INSIGHTS INTO ECONOMIC INTERACTIONS AND TROPICAL DEFORESTATION

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ABSTRACT

Tropical deforestation continues at an unsustainable pace of 13 million hectares annually. The depletion exacerbates global environmental issues such as global warming, and extinction of endangered species. In response, the international community has implemented a few intervention schemes across tropical countries. These interventions now beg the question – has anything changed about the status of tropical forests? This is the question that this study attempts to address. Employing data available from 1994-2004, our empirical estimations depart from earlier studies by revealing that investments aimed at diversifying tropical economies offer the most sustainable avenue to tropical forest conservation. More interestingly, this study reveals that labor force growth rate does not necessarily translate to increased deforestation as claimed by earlier studies. **JEL Classification**: Q23, Q27, Q50

INTRODUCTION

Tropical deforestation is still recognized today as one of the severe environmental issues threatening the world. This is particularly the case because of the unique roles tropical forests play in the world ecosystem as global public goods. Matters such as global warming, catastrophic wind, and soil erosion, and extinction of plant and animal species that have not yet been screened for their economic value to humankind, have all been linked to the depletion of tropical forests (Mahar 1989; WRI 1992). The issue of global warming is particularly worrisome because scientists have just informed us that the year 2016 was the warmest in recorded history**.** In addition, global surface temperature has risen by about 2.0 degrees Fahrenheit (1.1^{o}C) since the late 19th century, and greenhouse gases constitute a major driver of this unwelcome development. For the most part, tropical deforestation accounts for about 20 percent of annual emissions of greenhouse gases which contribute immensely to global warming. Furthermore, climatologists have estimated that global temperatures would rise by 2.0^{o}C by the year 2100 (Burgess et al., 2012; NASA, 2017; IPCC, 2014). One of the implications of rising temperature is an increase in the transmission of diseases that

are sensitive to climate. Global warming would facilitate a conducive atmosphere for these diseases to spread rapidly by "… shifting the vector's geographic range and increasing reproductive and biting rates and by shortening the pathogen incubation period." The diseases that could be transmitted accordingly include mosquito-borne diseases: malaria, dengue, and viral encephalitides (Patz et al. 1996). Hence, the depletion of tropical forests will likely usher in a multitude of environmental problems involving substantial economic and social costs

According to the Food and Agricultural Organization of the United Nations (FAO, 2015), about 13 million hectares of forests were converted to other uses or destroyed by natural forces annually between 2000 and 2010. The FAO's most comprehensive assessment of deforestation (*The Global Forest Resources Assessment 2015*) states that the world has lost 129 million hectares of forest since 1990. This is equivalent to losing an area equal in size to South Africa. As alarming as these figures might seem, they represent a slowing of the rate of deforestation when compared to about 16 million hectares rate of deforestation observed annually in the 1990s. To put these figures in a better perspective, while the total forested area in the world is about four billion hectares or 31 percent of the total land area, the world experienced a net loss of an area equal to the size of Costa Rica annually between 2000 and 2010 (FAO, 2010).

During the 1980s, thanks to the FAO, more reliable data on tropical deforestation became available. The data enabled economists and other scholars to undertake rigorous theoretical and empirical analysis of the economic factors driving tropical deforestation. Among others, the major factors driving tropical deforestation in the 1980s were identified as demand for agricultural land, debt service obligations, government policies, and the democratic/non-democratic nature of these countries and their disposition towards the exploitation of natural resources. Since the 1980s, the international community has become more enlightened about the disastrous consequences of tropical deforestation and a number of intervention schemes have been implemented across tropical countries. One such large-scale intervention was the recent reduction and/or forgiveness of the foreign debt of developing countries. Another massive intervention was the passage of the African Growth and Opportunity Act (AGOA) in 2000 by the U.S. Congress. This ACT offered African countries unprecedented access to the U.S. market by allowing duty-free access for most African products.

With regard to sustainable development practices, developing countries are now equally more aware that they cannot afford the depletion of tropical forests, and they are cooperating with and embracing the assistance of developed countries. For instance, many tropical countries have embraced the wave of democratization sweeping across the world and are designating large expanse of forests as protected forests. These countries are equally adopting better forest management policies. Furthermore, the FAO is gathering more reliable data on tropical deforestation which enhances the work of researchers. Moreover, the FAO confirms that, even though the rate of tropical deforestation remains unsustainable, the net annual rate of deforestation "has slowed from 0.18 percent in the early 1990s to 0.08 percent during the period 2010-2015" (FAO, 2015). Finally, most of the existing studies that highlighted the economic interactions responsible for the unprecedented depletion of tropical forests used cross-country data from the 1980s. Hence, the findings and results of these studies may not be applicable in the 1990s and beyond as empirical analysis with data from the 1990s may yield new and surprising insights.

All these developments now beg the question – what has changed about the status of tropical forests? Are the factors driving tropical deforestation today the same or similar to the factors that were driving forest depletion in the 1980s? In other words, are the factors driving tropical deforestation today same as 10 years, 15 years, 30 years, or even 40 years ago? What are the economic interactions leading to the continued unprecedented depletion of tropical forests? These questions need to be addressed as some scholars such as Boucher (2016) have alluded to. It is, therefore, imperative that a study evaluating the current status of the factors driving tropical deforestation be undertaken. This study, therefore, attempts to fill this void by investigating the impact, if any, of previously established drivers of tropical deforestation (i.e. debt, democracy, labor force growth, etc.) to determine if these same factors still hold sway today. In other words, what are the factors responsible for the alarming rate of depletion of tropical forests today? Are these the same factors that were identified as primary drivers 15 or 20 years ago or has anything changed?

The rest of the paper is organized as follows: Section 2 reviews the literature while data and methodology are discussed in section 3. Section 4 presents the empirical analysis and the paper ends with summary and conclusion in section 5.

LITERATURE REVIEW

The biggest losses in tropical deforestation were recorded in South America and Africa with net annual deforestation of four million and 3.4 million hectares respectively between 2000 and 2010. During this period, the forested area remained stable in North America and Central America, while Asia saw a net gain of 2.2 million hectares due to large scale afforestation programs in China, India, and Vietnam. Two countries which recorded the highest levels of deforestation in the 1990s – Brazil and Indonesia - significantly reduced their rates of deforestation in the 2000-2010 period. Although the rate of tropical deforestation remains alarming, in general, the FAO reports that improved forest policies and legislation and the enlistment of local communities have impacted favorably on tropical forest conservation in many countries (FAO, 2015).

While the proximate causes of deforestation are numerous, the demand for agricultural land continues to be the leading factor in tropical deforestation. Other factors contributing to the depletion of tropical forests include the absence of well-defined property rights, firewood and charcoal consumption by households and industries, commercial logging, government policies, lack of appropriate forestry management facilities, misguided government policies, and natural forces such fire and drought (Repetto and Gillis, 1988; Postel and Heise, 1988; Hassan and Hertzler, 1988; Mahar, 1989; Barbier et. al, 1991; WRI, 1992; Mendolsohn, 1994; Cropper and Griffiths, 1994; Deacon, 1995; FAO, 2015).

The plight of tropical forests is further exacerbated by international forces that are often beyond the control of tropical countries. Developing countries are regularly subjected to declining terms of trade in international transactions. For instance, as export revenues decline, the pressure to service external debt intensifies thereby exacerbating the pressure to deforest. Inevitably, these countries adopt myopic policies that are totally detrimental to the sustainable exploitation of tropical forest resources (von Moltke, 1990; Didia, 1996; Pearce and Warford 1993; Kahn and

McDonald 1995; Vaughan 1995; Chimeli et al., 2012). In their contribution to the effect of myopic policies induced by corruption, Barbier et al. (2005) conclude that increased corruption facilitated by the efforts of lobbyists is detrimental to tropical forest conservation whereas rising terms of trade impact positively on tropical forest conservation. Burgess et al. (2012) concur with Barbier et al. when they conclude that "the availability of rents from oil and gas extraction" facilitated by weak governance structures in tropical countries, are detrimental to tropical forest conservation

Other studies such as Didia (1997) and Salahodjaev (2016**)** have linked the unprecedented depletion of tropical forests to the system of governance in tropical countries. Specifically, these studies found a strong negative correlation between the rate of tropical deforestation and the level of democracy. In other words, countries with a democratic system of governance are better stewards of tropical forest resources. Therefore, as a country becomes more democratic, the level of deforestation should decline. Salahodjaev (2016) also states that intelligence is a causal factor in tropical deforestation. Specifically, the study finds that there is a negative relationship between intelligence as measured by IQs and deforestation. It could be that the study is inadvertently linking poverty, literacy rates, and underdevelopment which appear to have negative influences on deforestation to low IQ scores. However, it is worth noting that Scrieiu (2007) has cautioned that the factors driving tropical deforestation may vary across countries and regions. For instance, as Boucher (2016) notes, the major drivers of deforestation in Latin America, and the Brazilian Amazon are the beef industry ranches and other huge farms. Hence, more effective policy prescriptions may require the analysis of disaggregated data.

DATA AND METHODOLOGY

The data employed in this study come from mainly the FAO and the World Bank. The FOA's *The Global Forest Resources Assessment 2015* provides the most complete source of data on tropical deforestation. Table 1 lists sample countries, average annual deforestation, public debt levels and degree of democracy .

Based on previous studies as cited earlier, the following empirical model is specified.

$$Def = \beta_o + \beta_1 debt\ service + \beta_2 democracy + \beta_3 Xi + \varepsilon i \quad (1)$$

Xi represents a vector of control variables typically employed in previous studies. In other to minimize omitted variable bias, more control variables as typically included in empirical models of this nature, are at this moment adopted. The full empirical model estimated is hereby given in equation 2.

$$Def = f\{Dum1,\ Dum2,\ Debt\ service,\ demoindex,\ (Demonindex)^2,\ Laborgrowth,\ Govtexpd,\ Gcf,\ Export\ price\} \quad (2)$$

where:

Def = average annual deforestation (1000s ha)
Dum1 = dummy variable for the African region
Dum2 = dummy variable for the South American region
Dum3 = dummy variable for the Asian region (excluded from regressions)

Debt service = total debt service as percentage of export income
Demoindex = democracy index for each country
$(Demoindex)^2$ = the square of the democracy index variable
Laborgrowth = labor force annual growth rate
Govtexpd = government expenditures
Gcf = gross capital formation also known as investments
Export price = export price index

Data on deforestation were sourced from the FAO while the democracy index variable is sourced from Freedom House's "Annual Freedom in the World Survey" Country Ratings (1973-2016). (https://freedomhouse.org). All other variables are sourced from the World Bank. Table 2 lists simple correlation coefficients of the variables included in the study.

EMPIRICAL ANALYSIS

Due to possible simultaneous relationship between our dependent variable (average annual deforestation) and some of the independent variables, the two-stage least squares (2SLS) method of estimation is more appropriate for our empirical regressions instead of the commonly used ordinary least squares (OLS). If OLS is used instead of 2SLS, the simultaneity bias may lead to higher coefficients of the endogenous variables which appear as independent variables thereby leading to higher t-values. These higher t-values could then increase the chances of type one error, i.e. rejecting a true null hypothesis. Since the data is cross-sectional with large and small countries lumped together, all relevant variables are scaled by population and GDP to avoid observing relationships driven by size rather than economic interactions. Furthermore, scaling also minimizes the problem of heteroscedasticity which is always a theoretical possibility in cross-sectional data (Studenmund and Cassidy, 1992). In any case, all regressions are tested and corrected for heteroscedasticity. Dummy variables are included in the estimation to capture differential regional impacts if any, between Africa, South America, Central America & the Caribbean, and Asia.

The regression estimations were carried out with the personal computer version of STATA (version 10) econometric software. Table 3 displays empirical results explaining total deforestation scaled by population. The adjusted R^2 of 0.3126 portrays adequate explanatory power of the regression model given that we have a cross-country data. However, only one variable (debt service) is marginally statistically significant at the 0.10 level. The dummy variables (dum1, dum2) are not statistically significant indicating that regional differences may not exist between Africa, South America and the excluded Asia dummy. Overall, Table 3 leaves much to be desired in terms of capturing the economic interactions that result in the alarming rate of tropical forest depletion.

Empirical results explaining total deforestation scaled by GDP are displayed in Table 4. Table 4 shows a much more impressive outcome than Table 3. With an R^2 of 0.3586, this model delivers slightly more explanatory power than Table 3. The t-statistic for the South America dummy signifies that regional differences may exist between South America and the excluded Asia dummy. Debt service, a very important determinant of tropical deforestation, has the expected sign and statistically significant

at the five percent level. The export price variable is not statistically significant, indicating a contrary outcome compared to earlier studies. Gross capital formation (GCF) which captures investment in the economy is statistically significant at the five percent level and has the expected negative sign, which implies that as investments in the economy go up thereby diversifying the economic base, the rate of deforestation declines as the pressure to cut down tropical forests abates. The democracy index variable has the expected sign and it is statistically significant at the five percent level. The democracy index squared variable is statistically significant but with a confounding positive sign. Could there be such a thing as "too much democracy" which could portend disastrous consequences for tropical forests? The labor force growth variable is statistically significant with an unexpected negative sign which is contrary to earlier studies.

On the whole, the lessons from these empirical estimations are that debt service obligations, labor force growth, investments in the economy, and democratic governance with associated structures and institutions, constitute major determinants of tropical deforestation for the period 1994 – 2004. These results now take us back to the premise of this study – examining whether the factors that drove tropical deforestation in the 1980s still hold sway today. The answer is an unequivocal YES and NO. Yes, because debt service, and democracy index were equally confirmed in previous studies using data from the 1980s, and NO, because with data from 1994-2004, the investment variable which was not statistically significant in previous studies such as Kahn and MacDonald (1995) and Didia (1996), is now statistically significant.

Another striking outcome from Table 4 is that the labor force variable has remained statistically significant as in previous studies that used data from the 1980s. However, a major departure from earlier studies is that the sign of the coefficient has changed from positive as observed in Kahn and MacDonald (1995) and Didia (1996), to negative. This change in the sign of the coefficient may be reflecting increased level of urbanization observed in many developing countries. As the population increases, the new entrants (younger generation) into the labor force may be preferring to migrate to the urban areas in search of white and blue collar jobs rather continue in the tedious and laborious subsistence farming practiced by their forefathers. For instance, many young Nigerians migrate to the urban areas to engage in operating taxis and commercial motorcycles rather than take up farming in the rural areas. This is the trend across most countries in Africa. In effect, an increase in the labor force growth rate may not necessarily be associated with increased deforestation as a result of more people engaging in farming as claimed by studies using data from the1980s.

As Boucher (2016) stated, the increased depletion of tropical forests observed today in Latin America and the Brazilian Amazon is not as a result of more people taking up subsistence farming as a means of livelihood. Rather, the beef cattle industry and enormous farms owned by corporations are responsible for the unprecedented conversion of tropical forests. Similarly, in Africa, the younger generation is not flocking to subsistence farming like their parents, but rather are migrating to the urban areas in search of white collar and other skilled jobs. So, just as in Latin America, forests are being cleared in Africa to make room for more cash crop plantations, and not necessarily because of more entrants into subsistence farming.

Overall, the empirical estimations in Table 4 yield three new surprising insights indicating that the economic factors responsible for tropical deforestation may be evolving over time. While some of the variables from the 1980s still hold sway, it

is apparent now that investments in the economy and the labor force growth rate need to be re-examined in our quest for instruments or remedies to slow down the rate of tropical forest conversion. Clearly, it can be stated that things are changing (albeit slowly) with regard to tropical deforestation. The international attention cum interventions and overall awareness of the disastrous implications of tropical forest depletion may be yielding desired dividends. More foreign investments are coming into developing countries and this is absorbing some of the increase in the labor force, thereby mitigating the pressure on tropical forests.

SUMMARY AND CONCLUSION

Tropical forests are still being depleted at an alarming rate. Since the 1980s when economists began paying more attention to the unprecedented depletion of tropical forests, the international community, and tropical countries have embraced the urgent need to slow the rate of tropical deforestation. Over the years, several studies have explored the socio-economic determinants of tropical forest depletion, and several policy prescriptions have been adopted as result of these studies. In spite of the realization that the factors driving deforestation may be evolving, a search of the literature has failed to reveal any formal attempt to ascertain if the variables responsible for tropical depletion have evolved over time. It is, therefore, time to take stock and evaluate if and what has changed or remained the same concerning the status of tropical forests. This study, therefore, attempts to fill this void which has been largely ignored in the literature.

Our empirical estimations reveal that debt service obligations still remain a causal factor in tropical deforestation despite concerted efforts by the international community to forgive the most indebted developing countries. On a positive note, the wave of democratization in developing countries seems to be auguring well for tropical forest conservation. These results employing 1994-2004 data corroborate the findings of previous studies employing data from the 1980s. However, the results of this study depart from the studies of the 1980s as the empirical estimations reveal that investments aimed at diversifying these tropical economies probably offer the most sustainable avenue to tropical forest conservation. This is one surprising result that was not captured in previous studies using the 1980s data. Another surprising insight from our analysis is that the labor force growth variable sign switched from positive in previous studies to negative in this study. This clearly confirms that deforestation in developing countries is no longer driven mainly by new entrants in the labor force converting forests to subsistence farmlands. These new entrants are instead, migrating to the urban areas in search of white and blue collar jobs. Hence, increased investments in the economy is pulling a significant proportion of the labor force to opportunities available in the urban areas.

It appears now that increasing foreign direct investment which diversifies the economic base of tropical countries and deepening democratic governance will yield higher marginal benefits than other intervention initiatives aimed at reducing the rate of tropical deforestation. Another useful insight from this study is the realization or confirmation that the factors responsible for the unprecedented depletion of tropical forests may be evolving.

One limitation of this study is that even though the FAO has made remarkable

progress in forest data collection, the limited availability of data on annual deforestation rates does not permit the analysis of individual countries. More useful insights may be uncovered if disaggregated data on individual countries are analyzed. While more research is needed to adequately understand the evolution of the factors responsible for tropical deforestation, it is hoped that this paper has shed some light on this issue and will ignite more research in the area.

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TABLE 1: SAMPLE COUNTRIES, AVERAGE ANNUAL DEFORESTATION, PUBLIC DEBT LEVELS AND DEGREE OF DEMOCRACY

Country	Public Debt (1999-2004)*	Degree of Democracy**	Deforestation (Hectare)***
Bangladesh	6.65	Moderate Democratic	2600
Benin	0.69	Democratic	50000
Bolivia	3.71	Democratic	466067
Botswana	0.05	Democratic	118400
Burkina Faso	1.21	Moderate Democratic	59967
Burundi	0.34	Non-Democratic	11433
Cameroon	1.10	Non- Democratic	220000
Columbia	14.96	Moderate Democratic	314243
Comoros	0.06	Non-Democratic	600
Congo (Repub)	0.19	Non-Democratic	12833
Congo Demo	1.30	Non-Democratic	311400
Costa Rica	1.98	Democratic	22833
Ecuador	4.11	Democratic	78735
El Salvador	2.15	Democratic	4433
Fiji	0.06	Moderate Democratic	167
Gambia	0.27	Non-Democratic	1833
Ghana	2.51	Democratic	28467
Guatemala	2.32	Moderate Democratic	45000
Guinea-Bissau	0.14	Moderate Democratic	9933
Guyana	0.59	Democratic	5000
Haiti	0.35	Non-Democratic	800
Honduras	2.15	Democratic	120000
India	22.40	Democratic	424133
Ivory Coast	1.00	Non-Democratic	2233
Jamaica	1.60	Democratic	407
Kenya	1.33	Moderate Democratic	46833
Liberia	-	Non-Democratic	30000
Madagascar	1.85	Moderate Democratic	53667
Malawi	1.02	Moderate Democratic	33000
Malaysia	0.79	Non-Democratic	182300
Mali	1.26	Democratic	79000
Mauritania	0.90	Non-Democratic	5833
Mauritius	0.30	Democratic	90

Mexico	18.67	Democratic	123267
Nepal	1.11	Moderate Democratic	8800
Nicaragua	2.09	Democratic	70000
Niger	0.94	Moderate Democratic	12400
Nigeria	1.28	Democratic	409600
Pakistan	4.60	Non-Democratic	42967
Panama	1.05	Democratic	16667
Paraguay	1.17	Moderate Democratic	283933
Peru	8.92	Democratic	140133
PNG	0.50	Democratic	2633
Rwanda	0.67	Non-Democratic	11533
Senegal	1.66	Democratic	40833
Sierra Leone	0.59	Moderate Democratic	19600
Solomon Island	0.02	Moderate Democratic	5567
Sri Lanka	2.21	Moderate Democratic	4967
Sudan	1.00	Non-Democratic	174415
Tanzania	2.81	Moderate Democratic	400000
Thailand	4.47	Democratic	5533
Togo	0.16	Non-Democratic	19833
Uganda	2.32	Non-Democratic	127333
Zimbabwe	0.29	Non-Democratic	327000

**Average in 0.1 billion US$*

***Democratic Index is constructed based on Freedom in the world Country Ratings (1973-2016).*

****data between 1999 to 2004*

TABLE 2-PARTIAL CORRELATION

	Dfors/ Popu	**Dfors/GDP**	**Govt Expens**	**GCF/GDP**	**Export/GDP**	**DebtServ/ Export**	**Export Index**	**Demo Index**	**Labor Growth**
Dfors/Popu	1.0000								
Dfors/GDP	0.5504	1.0000							
GovtExpens	0.2961	.0900	1.0000						
GCF/GDP	0.1778	0.0450	-0.0180	1.0000					
Export/GDP	0.1291	0.1188	0.2597	0.3079	1.0000				
DebtServ/Export	0.1069	0.1903	0.0826	-0.2093	-0.3521	1.0000			
Export Index	0.0067	0.0286	0.0742	-0.0821	-0.1927	-0.0713	1.0000		
Demo Index	0.1737	0.0433	-0.3330	-0.4053	-0.3348	0.0331	0.0267	1.0000	
Labor Growth	0.0921	0.2845	-0.1484	-0.3770	-0.4474	0.1334	0.2570	0.3588	1.0000

TABLE 3 – TWO-STAGE LEAST SQUARES REGRESSION EXPLAINING DEFORESTATION (1994-2004)

Dependent Variable: Total Deforestation (1000 Ha) per Million People		
Independent Variable	**Coefficient**	**T-Statistic**
LaborGrowth	-2220.6670	-0.92
Dum1 (Africa)	-37.1258	-0.55
Dum2 (S. America)	-108.1613	-1.60
Debt Servic/Export	3.3154	1.81*
Export Price Index	0.2127	0.41
GovtExpen/Population	-0.2610	-0.92
GCF/Population	0.0372	0.30
DemoIndex	-50.1499	-1.11
DemoIndex Sqrd	2.9859	1.16
Constant	187.0319	0.86
Number Observations	39	
Wald Chi2	7.4100	
Prob> Chi2	0.5943	
Adj. R-Squared	0.3126	

*Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level

TABLE 4 – TWO-STAGE LEAST SQUARES REGRESSION EXPLAINING DEFORESTATION (1994-2004)

Dependent Variable: Total Deforestation (1000 Ha) per Million of real US$ GNP		
Independent Variable	**Coefficient**	**T-Statistic**
LaborGrowth	-267.495	-1.95*
Dum1 (Africa)	-4.046	-1.42
Dum2 (S. America)	-5.694	-1..79*
Debt Servic/Export	0.202	2.17**
GovtExpen/GDP	-0.171	-0.85
GCF/GDP	-0.465	-2.24**
Export Price Index	0.109	1.58
DemoIndex	-5.654	-2.87***
DemoIndex Sqrd	0.345	2.98***
Constant	19.709	2.28
Number of Observations	*40*	
Wald Chi2	*30.65*	
Prob> Chi2	*0.0003*	
Adj. R-Squared	*0.3586*	

*Significant at the .10 level
** Significant at the .05 level
*** Significant at the .01 level