood export	Volume of roundwood exported (m3)	ITTO**
Sawnwood production	Volume of sawnwood production (m3)	ITTO
Veneer production	Volume of veneer production (m3)	ITTO
Sawnwood export	Volume of sawnwood exported (m3)	ITTO
Veneer export	Volume of veneer exported (m3)	ITTO
Sawnwood price	The average price of Sawnwood export by m3 in FOB (USD)	ITTO
Vener price	The average price of Veneer export by m3 in FOB (USD)	ITTO
Sawnwood import	Volume of Sawnwood imported (m3)	ITTO
Veneer import	Volume of Veneer imported (m3)	ITTO
Agricultural value added	It includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production (% of GDP).	WDI***
Labor force	The labor force is the supply of labor available for producing goods and services in an economy. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers.	WDI
GDP per capita	Per capita gross domestic product in constant 2010 US$)	WDI
Manufacturing value added	Manufacturing refers to industries belonging to ISIC divisions 15-37 (% of GDP).	WDI
FDI inflows	Foreign direct investment are the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor (% of GDP).	WDI
Exchange rate	Official exchange rate (LCU per US$, period average)	WDI
Inflation	Inflation reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals (%).	WDI
Corruption	This is an assessment of corruption within the political system. Such corruption is a threat to foreign investment for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability; and, last but not least, introduces an inherent instability into the political process. Higher values indicate higher corruption.	ICRG****
Law and order	This variable forms a single component, but its two elements are assessed separately, with each element being scored from zero to three points. To assess the "Law" element, the strength and impartiality of the legal system are considered, while the "Order" element is an assessment of popular observance of the law. Thus, a country can enjoy a high rating – 3 – in terms of its judicial system, but a low rating – 1 – if it suffers from a very high crime rate if the law iroutinely ignored without effective sanction (for example, widespread illegal strikes). Higher values indicate higher law and order.	ICRG
Bureaucratic quality	The institutional strength and quality of the bureaucracy is another shock absorber that tends to minimize revisions of policy when governments change. Therefore, high points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. In these low-risk countries, the bureaucracy tends to be somewhat autonomous from political pressure and to have an established mechanism for recruitment and training. Countries that lack the cushioning effect of a strong bureaucracy receive low points because a change in government tends to be traumatic in terms of policy formulation and day-to-day administrative functions. Higher values indicate higher bureaucracy quality.	ICRG
Quality of government	The mean value of the ICRG variables "Corruption", "Law and Order" and "Bureaucracy Quality", scaled 0-1. Higher values indicate higher quality of government.	Quality Of Government Institute

*Forest Product Export Restriction; **International Tropical Timber Organization; ***World Development Indicators; ****International Country Risk Guide.

Table A2: Countries list, adoption and end years.

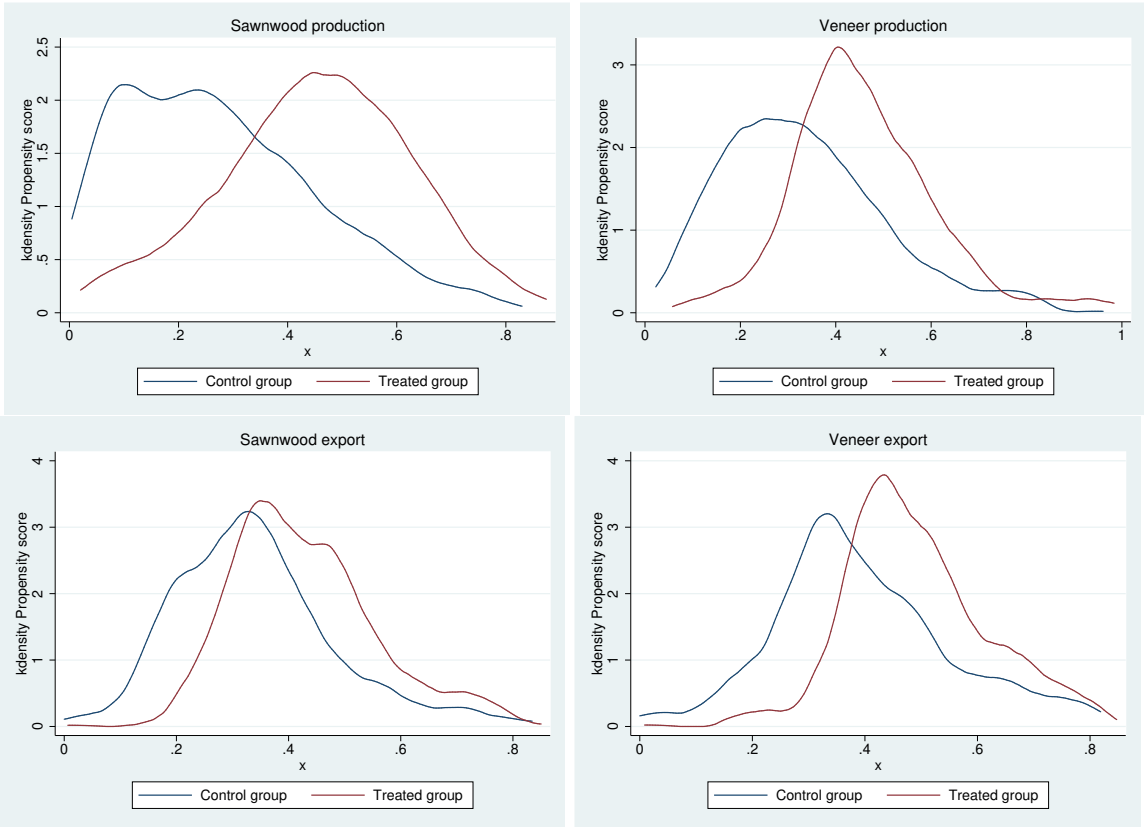
N°	Country	Income group	Adoption year	End year	N°	Country	Income group	Adoption year	End year
1	Afghanistan	Low Income			52	Liberia	Low Income		
2	Algeria	Upper-Middle Income			53	Libya	Upper-Middle Income		
3	Angola	Lower-Middle Income	2013		54	Madagascar	Low Income	2010	
4	Argentina	Upper-Middle Income			55	Malawi	Low Income	2008	
5	Armenia	Upper-Middle Income			56	Malaysia	Upper-Middle Income	1985	
6	Bangladesh	Lower-Middle Income			57	Mali	Low Income	2000	
7	Belarus	Upper-Middle Income	2016	2017	58	Mauritania	Lower-Middle Income		
8	Belize	Upper-Middle Income	2012		59	Mexico	Upper-Middle Income		
9	Benin	Low Income	2005		60	Moldova	Lower-Middle Income		
10	Bhutan	Lower-Middle Income			61	Mongolia	Lower-Middle Income		
11	Bolivia	Lower-Middle Income	1996		62	Montenegro	Upper-Middle Income		
12	Brazil	Upper-Middle Income	2005		63	Morocco	Lower-Middle Income		
13	Bulgaria	Upper-Middle Income			64	Mozambique	Low Income	2002	
14	Burkina Faso	Low Income			65	Myanmar	Lower-Middle Income	2014	
15	Burundi	Low Income			66	Nepal	Low Income		
16	Cambodia	Lower-Middle Income	1997		67	Nicaragua	Lower-Middle Income	2006	
17	Cameroon	Lower-Middle Income	1999		68	Niger	Low Income		
18	Central African Republic	Low Income			69	Nigeria	Lower-Middle Income	1985	
19	Chad	Low Income			70	Pakistan	Lower-Middle Income		
20	Colombia	Upper-Middle Income	1967		71	Papua New Guinea	Lower-Middle Income	1990	
21	Congo	Lower-Middle Income	2000		72	Paraguay	Upper-Middle Income	1972	
22	Congo Democratic	Low Income			73	Peru	Upper-Middle Income	1972	
23	Costa Rica	Upper-Middle Income	1996		74	Philippines	Lower-Middle Income		
24	Cote d'Ivoire	Lower-Middle Income	1995		75	Romania	Upper-Middle Income		
25	Cuba	Upper-Middle Income			76	Russian Federation	Upper-Middle Income		
26	Dominican Republic	Upper-Middle Income			77	Rwanda	Low Income		
27	Ecuador	Upper-Middle Income	2004		78	Samoa	Lower-Middle Income		
28	El Salvador	Lower-Middle Income			79	Senegal	Lower-Middle Income	1998	
29	Equatorial Guinea	Upper-Middle Income	2007	2009	80	Serbia	Upper-Middle Income		
30	Eritrea	Low Income			81	Sierra Leone	Low Income		
31	Ethiopia	Low Income			82	Solomon Islands	Lower-Middle Income	2012	
32	Fiji	Upper-Middle Income	1997		83	Somalia	Low Income		
33	Gabon	Upper-Middle Income	2011		84	South Africa	Upper-Middle Income		
34	Gambia	Low Income	2012		85	Sri Lanka	Upper-Middle Income		
35	Georgia	Upper-Middle Income			86	Suriname	Upper-Middle Income		
36	Ghana	Lower-Middle Income	1994		87	Syrian Arab Republic	Low Income		
37	Guatemala	Upper-Middle Income	1996		88	Tanzania	Low Income	2004	
38	Guinea	Low Income	2006		89	Thailand	Upper-Middle Income		
39	Guinea-Bissau	Low Income			90	Timor-Leste	Lower-Middle Income		
40	Guyana	Upper-Middle Income			91	Togo	Low Income	2012	
41	Haiti	Low Income			92	Tunisia	Lower-Middle Income		
42	Honduras	Lower-Middle Income	2007		93	Turkey	Upper-Middle Income		
43	India	Lower-Middle Income	2013		94	Uganda	Low Income		
44	Indonesia	Lower-Middle Income	2001		95	Ukraine	Lower-Middle Income	2005	
45	Iran	Upper-Middle Income			96	Uzbekistan	Lower-Middle Income		
46	Iraq	Upper-Middle Income			97	Vanuatu	Lower-Middle Income		
47	Jamaica	Upper-Middle Income			98	Venezuela	Upper-Middle Income	2001	
48	Kazakhstan	Upper-Middle Income			99	Viet Nam	Lower-Middle Income	1992	
49	Kenya	Lower-Middle Income			100	Zambia	Lower-Middle Income	1998	
50	Kyrgyzstan	Lower-Middle Income			101	Zimbabwe	Lower-Middle Income		
51	Lao	Lower-Middle Income	2016						

Table A3: Descriptives statistics

Variables	Observations	Mean	St.Dev	Min	Max
Sawnwood production (% - relative to roundwood production)	3,041	20.23	16.09	0	140
Veneer production (% - relative to roundwood production)	3,041	1.45	3.02	0	31.27
Sawnwood export (% - relative to sawnwood production)	2,983	22.28	30.39	0	395.5
Veneer export (% - relative to veneer production)	2,199	20.88	28.16	0	187.6
LEB dummy	3,073	0.26	0.44	0	1
Manufacturing, value added (% of GDP)	2,565	13.15	6.590	0	50.04
GDP per capita (constant 2010 US$)	2,851	3,057	3,094	178.8	20,533
Roundwood export (quantity m^3)	3.072	471,647	2,901,694	0	5.11e+07
Agriculture, value added (% of GDP)	2,727	19.47	12.73	0.893	79.04
FDI inflows (% of GDP)	2,799	3.44	6.86	-37.15	161.8
Labor force (number of people)	3,073	1.571e+07	4.538e+07	43,480	4.947e+08
Total trade (% of GDP)	2,718	71.37	35.44	0.0210	311.4
Exchange rate (LCU per $)	2,859	2.352e+06	1.257e+08	2.39e-09	6.723e+09
Inflation (%)	2,533	43.16	539.9	-18.11	23,773
Sawnwood price	2.78	470.09	493.45	16.42	13486.51
Veneer price	2.17	1492.01	2168.11	49.69	50960.73
Sawnwood import (quantity m^3)	3,073	131,796	351,521	0	3.083e+06
Veneer import (quantity m^3)	3,073	4,994	22,128	0	432,140
Quality of governance (0-1)	2,337	0.423	0.127	0.0417	0.806
Corruption (0-6)	2,256	2.278	0.867	0	5
Law and order (0-6)	2,256	2.971	1.074	0	6
Bureaucracy quality (0-6)	2,256	1.579	0.847	0	4

Note: authors' calculations.

Figure A1: Common support propensity



Source: authors