

The link between trade openness and deforestation for environmental quality in Nigeria

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Abstract This paper examines the effect of trade openness on deforestation for environmental quality in Nigeria. Autoregressive Distributed Lag bounds testing approach to cointegration was used to achieved the long-run equilibrium relationship among the variables. Economic growth, energy consumption and population were used as control variable. The long-run result shows that the coefficients of trade openness and economic growth are significant and inversely related to deforestation. This suggests that trade openness and growth reduce deforestation and improves environmental quality. Conversely, the long-run coefficient of population is significant and positively related to deforestation, meaning that population increases deforestation and environmental degradation. However, the long-run result for energy consumption did not produce statistical significance. Furthermore, all the short-run results were consistent with their long-run result.

Keywords Trade openness · Deforestation · Environmental safety · Nigeria

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Introduction

A recent development in the literature on climate change has put forward the importance of forests in climate change mitigation (Stern 2006). The motivation was given for reducing emissions from deforestation and forest degradation (REDD). Deforestation which refers to the conversion of tropical forests to agricultural land and other economic uses has shown signs of decreasing in some countries but continue at a high rate in other countries. About 13 million hectares of tropical forest were said to have been converted to other uses or lost through natural causes each year in the last 10 years with high rate of deforestation in Australia since year 2000 due to drought and forest fires (FAO 2014). Geist and Lambin (2001) noted that the role of forests in reducing global environmental degradation and climate change has been motivating efforts towards identifying the causes of deforestation.

The main goal of the United Nations Framework Convention on Climate Change (UNFCCC 2014) is to ensure stable greenhouse gas (GHG) concentrations in the atmosphere to a level that would prevent unfriendly anthropogenic interference with the ecosystem. This was proposed to be achieved within a time frame that is enough to allow ecosystems to adapt naturally to climate change, without causing any hindrance to food production so that economic development can proceed sustainably (IPCC 2007). As such sustainable forest management could reduce environmental degradation and deforestation and increase

benefits to the society and environment. At the societal level, sustainable forest management contributes to quality of lives, jobs and income generation, while at the environmental level, it provides useful services like carbon sequestration, soil and biodiversity conservation (FAO 2014). Among the usefulness of forests in environmental sustainability include reacting sensitively to a changing climate, producing wood fuels as an alternative to fossil fuels, and having the capacity to absorb up to one-tenth of world carbon dioxide emissions forecasted for the first half of this century into their biomass (FAO 2014).

Despite continuous improvements in energy Technologies, global energy use is projected to continue to increase, particularly as developing economies pursue industrialization. Should there be no substantial change in energy policies, the energy mix supplied to run the global economy in the 2025–2030 time frame will essentially remain unchanged. More than 80 % of the energy supply will be based on fossil fuels, with consequent implications for GHG emissions. Therefore, the projected environmental degradation through emissions of energy in 2030 is 40–110 % higher than in 2000 (IPCC 2007). This paper investigates the effect of trade openness on deforestation for environmental quality in Nigeria. The next section discuss literature review.

Literature review

Since the work of Simon Kuznets in 1955 which shows the link between income per capita and income inequality; inferences has been drawn from this work and apply to several related area of studies among which include the relationship between economic growth and environmental pollutants. The famous work of Kuznets postulates that income per capita is inversely related to income inequality at initial stage of production in an economy up to a certain point after which further increase in income per capita reduces inequality. Hence the relationship between per capita income and income inequality was found to be inverted U-shape and named before Kuznets as Kuznets Curve (KC).

Later on, the seminar work of Grossman and Krueger (1995) investigated the link between income and environmental quality and also found an inverted U-shape and hence represent the extension of Kuznets hypothesis to environmental and climate change

problems. The study relates income with environmental performance and in line with Kuznets (1955) their finding shows that the link between income and environmental quality is bell-shaped curve or non-linear, suggesting that the initial stage of income growth leads to higher environmental degradation up to a turning point after which additional expansion of income growth improves environmental quality. Since then several empirical works has documented how income, energy, foreign direct investment (FDI), trade relations and other economic variables has affected environmental safety. These findings have documented conflicting empirical outcomes due to differences in variables indicators used, frequency of data and the stage of economic advancement of the country under study. Among studies that investigated the Environmental Kuznets Curve (EKC) hypothesis include Bello and Abimbola (2010), Jalil and Feridun (2011), Choumert et al. (2013), Shahbaz et al. (2013a, b) and Ahmed et al. (2015).

However, most of the investigation on EKC hypothesis has focus on CO₂ emission as an indicator for measuring environmental quality with lesser emphasis on using deforestation as an indicator for measuring environmental performance. In recent times literature has been expanded to include investigating the link between deforestation and other macroeconomic variables for environmental safety. For instance, Choumert et al. (2013) investigated whether the EKC for deforestation is a threaten theory using meta-analysis of literature. They found that a turning point existed after year 2001 and concluded that EKC will not fade until theoretical alternatives are provided. Years before then, Culas (2007) conducted a study on the existence of some institutional factors on the EKC bond for deforestation in Latin American, African and Asian countries and found that the outcomes of the Latin American countries reveal significant evidence of EKC relationship for deforestation. Similarly, Ahmed et al. (2015) examine the impact of some macroeconomic variables on deforestation and found the existence of EKC evidenced by the diminishing effect of economic growth on deforestation for environmental quality. This study contribute to existing body of knowledge by employing agricultural land use of total land area as an indicator for deforestation, with trade openness and population in the same model. Agricultural land area in Nigeria occupies up to 80 % of land use in recent times (WDI 2015). The next section deals with the methodology.

Econometric modeling and estimations

The objective of this paper is to investigate the impact of trade openness on deforestation for environmental quality in Nigeria. To differentiate our work with previous literature, agricultural land percentage of land area was used to capture deforestation for environmental quality and population in largest city as proxy for population. To model the relationship among our variables the paper adopts the Autoregressive Distributed Lag (ARDL) bounds test to cointegration of Pesaran et al. (2001). As such we begin by modeling the functional relationship between deforestation and trade openness with economic growth, energy consumption and population as control variables. Deforestation which is the explained variable was expressed as a function of other variables mention earlier. This relationship is shown in Eq. 1. Were D_t represent deforestation, T_t represents trade openness, Y_t denotes economic growth, E_t indicates energy consumption and P_t represent population.

$$D_t = f(Y_t, E_t, P_t, T_t) \tag{1}$$

To reduce skewness in time series data, the log linear specification provides better result compared to functional form linear equation. As such, following Authors like Ahmed et al. (2015), Epule et al. (2014), Shahbaz et al. (2013a, b), Scricciu (2007) and Culas (2007) we modify and developed a log linear econometric model to include the drift parameter and the stochastic error term, where the error term is expected to be normally distributed with zero mean and constant variance. The econometric relationship of our variables is shown in Eq. 2 below:

$$\ln D_t = \theta_0 + \theta_1 \ln Y_t + \theta_2 \ln E_t + \theta_3 \ln P_t + \theta_4 \ln T_t + \mu_t \tag{2}$$

Since we have adopted the ARDL bounds testing approach to cointegration of Pesaran et al. (2001), the econometric model is further transformed into dynamic unrestricted error correction model (UECM), where deforestation was expressed as a function of its previous lag along with level and first difference of other dependent variables in the model. The ARDL model was used to verify the long-run equilibrium relationship between the explained variable deforestation and the explanatory variables of trade openness and other control variables in the model. Some of the advantages of using the ARDL bound test include: 1.

providing good property for small sample size 2. use of level or first difference of variable stationarity or combination of both 3. simultaneous computation of long-run and short-run results to include error correction coefficient and flexibility of selecting optimum lag that minimize degree of freedom and 4. the model does not need formal unit root test. The dynamic ARDL model is constructed as shown on Eq. 3.

$$\begin{aligned} \Delta \ln D_t = & \pi_0 + \sum_{i=1}^n \pi_{1i} \Delta \ln D_{t-i} + \sum_{i=0}^n \pi_{2i} \Delta \ln Y_{t-i} \\ & + \sum_{i=0}^n \pi_{3i} \Delta \ln E_{t-i} + \sum_{i=0}^n \pi_{4i} \Delta \ln P_{t-i} \\ & + \sum_{i=0}^n \pi_{5i} \Delta \ln T_{t-i} + \lambda_1 \ln D_{t-1} + \lambda_2 \ln Y_{t-1} \\ & + \lambda_3 \ln E_{t-1} + \lambda_4 \ln P_{t-1} + \lambda_5 \ln T_{t-1} + \varepsilon_t \end{aligned} \tag{3}$$

To determine the speed of convergence when there is deviation from long-run equilibrium resulting from short term shocks, we developed error correction model as specified in Eq. 4. Symbol ρ represent the coefficient that shows how fast or slow the convergence to long-run equilibrium will be.

$$\begin{aligned} \Delta \ln D_t = & \beta_0 + \sum_{i=1}^n \lambda \beta_{1i} \Delta \ln D_{t-i} \\ & + \sum_{i=0}^n \beta_{2i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \beta_{3i} \Delta \ln E_{t-i} \\ & + \sum_{i=0}^n \beta_{4i} \Delta \ln P_{t-i} \\ & + \sum_{i=0}^n \beta_{5i} \Delta \ln T_{t-i} + \rho ECT_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

To estimate the long run equilibrium relationship among the variables, we test the combine null hypothesis of no cointegration on the level variables against its alternative hypothesis that suggests the existence of cointegration. The null hypothesis is $H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$ while the alternative hypothesis is given by $H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq 0$. The existence of cointegration or its absence is based on the outcome of F-statistics test obtain through the OLS variable addition test. The joint F-statistics value will then be compared with critical values in Narayan (2005) Table. If the computed F-statistics value is greater than the upper bound value

of the table, cointegration exist. However, if computed F-statistics is lower than the lower bound, cointegration does not exist. On the other hand, if the F-statistics falls within the upper and lower bounds, the result is inconclusive.

Data and empirical results discussion

The data used for this paper were extracted from World Development Indicators (WDI) this year for the period of 1981–2011. Agricultural land (% of land area) was used to measure deforestation, GDP (constant 2005 US\$) was used as proxy for economic growth, Energy use (kg of oil equivalent per capita) measures energy demand, trade % GDP was used as indicator for trade openness while Population in largest city was used as proxy for population. The use of agricultural land area for deforestation and the inclusion of trade openness and population in the bivariate model further differentiate our work with other literature especially for the case of Nigeria. The Bar representation and trend of the variables are presented in Fig. 1.

The descriptive statistics which include the mean, media, maximum, minimum, standard deviation, skewness, kurtosis, jarque–bera and probability were computed and presented in Table 1. The statistics of Jarque–Bera suggest that the entire variable have achieved the requirement of normal distribution. The result of the descriptive statistic is shown in Table 1.

Despite that ARDL bounds test of Pesaran et al. (2001) does not need formal unit root test to verify the stationarity property of our variables, we have conducted the test to enhance robustness of result and to eliminate spurious results. The unit root test will also help to ensure that stationarity beyond $I(1)$ are not included in the model. The result of the stationarity test shows that all the variables which include deforestation, trade openness, economic growth, energy consumption and population are stationary at level or first difference. The results of the unit root test as presented in Table 2, suggest that we can safely proceed with the cointegration test.

After estimating the ARDL model of Eq. 3, the joint F-statistic value obtained (7.1152) was greater than the upper bounds critical values of Narayan (2005) at 1 %, 5 % and 10 % level of significance, suggesting the presence of strong cointegration among

deforestation, trade openness and other control variables of economic growth, energy consumption and population. This informed the decision of accepting the alternative hypothesis and rejecting the null hypothesis. Therefore, long-run equilibrium relationship exists among our variables. The result of the cointegration is presented in Table 3 with maximum lag length of 1 covering 31 years.

The existence of cointegration provides a safe ground and justification to estimate the long and short-run models. The result of the long-run model was estimated and presented in Table 4. The long-run coefficient of trade openness reveals significant and inverse relationship with deforestation. This means that trade relation with other part of the world reduces deforestation and improves environmental quality. When trade openness increase by 1 % deforestation will reduce by 0.2110 %. This improves forest reserves and increase environmental quality through forest carbon sequestration. This result is also intuitive with the findings of Ahmed et al. (2015).

More so, the long-run coefficient of economic growth reveals significant and negative relationship with deforestation, suggesting that economic growth in Nigeria reduces deforestation and improves environmental safety. When economic growth increase by 1 % deforestation will reduce by 0.3465 %. This implies that economic growth in this model reduces environmental degradation by reducing deforestation. This finding is in line with the result of Shahbaz et al. (2013a, b) for a similar study. The coefficient of energy consumption is positive but did not produce significant outcome during the long-run, suggesting a lower potential for making any inference.

Similarly, the long-run coefficient of population indicator is significant and positively related to deforestation. The significant level was estimated to be 1 % provided by the probability value. This suggest that population increase is a major cause of deforestation which also increase environmental degradation in Nigeria. More precisely, an increase in population by 1 % increase deforestation by 0.6540 %. Therefore, population expansion encourages land opening for residential and various economic activities which increase deforestation and reduces environmental safety. The result is in agreement with the findings of Ahmed et al. (2015) for Pakistan.

Furthermore, the result of the short-run model were also estimated and presented along with the long-run

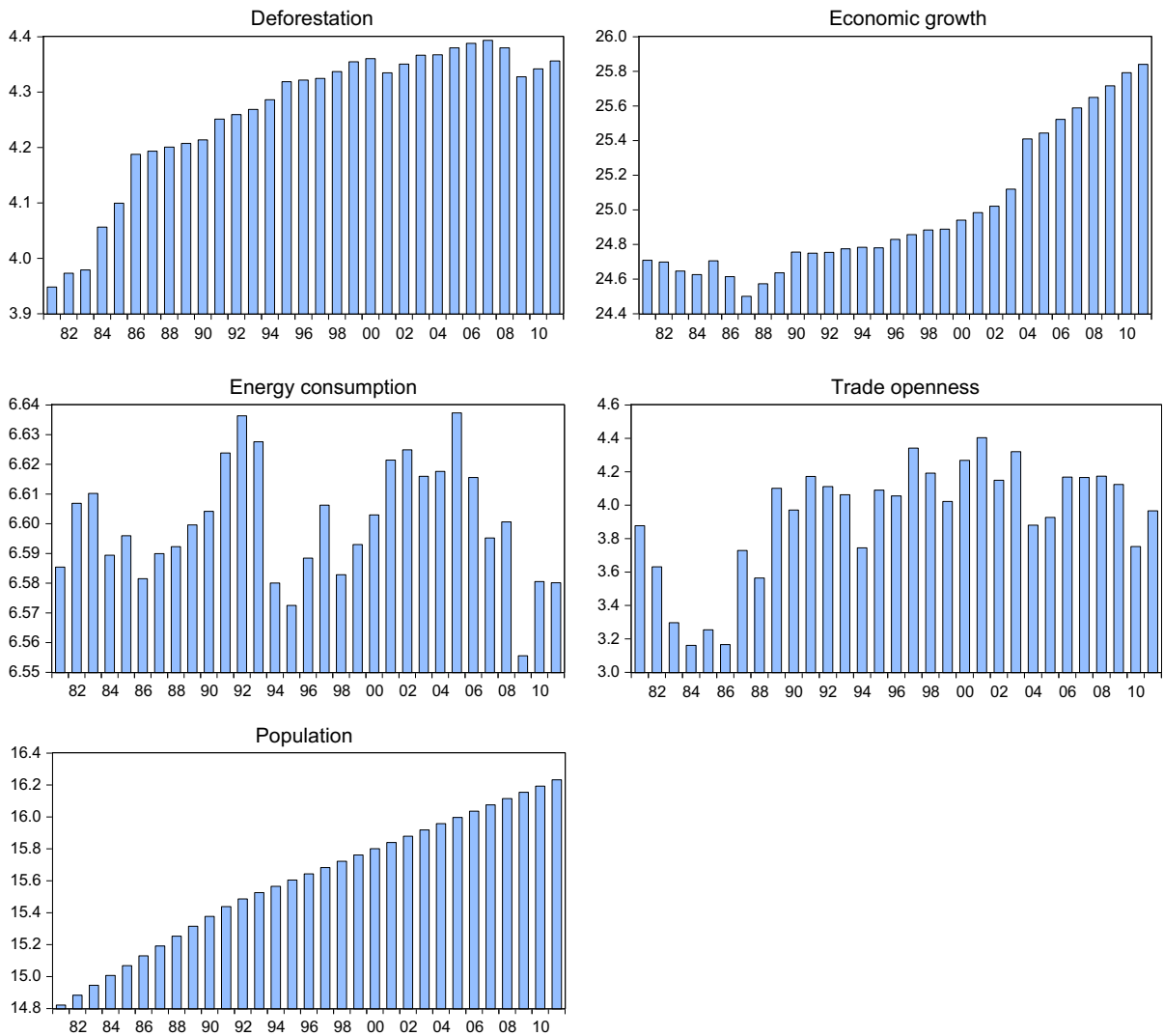


Fig. 1 Bar representation and trend of variables

Table 1 Descriptive statistics

Variables	$\ln D_t$	$\ln Y_t$	$\ln E_t$	$\ln P_t$	$\ln T_t$
Mean	4.262211	24.99349	6.600463	15.60073	3.930567
Median	4.321757	24.82960	6.599615	15.64369	4.055101
Maximum	4.393468	25.84000	6.637309	16.23256	4.404434
Minimum	3.948265	24.50055	6.555561	14.82184	3.161623
SD	0.129236	0.404777	0.019486	0.417131	0.343734
Skewness	-1.206212	0.901244	0.037994	-0.277366	-0.981755
Kurtosis	3.377754	2.379171	2.536756	1.956625	3.037157
Jarque–Bera	7.701548	4.694418	0.284644	1.803629	4.981637
Probability	0.021263	0.095636	0.867342	0.405833	0.082842

Jarque–Bera shows that all variable are normal distributed

Table 2 Unit root test

Variables	Level ADF	1st difference ADF	Level PP	1st difference PP
ln D _t	-3.738 (0.0085)***	-3.995 (0.0046)***	-11.089 (0.0000)***	-3.971 (0.0049)***
ln Y _t	1.849 (0.9996)	-4.043 (0.0041)***	1.767 (0.9995)	-4.029 (0.0043)***
ln E _t	-2.798 (0.0705)*	-5.841 (0.0000)***	-2.919 (0.0549)*	-7.364 (0.0000)***
ln P _t	-1.779 (0.3828)	-1.582 (0.4782)	-5.127 (0.0002)***	-1.211 (0.6558)
ln T _t	-2.065 (0.2593)	-2.721 (0.0859)*	-1.928 (0.3156)	-7.328 (0.0000)***

*** and * indicate 1 and 10 % significance respectively

Table 3 ARDL cointegration test result

Narayan bounds test case III: unrestricted intercept and no trend	
Estimated equation	$\ln D_t = f(\ln Y_t, \ln E_t, \ln P_t, \ln T_t)$
Optimal lag structure	(1, 0, 0, 1, 0)
F-statistics	7.1152***
Significant level	Critical values (T = 31)
	Lower bounds (0) Upper bounds (1)
F-statistics is greater than the upper bounds at 1, 5 and 10 %, suggesting strong cointegration among variables	1 % 4.768 6.670
	5 % 3.354 4.774
	10 % 2.752 3.994

Table 4 Long-run and short-run models

Dependent variable = ln D _t		
	Coefficients	T-ratio (p values)
Long-run regressors		
ln Y _t	-0.3465	-4.0912 (0.000)***
ln E _t	0.7820	1.3393 (0.193)
ln P _t	0.6540	6.1659 (0.000)***
ln T _t	-0.2110	-2.0493 (0.052)*
Constant	-1.5956	-0.43509 (0.667)
Short-run regressors		
Δln Y _t	-0.1295	-4.6424 (0.000)***
Δln E _t	0.2923	1.5844 (0.126)
Δln P _t	0.2445	4.1895 (0.000)***
Δln T _t	-0.0466	-2.4368 (0.022)**
Constant	-0.5964	-0.4564 (0.652)
ECM (-1)	-0.3738	-2.8156 (0.009)***

***, ** and * indicate 1, 5 and 10 % significance respectively

in Table 4. The short-run coefficient of trade openness was found to be significant and negatively related to deforestation, implying that trade openness reduces

deforestation and improves environmental quality. An increase in trade openness in the short-run by 1 % will reduce deforestation by 0.0466 %. This implies that the long-run power of trade openness to reduce deforestation for environmental safety is greater than that of the short-run.

The coefficient of the short-run economic growth is also significant with a negative sign suggesting that economic growth has not taking place at the expense of deforestation. The short-run result is intuitive with the long-run outcome, indicating that economic growth reduce deforestation and improves environmental safety in both period. However, the power of economic growth to reduce deforestation in the long-run is more robust than the short-run. During the short-run, increase in economic growth by 1 % reduces deforestation by 0.1295 %. The result is consistent with the findings of Shahbaz et al. (2013a, b). In line with the long-run result, energy consumption is also positive during the short-run but did not produce a significant outcome. Therefore, energy consumption in both periods has no impact on deforestation and environmental quality.

More so, the short-run coefficient of population indicator is significant and positively related to deforestation, suggesting that increase in population will take place at the expense of deforestation which may result to environmental degradation. This result, although not as robust as the long-run provides support to the long-run outcome. Therefore, population was consistently identified as a major cause of deforestation and environmental hazard in the model. This result also supports the findings of Ahmed et al. (2015). In addition, the coefficient of the error correction model 0.3738, represent the speed of adjustment for convergence back to long-run equilibrium when short-run shock occurs. The estimation of the results in Table 4 is based on Schwarz Bayesian Criterion (SBC) due to its ability to select parsimonious model that minimizes the loss of degree of freedom.

After estimating the long-run and short-run models, a diagnostic test was conducted to further strengthen the reliability of our result. Diagnostic test are carried out to ensure models are free from problems such as autocorrelation, specification problem, heterogeneity and white noise problems among others. The result of the diagnostic test reveals that the model passes the four major diagnostic checking of serial correlation, functional form, normality and heteroscedasticity, suggesting that the model is reliable. The result of the diagnostic test was presented in Table 5.

Passing all the diagnostic tests may not suggest that the model is stable. Therefore, to further enhance the robustness of our result, the model was diagnosed for stability test using the cumulative sum of recursive residuals and cumulative sum of square of recursive residuals stability tests of Brown et al. (1975). The test incorporates the short-run dynamics to the long-run

via residuals and the statistics are updated recursively and plotted against the break points of the model (Halcioglu 2009). Once the plots of the statistics fall within the critical bounds at 5 % level of significance, one assumes that the coefficients of a given regression are stable, consistent and reliable. The result of the stability tests are presented in Figs. 2 and 3.

Conclusion and policy recommendations

The objective of this paper is to examine the effect of trade openness on deforestation and environmental quality in Nigeria. The paper adopted the ARDL bound test advanced by Pesaran et al. (2001) to verify the cointegration and equilibrium relationship among the variables. With the exception of energy consumption which does not possess statistical power, all the explanatory variables were significant. The long-run coefficients of trade openness and economic growth were found to be significant and inversely related deforestation, indicating that trade openness and economic growth reduce deforestation and environmental degradation in Nigeria and therefore, trade and growth have not taking place at the cost of deforestation and environmental quality. In order to add to these benefits, we suggest that trade relations be enhance to their turning point with rest of the world to include consideration for greener and friendly environment. On the other hand, the long-run coefficient of population indicator reveals positive and significant relationship with deforestation, suggesting that increase in population trigger's deforestation and environmental degradation. Therefore, population increase will be at the expense of forest reservation and quality environment.

Table 5 Diagnostic test results

Test statistics	LM version	F version
A: Serial correlation	(1) = 0.33845 [0.561]	(1, 23) = 0.25388 [0.619]
B: Functional form	(1) = 0.62983 [0.427]	(1, 23) = 0.47699 [0.497]
C: Normality	(2) = 0.029759 [0.985]	Not applicable
D: Heteroscedasticity	(1) = 2.5317 [0.112]	(1, 29) = 2.5790 [0.119]

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

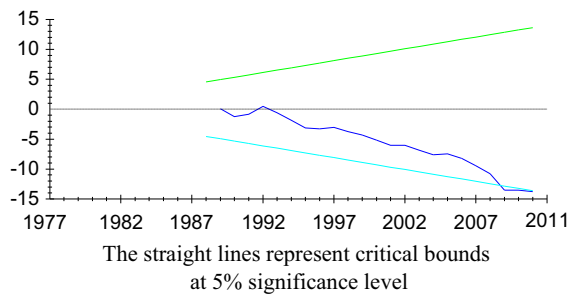


Fig. 2 Plot of cumulative sum of recursive residuals

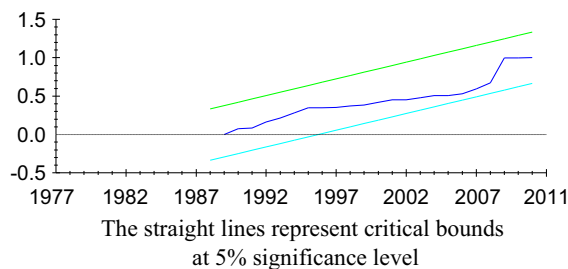


Fig. 3 Plot of cumulative sum of squares of recursive residuals

Furthermore, the short-run coefficient of trade openness, economic growth, population and even energy consumption produced consistent results in line with the long-run outcomes. While trade openness and economic growth reduce deforestation and improves environmental quality, population increases deforestation and reduces environmental safety in the short-run period. In addition the speed of adjustment in converging short term shock is slow, meaning that it will take longer time to correct deviations from equilibrium. This provides some insight to policy maker on the inelastic nature of deforestation in responding to shocks in the short-run when these explanatory variables are consider in a model of this nature.

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