The forest taxation and log export ban effect on deforestation: Evidence from Cameroon*

Thierno Bocar Diop[1], Lionel Vedrine[2]

[1]*CESAER, AgroSup Dijon, INRAE, Université Bourgogne Franche-Comté, F-21000 Dijon, France, thierno.diop@inrae.fr*

[2]*CESAER, AgroSup Dijon, INRAE, Université Bourgogne Franche-Comté, F-21000 Dijon, France, lionel.vedrine@inrae.fr*

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Abstract

The conservation of forests is undeniably important in the fight against climate change. With the second-largest tropical forest after the Amazon, the countries of Central Africa have an important role to play in the global warming fight. They have undertaken reforms of forestry codes with a better defined forest taxation. In this study, we want to measure the effect of a mix of forest taxation and partial log export ban on deforestation in Cameroon. Using geographic regression discontinuity with national borders between Cameroon and Gabon as a source of discontinuity, our results show that the combination between these measures increased deforestation from 2003 to 2009 in Cameroon. The results are robust to different specifications (parametric and nonparametric).

Key words: Forest taxation, Deforestation, Export ban, Geographic Regression discontinuity, Cameroon, Gabon.

JEL Codes: C14, C21, O13, Q23, Q27, Q28, Q58

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1 Introduction

Climate Change is one of the biggest threats for future generations. Its effects will affect the entire world particularly people from developing countries who are more vulnerable. Progress in terms of reduction of greenhouse gases should be made in order to prevent from the change. The Paris Agreement in 2015 has defined ambitious objectives of greenhouse gases reduction to limit global warming to 2 °C. Thenceforth, each country decided to play his share is this fight.

Countries of Central Africa highlighted the role of forest in these objectives (De Wasseige et al., 2015). Indeed, forests allow carbon sequestration and help reduce greenhouse gas emissions. Therefore, conservation of forests is essential in the fight against climate change.

Questions relative to the conservation of forests are of paramount importance in Central Africa. These countries have the second-largest tropical forest after the Amazon (De Wasseige et al., 2009; Tchatchou et al., 2015). It has a surface of 200 millions of hectares and more than 60 million people depend on it (De Wasseige et al., 2012; Watch, 2005). Conservation of these forests would then help fight efficiently against climate change but would also help maintain the revenue of a large part of the population.

In that vein, many governments in Central Africa have decided to revise their forestry laws. In fact, a better design of forestry laws and jurisdictions could help preserve the forest resources. It might prevent countries from the conversion of forest to agricultural land but also to develop a timber processing industry (Cameroon, 1994; Gabon, 2001). Among the measures taken, we have partial and complete log export ban, taxes and royalties and the establishment of protected areas.

In this context, the objective of this study is to evaluate the effect of a mix of fiscal and economic measures. Indeed, we want to know if a partial log export ban combined with forest taxation.[1] can have an impact on deforestation.

Cameroon has started fiscal reforms at the initiative of the World Bank. In 1999, the country decided to put a partial log export ban and export surtax on unprocessed wood (Décret N° 99/781/PM, 1999, Article 2). The factory admission tax has also been applied in replacement of the tax on processed products by the Finance Law 2000-2001 (Karsenty, 2009).

The forest taxation can help achieve simultaneously many goals: more fiscal resources for the country and more sound environmental and forestry practices (Grut et al., 1991; Gray, 2002). But little do we know about the effect of forest taxation on deforestation. Indeed, there are few empirical studies on this relationship. Hansen and Lund (2018) made a literature review on the topic. They distinguished two strands. The first, with neoclassical ideology, try to formalise how

[1]The forest taxation encompasses all taxes and royalties in the forestry code. However, in this study, the term forest taxation is used for only the export surtax and the factory admission tax in Cameroon. This is done in order to simplify explanation.

forest taxation can generate revenues for governments while being incentive about the management of forest resources (Vincent, 1990; Gray, 2002). The second, based on political economy and political sciences, evaluate the results of forest taxation and forest sustainable management policies (Spratt et al., 2018).

As far as this second strand is concerned, Gillis (1992) showed that lower level of forest taxation create rent-seeking attitudes and increase the conversion of forest to agricultural land. This result is in line with those of Vincent (1990); Gray (2002); World-Bank (2003). Some others suggest that "export taxes don't have any incentive effect on the improvement of forest management - unless we consider the local wood processing is *ipso facto* a guarantee of good management" (Karsenty, 2002, p. 28). Therefore, problems can arise with forest taxation. This question is studied empirically by Tumaneng-Diete et al. (2005). They evaluate the effects of forestry policies, including export tax, on deforestation in the Philippines. Their results suggested that forestry policies help reduce deforestation by reducing the production of timber. The authors said that "if curtailing deforestation is the only goal of forest policies, then the existing set of policies helped achieve this goal by reducing log production" (Tumaneng-Diete et al., 2005, p. 194). As far as the log export ban is concerned, its effect has been studied theoretically and empirically. Deacon (1995) showed theoretically that export restrictions helped fight against deforestation by reducing the demand. Gillis (1988) points out the lack of efficiency of local processing industry that accompanied an export ban. This inefficiency generates an excessive logging and increased deforestation. Therefore, there are controversies about the effects of forest taxation on forest conversion.

Our study aims at bringing some evidence on this debate. This is the first attempt, to the best of our knowledge, trying to evaluate empirically the effect of forest taxation on deforestation in Cameroon. Moreover, we will use a quasi-experiment methodology to evaluate the effects. Indeed, we will use the regression discontinuity for our identification strategy. This methodology is considered as the most credible impact evaluation method (Lee and Lemieux, 2010). We will compare Cameroon and Gabon by using national borders as a source of discontinuity. The analysis will be focused on pixels that are very close to border as they are likely to be similar in agro-ecological (precipitation, slope, etc.) and socio-economic (access to market, infrastructure) aspects. By using this methodology, we will be able to identify the causal effect of the mix of forest taxation and partial log export ban on deforestation in Cameroon. "Whether this combination of policies causes deforestation is an empirical question, and to date the necessary empirical tests have not been conducted" (Deacon, 1995, p. 16). We will try to bridge this gap and enlighten the ongoing debate.

The article is organised as follows: section 2 will make a literature review while giving an overview of forestry law in Cameroon and Gabon; then data and methodology will be presented in section 3; section 4 will explain the results found; we will check the robustness of our results in section 5 and section 6 will conclude.

2 Background and literature review

2.1 Overview of forestry laws and jurisdictions in Cameroon and Gabon

The forestry code of 1994 is the one in force in Cameroon (Cameroon, 1994). It is the results of government willing to overhaul the forestry sector and better manage forest resources. Under the impulse of the World Bank, Cameroon established a new forestry code in 1994 with the following objectives: an increase of the participation of the sector in the economy, a higher industrialisation with more wood processing and a better management of forest resources. In this new code, the government gave an ultimatum of five years to logging operators in order to prepare and to adapt themselves to complete local wood processing (Cameroon, 1994, Article 70(1)). During the 1994-1999, 70% of the timber production should be processed. The new forestry code also includes some news taxes compared to the last one (Cameroon, 1982) (e.g. the annual forest royalty, the felling tax, the exit duty on logs, etc.).

In 1999, many decrees have been issued (Décret N° 99/781/PM, 1999; Décret N° 99/370/PM, 1999). The Décret N° 99/781/PM (1999) in its Article 2 established a partial log export ban for some species, an exit duty on logs and export surtax on undressed wood for other species. These measures aim at protecting the log processing industry but also the species that are forbidden on export. Indeed some wood species as Acajou Bassam or Iroko are considered to be vulnerable (World-Bank, 2016; Robin des Bois, 1998). Some others as the Bubingua have a cultural value and its logging is considered as a traditional and cultural loss (Robin des Bois, 1998). Therefore, by increasing the opportunity cost of logging, these measures can reduce the incentive to deforest.

For Gabon, the latest reform of the forestry code was in 2001. In its Article 3, the Finance Law Gabon (2001) wants to protect the forest ecosystem by having a sustainable management of resources. Gabon wanted to make the forestry laws and jurisdictions more compatible with the reality. The Finance Law of 2002 completed the forestry code by amending almost all taxes and royalties expect the felling tax and area tax.

The comparison of both forestry code[2] from 2001 to 2003 shows that the difference between the two countries are the partial log export ban, the export surtax and the factory admission tax[3]. The objective of this study is to measure the effects of these differences namely a mix of the three measures cited above.

[2]The AppendixB presents a more details explanation of forestry code for the two countries from 1999 to 2010.

[3]Export duty logs have been amended by the Finance Law of 2001-2002 in Cameroon (Topa et al., 2009).

2.2 Literature review

Deforestation is one of the biggest concerns in countries rich in forest resources. Many studies have analysed the cause of deforestation in order to propose solutions. Recent articles showed the effects of pre-colonial institutions and economic development on deforestation. For example, Larcom et al. (2016) studied these effects in Africa. Their results suggest that deforestation is higher in villages where the heads are appointed through social norms compared to where the rule of succession is applied to the head. In fact, in places where succession rule is based on heredity, there is the surveillance of the local community who wants the head to follow ancestral tradition. Therefore the management of public goods was less sensitive to corruption which implies a better management of forest. Cuaresma and Heger (2019) studied the effect of economic development on deforestation. They used the regression discontinuity for fourteen contiguous countries. They found that economic development promotes deforestation especially for low-income countries. For high income countries, there is no significant effect.

Therefore, according to these results, Cameroon and Gabon should (or will) experience high levels of deforestation. This is particularly concerning if the economic development is accompanied with higher exchange with the rest of the world. Indeed, some authors suggest that openness to international trade can increase deforestation. This result was found by Faria and Almeida (2016) who showed how Brazilian municipalities experienced higher rates of deforestation between 2000 and 2007 while they were more open to international trade. In the same vein, Barbier et al. (2005) showed that policies encouraging the increase in terms of trade are accompanied by higher deforestation especially in corrupt countries.

Other factors have been identified to influence deforestation[4]: forest conversion to agricultural land (FAO, 2005; Leblois et al., 2017), the quality of institutions (Bohn and Deacon, 2000; Nguyen-Van and Azomahou, 2007; Barbier and Burgess, 2008), property rights (Araujo et al., 2009; Liscow, 2013), exchange rates (Arcand et al., 2008), production and investments in biofuels (Keles et al., 2018; Conigliani et al., 2018) or protected areas (Kere et al., 2017; Amin et al., 2019).

To fight deforestation, many public policies have been set. By doing so, governments wanted to protect the biodiversity and the forest ecosystem. Barua et al. (2012) studied the effects of carbon credits and taxes on forest revenues. They found that taxes on revenues didn't reduce deforestation. However carbon credit for CO_2 help reduce it. Indeed, these payments increase the opportunity cost of forest logging and then allow producers to conserve the forest. The main idea of this paper is to say that taxes on forest revenues and seeds cannot, alone, reduce deforestation. The credit carbon can then complement the taxes in order to reduce deforestation efficiently. This complementary between measures is reinforced by Schwerhoff and Wehkamp (2018) who showed that tariff on export of

[4]See Leblois et al. (2017) for an extensive literature review on the causes of deforestation.

agricultural products and public investments in agriculture can reduce deforestation while keeping constant the level of production and the price in agriculture.

Protected areas are also known to be a solution in the fight against deforestation. Kere et al. (2017) analysed the effect of protected areas in Brazil. They found some heterogeneity in the effect of protected areas. The sustainable use areas and the integral one are found to be less efficient in the fight against deforestation than the indigenous protected areas. The decrease of deforestation depends on the type of protected areas. This result is similar to the one of Amin et al. (2019) who found that indigenous areas and integral one help reduce deforestation whereas sustainable use areas do not.

Among the public policies design to fight against deforestation, we also have laws and national jurisdictions. Nolte et al. (2017) study the effect of a law introduced in 2007 in the Chaco region of Argentine. The law aims at protecting indigenous forests by defining land-use zoning in provinces. Using matching differences-in-differences, the authors found that protected forests (with strong and average conservation value) experienced a reduction in deforestation compared to non-protected ones. The results show that a better protection of forest via forestry law can help reduce deforestation.

Burgess et al. (2012) study theoretically and empirically the effects of decentralisation on forest conversion in Indonesia. Their results suggest that an increase in the number of jurisdictions tends to increase deforestation. They explained it as the fact that an increase in administrative divisions tends to reduce the enforcement of the law. Newly created divisions have difficulties to control the good application of laws. Therefore, it creates higher illegal activities and an increase in logging.

In the light of these results, the effects of law and jurisdictions are mitigated. This paper wants to produce evidence to enlighten this ongoing debate. We will analyse the effect of a mix of forest taxation and partial export ban in the fight against deforestation. A particularity of this study is to analyse the impact of a mix of fiscal and economic policies related to the forestry sector but also to use a relevant quasi-experiment that helps identify the causal effect of these measures on forest conversion.

3 Data and methods

3.1 Data

The deforestation data are from Hansen et al. (2013). These data are fruits of collaboration with Google Earth Engine to detect the forest cover worldwide, the loss and the gain of forest with a resolution of 30 m (Leblois et al., 2017). In this study, we are interested in forest loss data. Forest loss is defined as " *as a stand-replacement disturbance or the complete removal of tree cover canopy at the Landsat pixel scale*"(Hansen et al., 2013, p.850). For computation matters, we have decided

to extract data from pixels of resolution of 1 km. It helps us ease the computation time.

The choice of covariates is based on the literature studying the causes of deforestation. We choose four covariates namely slope, precipitation, travel and light. These variables are known to impact on deforestation (Burgess et al., 2018; Leblois et al., 2017; Ghosh et al., 2010). The effect of precipitation on forest conversion was studied by Nelson and Chomitz (2011). They showed that deforestation is lower in area with lower precipitation and then lower agricultural activities. A raid slope is known to reduce the agricultural activities. Therefore there is little incentive to convert forest to agricultural land in the area with higher slopes (Robalino and Pfaff, 2012).The night light data (Light) are used as a proxy for the economic activities and infrastructure (Ghosh et al., 2010). The travel market time can also impact deforestation. The more closer logging owners are to the market, the lower is the transport cost. This can hinder deforestation especially for areas closer to market hubs. More explanations of variables can be found in Table A2.

3.2 A Geographic Regression Discontinuity Using Borders

We want to evaluate the effect of a mix of forest taxation and partial log export ban in Cameroon. In order to do so, we will use the national border between Cameroon and Gabon as a source of discontinuity. In fact, Gabon did not apply measures under study from 2003 to 2009. Therefore, it is a perfect counterfactual. And as the two countries are neighbours and the measures have a territorial character, the geographic regression discontinuity suits perfectly to our study.

The first application of the regression discontinuity is the study of Thistlethwaite and Campbell (1960). From this pioneer article, many uses of this method have been made in different areas (e.g. Michalopoulos and Papaioannou, 2013; Cuaresma and Heger, 2019; Dell, 2010; Ehrlich and Seidel, 2018)[5].

The geographic regression discontinuity has known much of interests lately (Keele and Titiunik, 2016; Dell, 2010; Ehrlich and Seidel, 2018; Giua, 2017; Burgess et al., 2018). Keele and Titiunik (2015) offer a thorough explanation of the methods with geographic boundaries as a source of discontinuity between treated and non-treated. Indeed, in our study the boundary between Cameroon and Gabon will be the running variable. Pixels closer to the border from each country will be compared to evaluate the causal effect of the mix of forest taxation and partial log export ban on deforestation in Cameroon.

One of the main hypotheses of this method is that covariates should evolve smoothly according to the border. It means that there should be no other discontinuity except the policy evaluated at the border. This hypothesis, if it is respected, reduce the variance of the estimator and therefore increase its precision (Calonico

[5]See Imbens and Lemieux (2008) and Lee and Lemieux (2010) for a literature review and methodological guide in economics. Cattaneo et al. (2018a,b) offer a comprehensive guide for the use of the regression discontinuity with examples in Stata and R.

et al., 2018). Keele and Titiunik (2015) precise another condition that is specific to the geographic regression discontinuity. This condition is named the random assignment of observations. In other terms, observations should not be able to self-select themselves in the treated or control group. Michalopoulos and Papaioannou (2013) showed that the set-up of African boundaries is completely arbitrary. The location and shape of boundaries have been decided in the 19th century in European cities. The colonisers, at that period, didn't settle yet in Africa and had little knowledge about the political, social and geographical aspects of territories (Michalopoulos and Papaioannou, 2013, p.171). This means that boundaries did not take into account any aspect of the economy or forest resources. Moreover, the African Union has decided in 1964 not to modify boundaries from colonialism (Loulichki, 2018)[6]. All these facts allow us to state boundaries are not related to the measures under study.

All these conditions respected, we can state that we have a quasi-experiment situation and the geographic regression discontinuity allows us to evaluate the proper effects of forest taxation and partial log export ban on deforestation.

3.3 Model

We use both nonparametric and parametric specification to study the effect of a mix of forest taxation and partial export ban on deforestation. For nonparametric specification, we compute fifteen points along the border. This is suggested by Keele and Titiunik (2015) and is also used by Ehrlich and Seidel (2018)[7]. We estimate then the effect for each of the fifteen points. The running variable is the vector of coordinates of pixels (longitude and latitude), we then have a multidimensional regression discontinuity as in Dell (2010)[8]. From then, compute the average effect using the delta method as suggested by Keele and Titiunik (2015).

As far as the parametric estimation is concerned, we follow the specification Burgess et al. (2018) and adopt linear and quadratic forms as recommended by Gelman and Imbens (2019). Our running variable is the minimal distance between each pixel and the fifteen border points as in Ehrlich and Seidel (2018). Equation 1 shows the specification used:

$$Y_i = \alpha + \beta Combinaison_i + f(dist_i) + \phi X_i + \varepsilon_i \tag{1}$$

with Y_i the dependent variable (forest loss for the pixel i);

$$Combinaison_i = \begin{cases} 1 & \text{if } \{i\} \in Cameroon \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

[6]This decision is known as intangibility of borders.

[7]The number of points to use for the border is not fixed and can then be considered as ad hoc. But as we are interested in the average effect along the border, we will compute the mean of effect.

[8]We chose the package mdrd in STATA to compute the effect for each border point.

and

$$f(dist_i) = Combinaison_i * f^{Cameroon}(dist_i) + (1 - Combinaison_i) * f^{Gabon}(dist_i) \quad (3)$$

which is $f(dist_i)$ the distance function from each pixel to the border points between Gabon and Cameroon. X_i is the vector of covariate explained in subsection 3.1 and β is the parameter of interest.

4 Results

We first check if our covariates vary smoothly over the national border. Indeed, it is important to test this assumption. If it is respected, it reinforces our identification strategy and can also serve as a falsification test (Keele and Titiunik, 2015). The results are presented in Table A3. We prefer the robust coefficients in all results of this study as suggested by Calonico et al. (2014). All covariates are not significant at any confidence levels. They vary smoothly across national borders and there is no difference for pixels closer to the border in terms of infrastructure (light), precipitation, slope and access time to market hub (travel). Having that hypothesis verified, we can run our estimation.

The Table 1 presents the results for 2003-2009 periods from estimations with parametric and nonparametric specification.

Table 1: Effects of forest taxation on forest loss in Cameroon from 2003 to 2009

	Parametric		Nonparametric
	Linear	Quadratic	
Policy	0.632***	0.318***	0.223***
	(9.79)	(4.12)	(6.08)
Adjusted_R2	0.0067906	0.0073897	-
AIC	178,61	178,587	-
BIC	178,644	178,639	-
Obs.Total	40,875	40,875	-

t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01. The bandwidth is selected with the default option for rdrobust packages (mserd). The robust estimates are presented instead of conventional and bias-corrected estimates.

As shown by the Table 1, the combination of partial log export ban and forest taxation have a positive and significant effect on forest loss. The result is robust for both parametric or nonparametric specification. In other words, the public intervention increases deforestation in Cameroon. It can be explained by the fact that the log export ban does not concern all the wood species. The "Ayous" species

are the most used and traded despite the ban and taxes. Moreover, people process wood species that are banned and export it as the export ban is only for undressed wood. The "Sapeli" species are the second most traded wood despite the fact that it is in the ban list (World Bank, 2002). If this aspect is combined with inefficiency in the transformation sector, we will have a waste of wood and therefore more logging and deforestation.

In fact, the wood-processing industry should be extremely competitive in order to ensure the good effect of forest taxation. It will allow producers to maintain their margins before the measure. Therefore, they will not need to compensate for the export ban with the overuse of wood resources. First, The industry should be more competitive than before the measures took place. Wood producers can then compensate their lost with the gain from wood processed in terms of value added. Second, it should at least be as competitive as industries from other countries. If it is not the case, the price of Cameroonian wood will be higher for the export and then less demanded.

However, the efficiency is not met (Karsenty, 2002). The export ban is combined with an obligation of processing wood. The national demand for processing then increased, and the activity becomes more profitable. Many enterprises which were lacking competitiveness came into the market (Karsenty, 1999). We see from then some over-capacities of processing and a reduction of efficiency in the sector (World Bank, 2002; Gillis, 1988). Treue (2001) showed that forest taxation has had adverse effects on the management of forest resources in Ghana. It resulted in the overuse of wood, particularly more precious species. It seems that the same thing happened in Cameroon.

Another possible explanation is the existence of community forests. The exploitation of these forests is dedicated to local communities. All the resources from these forests are exclusively for local communities(Cameroon, 1994, Article 37(3))[9]. However, Karsenty (2010) has shown that there is no control in these forests in terms of exploitation. As these forests are exempt from forest taxation, foreign enterprises set up deals with local communities guides and extract wood at low cost and then take advantage of the tax exemption. This shown how limits of the forestry code and legislation are helping firms bypass the forest taxation and export ban.

Moreover, the disincentive character of the taxation system can explain the results. Indeed, taxes and legislation seem to privilege the fiscal resources rather than forest conservation. As shown Figure 1, the production of wood decline in 2001 before coming back to its pre-export ban level despite a reduction in exports.

The presence of illegal or informal logging [10] as well as corruption could also

[9]"Article 37(3)" means Article 37, alinea 3.

[10]These activities are mainly done by small producers. As they are not taken into account in the forestry code, many say that their activities are not illegal per se and by the way prefer to use informal (Mahonghol et al., 2016)

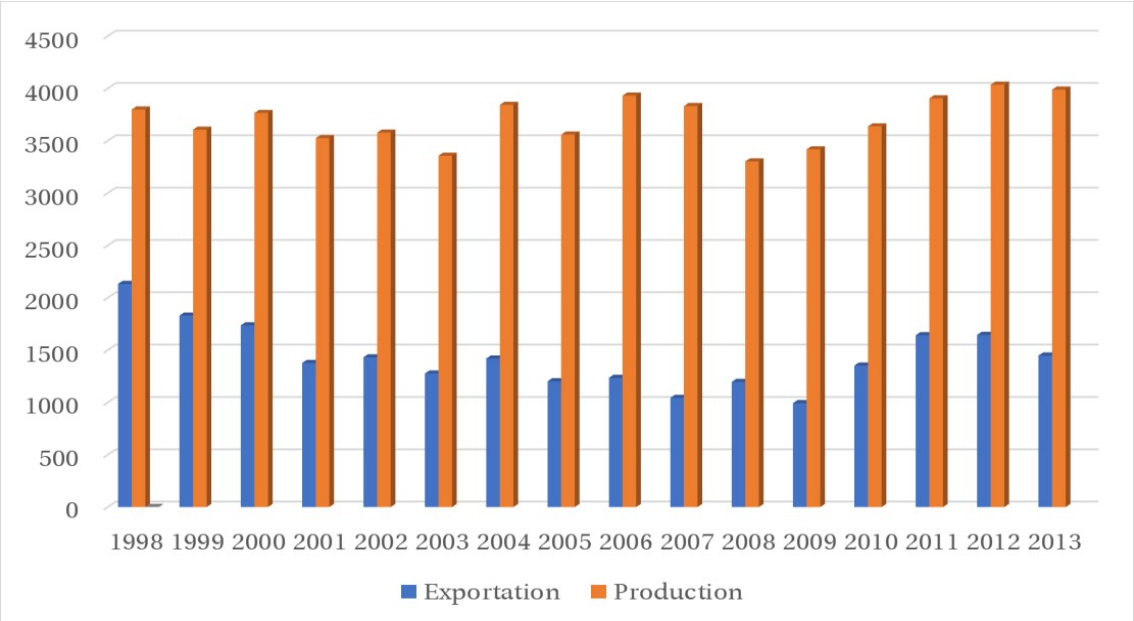

Figure 1: Production and export of wood in 1000 m^3 in Cameroon from 1998 to 2009.

Note: Authors based aggregated data from International Tropical Timber Organization (ITTO)

explain the results of Table 1. Mahonghol et al. (2016) showed that the forest taxation, as it defined presently in Cameroon, is largely inefficient particularly for small log owners. There is a considerable amount of informal or illegal activities in all the steps of the wood value chain that bypass the fiscal regulations. The same for Amacher et al. (2012) who showed that corruption and bribe increase the surfaces of forest logging legally defined by the legislation. This can hinder public policies and increase forest loss.

We can see that there are many explanations to the fact that the mix of forest taxation and partial log export ban did not reduce deforestation but instead increase it. Our results are in line with the one of Karsenty (2002, 2010); Gillis (1988, 1992) but go against the one of Tumaneng-Diete et al. (2005); Deacon (1995).

5 Robustness

The results in Table 1 show that the mix of forest taxation and export ban increased the forest loss in Cameroon from 2003 to 2009. In this section we will check the robustness of these results. Firstly, we decide to adopt another parametric specification based on Ehrlich and Seidel (2018). Their parametric specification is a function of longitude and latitude instead of the minimal distance. They used the cubic specification. But we decided to keep the linear and quadratic specification following still the recommendation of Gelman and Imbens (2019). The results are presented in Table 2.

Based on AIC and BIC criteria, the quadratic form performs better for our data. The results suggest that the mix of forest taxation and export ban increased defor-

Table 2: Parametric results in Cameroon from 2003 to 2009

Parametric à la Ehrlich and Seidel (2018)		
	Linear	Quadratic
Policy	0.388***	0.620***
	(6.96)	(9.46)
Obs.Total	40,875	40,875
Adjusted_R2	.022691	.033132
AIC	177,95	177,514
BIC	177,985	177,575

estation. They are in line with results presented in Table 1, which means that they are robust to different specifications.

Secondly, we separate the initial period (2003-2009) in two different ones. The idea is to see whether the policy has had an effect earlier before logging owners adapt them themselves and find a way to bypass it. This specification is also different from the one presented in Table 1 in a sense that we choose the minimal distance from the border point as the running variable instead of coordinates. We compute distance from each border point to pixels, and we keep the minimal distance of each observation as in Ehrlich and Seidel (2018). The results are presented in Table 3:

Table 3: Nonparametric results for 2003-2009, 2003-2006 and 2007-2009

Dependent variable: Forest loss			
	2003-2009	2003-2006	2007-2009
Conventional	0.597***	0.277***	0.248***
	(8.19)	(5.35)	(3.36)
Bias-corrected	0.486***	0.288***	0.333***
	(6.66)	(5.55)	(4.51)
Robust	0.486***	0.288***	0.333***
	(5.98)	(5.26)	(4.41)
Obs.Total	683,219	683,219	640,284
Obs. Effec	32,634	13,351	16,713
Bandw. Left	64.38501	29.00712	37.74472
Bandw. Right	64.38501	29.00712	37.74472

t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01. The bandwidth is selected with the Mean Squared Error bandwidth selection .

We can see that the mix of forest taxation and partial export ban has increased

deforestation in both two periods. The magnitude is, however, lower in the first periods. But basically, the results confirm those found in Table 1.

6 Conclusion

As there is a fierce debate on the effects of public policies on deforestation, this paper aims at shedding some lights in this context. The main objective of this paper is to analyse the impacts of a mix of forest taxation and partial log export ban on deforestation in Cameroon.

Using the geographic regression discontinuity as methodology where the national border between Cameroon and Gabon is our source of discontinuity, our results suggest that the policies (combination of forest taxation and partial log export ban) have increased deforestation in Cameroon from 2003 to 2009. The main explanations are the partial character of the export ban, the inefficiency of the processing industry, the non-incentive character of taxes, the illegal logging and the presence of corruption as well as the abuse use of community forests. These results are robust whether we use parametric or nonparametric estimation but also to different sub-periods in 2003-2009.

Policy implications can be derived from our results. First, the forest taxation and export ban should be more incentive. The results give us the impression that the system is more for collecting fiscal resources than fighting against deforestation. A complete export ban could perhaps be better at preventing abusive logging. Second, the processing industry should be regulated. This will help reduce the waste of wood resources. Third, small loggers should be taken into account for the following reforms of forestry code. It will help fight against informal logging but also the corruption.

However this paper suffers from some limits. As a first limit, we are not able to evaluate the effect from 1999 as it is the year of enforcement of measures. Indeed, the situation in Gabon didn't allow us to start from then. But we believe that it does not hinder greatly our results in so far as there might exist reasonable delay in the enforcement of laws. Therefore, the real effect could be seen for years after the measures take place. A second limit is we did not take into account the proximity to protected areas and forest communities. This seems to us to be an interesting avenue of research and a complement to our study.

Indeed, include protected areas and community forest locations can help more understand the transmission channel of the effect of measures on deforestation. Another interesting future research that can be done is to analyse whether a stronger export ban as the one implemented in Gabon in 2010 is more efficient than measures studied in this paper.

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7 Appendices

AppendixA Descriptive statistics and other estimations

Table A1: Descriptive Statistics for variable

Variable	Cameroon					Gabon				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean Std.	Dev.	Min	Max
Deforestation	548,379	49.779	3.162	0,000	50,000	309,534	49.601	4.260	0	50
Night Light	548,379	0.573	1.553	0,000	62.185	309,534	0.400	2.512	0	60.928
Precipitation	548,348	1657.462	533.02	224.881	4269.6	309,534	1852.624	267.312	-3748.051	3470.837
Slope	438,437	1.317	2.101	0,000	24.705	247,596	1.060	1.250	0	13.360
Travel	436,602	3.939	4.060	0.049	35.076	246,617	9.215	7.382	0.022	49.390
Distance	548,379	408.930	257.643	0.208	1209.197	309,534	329.407	152.886	0.156	691.094

Table A2: Data description of variables

Name	**Details**	**Links**
Deforestation	Forest loss during the year at pixels of 30 m of resolution	Hansen et al. (2013)
Precipitation	Annual precipitation data from Climate Hazard Group Infrared Precipitation with Station Data (CHIRPS)	CHIRPS
Night Light Data	Night light detected weighted by the frequency of detection	NOOA
Travel	Travel time to the nearest market, 2010 is the benchmark. The travel time was computed using a cost distance function to compute time to the nearest human settlements for all the possible paths. And they retained the least time made for a path	IFPRI
Slope	Area slope	IFPRI

Table A3: Covariate check for estimation from 2003 to 2009

	Light	Precipitation	Slope	Travel time
Conventional	-0.0231***	-9.486***	0.223***	-1.375***
	(-4.12)	(-6.47)	(19.98)	(-6.77)
Bias-corrected	-0.00248	1.358	-0.0308***	-0.366*
	(-0.44)	(0.93)	(-2.76)	(-1.80)
Robust	-0.00248	1.358	-0.0308*	-0.366
	(-0.29)	(0.56)	(-1.95)	(-1.13)
Obs.Total	857,913	857,882	686,033	683,219
Obs. Effec	40,875	40,875	32,634	32,634
Bandw..Left	64.385	64.385	64.385	64.385
Bandw..Right	64.385	64.385	64.385	64.385

AppendixB Synthesis of Forest Codes in Cameroon and Gabon

Overview of forestry code in Gabon

Forestry code of 2001: Gabon establishes a new forestry code (Gabon, 2001) with a better understanding and management of the forest ecosystem.

Amending finance law 2002: The article 11 amended taxes and other royalties except the felling tax (5% on the FOB of undressed wood) and the area tax (1000 FCFA/ha)

Finance law 2003: the articles 11 and 31 define the two taxes with greater precision as well as their collection method.

Finance law 2004: Modification of articles 11 and 31 with more precision on the type of wood (processed or not, exported or not) and people that are concerned by the laws.

November 2009: Complete log export ban on unprocessed wood by ministerial decision. The ban will come in force in 2010.

Ordonnance n°008/PR/2010 (2010): Modification of articles 227 and 244 of the forestry code and reinstatement of taxes and royalties previously amended.

Overview of forestry code in Cameroon

Forestry code 1994: The forestry code of 1994 (Cameroon, 1994) replaced the one of 1982 (Cameroon, 1982). The main objectives are local processing of wood, the development of the wood industry and forest resources conservation.

Décret N° 96/642/PM (1996): defined the tax bases and methods of collections, royalties and selling prices of forestry products.

Décret N° 99/781/PM (1999): the log partial export ban of unprocessed wood came into force. There is also a modification of the export surtax, felling tax and the sawmill entry fee.

Décret N° 2001/1034/PM (2001) amended the decree n°98/003/PM of January 23, 1998, and some article of the Décret N° 99/781/PM (1999). There are new tax bases and new methods of collection of royalties and taxes.

Tax codes 2002: defined rates and the amounts of taxes, royalties and forest law in conformity with the forestry code of 1994:

- *Felling tax:* shall be 2,5% and calculated on the basis of the FOB value of undressed timber (article 242).
- *Annual forestry royalties:* shall be assessed on the basis of the area with minimum prices (2500 FCFA/ha for sales of standing volume, 1500 FCFA/ha for licenses and 1000 FCFA/ha for concessions). The proceeds of annual forestry royalties are allocated as follows: State (50%), local village communities (50%) (article 243).
- *Export Surtax:* are fixed according to wood species (3000 FCFA/m3 for Ayous, 3000 FCFA/m3 for first grade promotion timber, other than Ayous and 500 FCFA/m3 for second grade promotion timber (article 244 A).
- *Factory admission tax:* which is a tax on undressed wood at the entry of factories and paid by processors. It is fixed at 2,25% of the FOB value.

Finance law 2004: amended the minimum price for licenses for the annual forestry royalties. There is also new dateline for the payment of the tax.

Finance law 2009: amended the factory admission tax for wood from first and second processing.