The Impact of Trade Liberalization on Air Pollution: In Case of Ethiopia

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2015

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Abstract

The policy of trade liberalization and increased openness is seen as a means of stimulating economic growth for developing countries. However, there is argument from environmentalists' side that trade has adverse environmental effects. Given the potential benefits of trade liberalization policies, it is important to examine whether such policies are in fact in conflict with the environment as they accelerate economic growth.

This paper with aim of studying the impact of trade liberalization on environment has made use of a time series data from 1970 to 2010. The impact of trade on environment was analysed by decomposing into scale, composition, and technique effect. The Johansen co-integration and error-correction model technique has been used in order to examine the long run and the short run dynamics of the system respectively. The result indicate that scale effect, Economic growth and Population density are positively related to air pollution while it is negatively related with trade intensity and composition effect. In short run, scale effect and population density have negative environmental effects while trade intensity and composition effect are environmental friendly similar to long run results. Thus, there is a need to diversify on areas where the country has comparative advantage in international trade to maximize the gains from trade and Ethiopia has to critically examine and identify her trading opportunities so as to ensure that decisions which endanger areas where Ethiopia exhibits comparative advantage should not compromised

Key Words: *Trade liberalization, Trade intensity, Scale effect, Composition effect, Technique effect, Ethiopia.*

1. Introduction

There is Extensive debate over the question of the relationship between environmental quality and trade among free traders and the Environmentalist. The discussion started in the late 1970s and is still burning issue in the literature (Muradian and Martinez-Alier, 2001). Although a lot

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of research has been conducted, “a consensus view'' does not exist, and no clear-cut results can be derived from both economic theory, and empirical evidences (Copeland & Taylor, 2001)

Both from economic theory and empirical evidences, the effect of trade on environmental sustainability is quite ambiguous. Theoretically, trade increases the size of the economy which may cause more pollution. This is particularly true for countries which export products that are generally associated with creating pollution, for example goods whose production depletes natural resources and whose combustion leads to emission of greenhouse gasses. On the other hand, through transfer of environmental friendly technologies, trade can lead to better environmental quality. Grossman and Krueger (1991) have analysed the trade-environment linkage via the impact of economic growth on the environmental quality. They found environmental conditions deteriorate initially as per capita income rises, but improve as per capita income increases beyond a certain point. This inverted U-relationship between environment and economic growth was the Environmental Kuznets Curve (EKC) hypothesis.

Shafik and Bandyopadhayay (1992) analysed the relationship between environmental degradation and per capita income defined in purchasing power parity for ten different environmental indicators: lack of clean water, lack of urban sanitation, ambient levels of suspended particulate matter in urban areas, urban concentration of sulphur dioxide, change in forest area between 1961 and 1986, annual rate of deforestation between 1961 and 1986, dissolved oxygen in rivers, faecal coliforms in rivers, municipal waste per capita, and carbon dioxide emission per capita. Lack of clean water and lack of urban sanitation were found to be uniformly decline with increasing income, while the two measures of deforestation; change in forest area and annual deforestation rate do not depend on income. River quality found to be worsening with increasing income. Two of the air pollutants- ambient level of suspended particulate matters in urban areas and urban concentration of sulphur dioxide were found to confirm the EKC hypothesis. However, CO_2 emissions, a major contributor to greenhouse gases do not fit the EKC hypothesis, rising continuously with income.

Grossman and Krueger (1995) further examined the relationship between national income and various indicators of local environmental conditions in per capita for both developed and developing countries using panel data from the Global Environmental Monitoring System (GEMS). They found that environmental conditions are worsening with increase in GDP in very poor countries, however, air and water quality appear to benefit from economic growth once some critical level of income has been reached. Once again they proof the existence of EKC. Hitam et al (2012) employing a time series data from 1965 to 2010 have studied the impact of FDI, economic growth and the Environment on quality of life in Malaysia. They have investigated the EKC employing yearly carbon emission as environmental indicator and GDP in per capita at constant market price as a measure of income; and they found the existence of EKC for Malaysia.

However, environmentalist argues that, if the economic process that generates economic growth results in irreversible environmental degradation, then the very process that generates demand for environmental quality in the future will undermine the ability of the ecosystem to satisfy such demand, which may lead to loss of biodiversity. Once some natural environmental resources surpass their threshold, it is impossible or too difficult to come back to the initial state. They argue that it is not good to follow blindly the principle of 'damage the environment in order to grow, and then with the revenues cure it' (Goodland and Daly, 1993).

This complex trade-environmental relation has generated a debate leading to different theoretical explanation for trade-environmental linkage and how trade related environmental problems were transferred from one country to another. Among many conflicting hypothesis, two of them dominate the theoretical discussions about trade-environmental linkages. The first one is the factor endowment hypothesis (FEH),which postulates that factor abundance and technology determine trade and specialization patterns, and countries with relatively abundant in factors used intensively in polluting industries will on average get dirtier as trade liberalizes and vice versa.

Under this hypothesis, on the assumption that capital intensive industries are more pollution intensive than labour intensive industries, heavily capital intensive process will migrate to capital abundant affluent countries. Thus, since developed countries are well developed with capital, this hypothesis predicts that developed countries specialize in producing polluting goods (Perman et al, 2003).

The second hypothesis, the Pollution Haven Hypothesis (PHH), argues that differences in the strictness of environmental regulations between developing and developed countries will generally result in increased pollution intensive production in the developing countries (Cole, 2004). In a country with weak environmental regulations, the use of the environment is relatively cheap to the firm and the use of environment is costly for firms in those countries with strong environmental regulations. Therefore, free trade would lead the South (weak environmental standards), which have a comparative advantage in pollution intensive production, to specialize in pollution intensive goods, while the North (strong environmental standards) having comparative advantage in cleaner goods, specializes in clean[2] production. The works of Copeland and Taylor (2004) supports this view and they have stated that the 'south provides pollution intensive products for the North via trade'.

According to the comparative advantage theory, mutually beneficial trade would emerge if each country specializes in the production and export of the good in which it had a comparative advantage. For instance, the Heckscher–Ohlin (H–O) theory predicts a country has a comparative advantage in producing and exporting the commodity in the production of which the relatively abundant production factors at home are used. However, this theory does not consider environmental externalities that may be associated with the production or consumption of goods (Harris, 2004).

Since 1980s, many of African countries have adopted the structural adjustment program (SAP) aimed at liberalizing their markets, in particular exchange rate policies to improve their trade performance. Ethiopia adopted the Structural Adjustment Program (SAP) in 1992. Before this period, different trade and economic policies were implemented by the different governments that ruled the country. The current government has undertaken trade policy reform as recommended by World Bank and has undertaken comprehensive trade policy reforms on both export and import side. Subsequent policy reforms were made which intends to boost the export sector of the country. More recently, by August 31, 2010, bold exchange rate policy reform has been made by national bank of Ethiopia (NBE), devaluating the exchange rate by 20%, to stimulate the export sector and hence economic growth. Currently the country is following the growth and transformation plan (GTP), which has the ambition to meet the middle-income target before 2025, as outlined in GTP. To put the plan in action, the role of trade is significantly recognized, export need to grow from 14%of GDP to 23% (FDRE, 2011).However, trade liberalization that contributes to growth will contribute to higher levels of pollution and the depletion of natural resources unless the necessary measures are taken to prevent this from happening. Taking the necessary measures, however, involves problem identification first. This study, therefore, is meant to pinpoint the problem.

The policy of trade liberalization and increased openness is seen as a means of stimulating economic growth, especially for developing countries. However, while trade may stimulate

[2]The concepts of clean and dirty product in this paper refer to whether the production process of the commodity or goods/ services releases pollution as by-product or not.

growth, it may simultaneously lead to more environmental pollution. So, it is important to examine whether trade liberalization policies are in fact in conflict with the environment as they accelerate economic growth. Hence such study is timely and crucial. Here question that springs to mind are: Is Ethiopia is attracting dirty industries as the Pollution Haven Hypothesis predicts? Has the current wave of trade positive or negative impact on environment and sustainable development in Ethiopia? In light of these issues, this paper investigates the impact of trade liberalization on environment and how it relates to sustainable development of Ethiopia.

2. Research Methodology

2.1. Nature and Sources of Data

A time series data on both the explanatory and dependent variables from 1981 to 2010 is used. The study has used the data coming from World Development Indicators (WDI), the World Bank data.

Data relating to the capital labour ratio (KL), trade intensity and GDP of Ethiopia used in this study were taken from Penn World Table (PWT). The capital labour ratio figure was deflated by 2000 GDP deflator to make consistent with real GDP which was calculated based on 2000 constant market price in the economy. Finally data referring to the environmental pollution, carbon dioxide (CO_2) emissions were obtained from the Carbon Dioxide Information Analysis Center (CDIAC) (www. cdiac.ornl.gov).

To analyze the impact of trade liberalization on air quality in Ethiopia, the study selected carbon dioxide (Mt of per capita) as a proxy variable for air pollution.

In line with the theoretical explanations, the expected sign and how the explanatory variables are computed is discussed below.

Trade Intensity (TI): Trade intensity is considered as an indicator to measure the level of trade liberalization, trade openness and integration’s level to the world economy. This variable aims at capturing effects of trade liberalization and openness to the world economy has on the environment.

Trade intensity or the level of openness is calculated as the ratio of the sum of exports (X) and imports (M) of goods and services to GDP; (X+M)/GDP).

Per capita GDP (GDPC): per capita GDP is calculated as the ratio of total GDP of the country during specific year to the total population of the same year, it captures the scale effects of trade. The scale effect of trade refers to the increase in the economic activity caused by freer trade, the higher economic activity the higher expected environmental pollution. So, it is expected that scale effect of trade liberalization is negatively related to environmental quality or positively related with air pollution.

Per capita GDP square (GDPCsq): is the squared of per capita GDP, it measures the technique effect. The technique effect refers to the changing techniques of production that are likely to accompany liberalized trade. The technique effect of trade liberalization on environmental quality is expected to be positive.

Capital Labour Ratio (KL[3]): It is the capital abundance obtained from physical capital stock per worker, captures the composition effect of trade. The composition effect of trade refers to the change in economic structure as countries start to specialize in activities in which they have comparative advantage. This may have either positive or negative impact on environment depending on whether the country attracts dirty or clean industry when trade is liberalized.

Economic Growth (EG): Economic growth is calculated as the percentage change in real GPD of the country, based on 2000 constant market prices. This variable is used for measuring impacts of economic growth on environmental pollutions. Rapid economic growth is necessary to improve human well-being. However, rapid economic growth itself is not sufficient for the improvement of environmental quality unless it is on sustainable basis. So, the effect of economic growth on environment depends on whether the growth path of the country is on sustainable basis or not. Meaning economic growth can have either positive or negative impact on environmental quality depending on whether it is on sustainable base or not.

Population Density (POPD): Population density is computed as the total number of population the country at year t divided by the total surface area of the country (Pop/ S). People uses environment in his /her daily life either directly or indirectly. As such, higher population density degrades the environment more. Population density is chosen as an explanatory variable in order to capture impacts of an increased in population on environment.

2.2. Estimation Method

The study aims at investigating the environmental impact of trade liberalization and implications for sustainable development in Ethiopia. In doing so, the Johansen co-integration and error-correction model technique were used in order to examine the long

[3] Capital stock is the sum of residential, non residential and other construction, transport equipment and other machinery (source: Penn World Table)

run and the short run dynamics of the system respectively. All the variables used for the empirical analysis of this study are time series. However, the problem of non-stationarity is the main challenge in the practice of econometric analysis in dealing with time series variables. In regressing one time series variable on another time series variable, a very high R^2 significant t-values and F-statistics can be obtained although there is no meaningful relationship between the variables. This problem is referred to spurious regression (Gujarati, 1995). Therefore, it is very important to find out if the relationship between economic variables is true or spurious. This is done by first identifying stationary and non-stationary variables. The stationarity of the variables of the model will be tested by DF/ADF and the PP unit root tests.

2.3. Model specification

The model employed in this study is similar to the one utilized by Antweiler et al (2001) in which trade related pollution determinants were decomposed into scale, composition and technique effects. Many recent empirical studies on environmental impact of trade liberalization have employed Antweiler et al (2001) specifications, for example Feridun (2006), Bruhetayet Mulu (2009), Alam et al (2011), and Hitam et al (2012). This study is more similar to that of Bruhetayet Mulu (2009) with respect to variables used in the model.

However, unlike her study, this study focuses on the short run and long run impact of trade on environment using a time series data of single country (not cross country evidence). More specifically, the study employs the empirical model of the following functional form:

$$C0_{2_t} = \beta_0 + \beta_1 TI_t + \beta_2 GDPC_t + \beta_3 GDPCsq_t + \beta_4 KL_t + \beta_5 EG_t + \beta_6 POPD_t + \mu_t \qquad (1)$$

Where $C0_{2_t}$ is metric tons of per capita Carbon dioxide emission at year t, TI_t is the trade intensity or trade openness at year t, $GDPC_t$ is the GDP per capita at year t, $GDPCsq_t$ is the GDP per capita square, KL_t is the capital labour ratio, EGt is the economic growth, $POPD_t$ is the population density at time t, and μ_t is error term.

3. Results

3.1. Stationarity Test

The ADF test result summarized in table 1 shows all variables are stationary after differenced one under both scenarios: when both trend and constant is included and with constant term. So, the null hypothesis of non- stationarity is rejected for all variables at 1%.

Table 1: ADF Unit Root Test

Variable		DF test statistics		ADF test statistics	
		Level		First difference	
		Constant only	Const. and trend	Constant only	Const. and trend
CO_2		-2.165 [0]	-2.086 [0]	-6.397* [0]	-6.387*[1]
TI		-1.041 [0]	-1.897 [0]	- 6.026*[0]	-5.939*[0]
GDPC		-0.098 [0]	-0.329 [0]	-7.263*[0]	-7.714*[0]
GDPCsq		-0.098 [2]	-0.329 [5]	-7.263*[0]	-8.157*[0]
KL		-2.607 [0]	-2.570 [0]	-4.250*[0]	-4.254*[0]
POPD		-0.203 [0]	-1.465 [0]	-4.911*[0]	-4.855*[0]
EG		-2.093 [2]	-2.925 [1]	-10.452*[0]	- 10.355*[0]
Critical values	1%	-3.623	-4.241	-3.613	4.212
	5%	-2.941	-3.540	-2.934	-3.536

Note: Figures in brackets are lag order

Similar test is also conducted using the Phillips-Perron (PP) unit root test. The same result is obtained confirming that all variables are non stationary at their levels and become stationary after differenced once.

Table 2: PP Unit Root Test

Variable		PP test statistics			
		Level		First difference	
		Constant only	Const. and trend	Constant only	Const. and trend
CO_2		-2.035	-2.942	-9.346*	-10.440*
TI		-1.073	-1.972	-6.051*	-5.972*
GDPC		-0.172	-0.110	-7.202*	8.218*
GDPCsq		-0.172	-0.108	-7.203*	-8.219*
KL		-1.972	-1.889	-4.152*	-4.077*
POPD		0.098	1.708	-4.986*	-4.881*
EG		2.156	2.098	-7.631*	-7.48*
Critical values	1%	-3.605	-4.205	-3.610	-4.211
	5%	-2.936	-3.526	-2.938	-3.529

Source: author’s computation from Eviews6

This suggests that all variables are integrated of order one, I (1) and hence, the regression under consideration is not spurious

3.2.Estimation of Long run Relationship

Once the variables were found to be stationary and integrated of order one, the next step is the employment of VAR model to estimate the long run co-integration relationship among variables of the model using the Johansen's maximum likelihood method. The Johansen's reduced rank approach to co-integration analysis requires the underlying variables to be integrated of order one, I (1). This was confirmed in previous section using the ADF and PP unit root tests where all variables of the model were found to be stationary at their first difference and hence I (1), satisfying the requirement for employment of Johansen's maximum likelihood approach.

The optimal lag length need to be selected before conducting the Johansen co-integration test. This is done using the well-known information criteria: Akaike information criterion (AIC) and the Bayesian information criterion (BIC). The two criteria differ in their trade-off between fit, as measured by the log likelihood value and parsimony, as measured by the number of free parameters. BIC has the property of selecting almost surely the true model for large number of observation if the model is in class of ARMA while AIC criterion tends to result asymptotically in overparametrized models Hannan (1980) cited in (Verbeek, 2004).

Setting one lag for all variables based on BIC, the following co-integration regression is obtained.

Table 3: Johansen Maximum Likelihood Co-integration Test for CO_2 TI GDPC GDPCsq KL EG POPD Series; the Trace Statistics Approach

Hypothesized number of co-integration equation(s)		Eigen-values	Trace statics	
Null	Alternative		Trace stat.	5% critical Value
r=0**	0<r≤ 7	0.72709	129.4441	124.24
r≤1	1<r≤ 7	0.55818	78.4126	94.15
r≤2	2<r≤ 7	0.39827	45.7387	68.52
r≤3	3<r≤ 7	0.28032	25.4211	47.21
r≤4	4<r≤ 7	0.18471	12.2629	29.68

r≤5	5<r≤ 7	0.08049	12.2629	15.41
r≤6	6<r≤ 7	0.01829	0.7382	3.76

Note: ** denotes the rejection of null hypothesis at 5% level of significance.

Table 4: Johansen Maximum Likelihood Co-Integration Test for CO_2 TI GDPC GDPCsq KL EG POPD Series, the Maximum Eigen-Value Statistics Approach

Hypothesized number of co-integration equation(s)		Eigen-values	Maximum Eigen-Value	
Null	Alternative		Max. Eigen-Value Statistics	5% critical Value
r=0**	r=1	0.72709	51.0315	45.28
r≤1	r=2	0.55818	32.6739	39.37
r≤2	r=3	0.39827	20.3176	33.46
r≤3	r=4	0.28032	13.1582	27.07
r≤4	r=5	0.18471	8.1683	20.97
r≤5	r=6	0.08049	3.3564	14.07
r≤6	r=7	0.01829	0.7382	3.76

Note: ** denotes the rejection of null hypothesis at 5% level of significance.

The maximum and trace statistics of Johansen's con-integration test results reported in table3 and table 4 shows that null hypothesis of no co-integration is rejected in favour of alternative hypothesis of one co-integrating equation at 5% level of significance. This indicates that there is one co-integrating equation that offers long run equilibrium relationship among the variables of the model: Per-capita CO_2 (Mt of per capita), TI, GDPC (in US dollar), and GDPCsq (in US dollar), and KL (in US dollar), EG and POPD

However, the result from table3 and table4 does not convey information about which variable is explained as a linear combination of the others. This necessitates undertaking the weak exogeneity test. The weak exogeneity test undertaken using the first column of α-coefficients was reported in table 5 and the result shows that the null hypothesis that 'the variable is weakly exogenous' is rejected only for CO_2. TI, GDPC, GDPCsq, KL, EG and POPD were accepted to be weakly exogenous.

Table 5: LR Test on Zero Restriction on α Coefficient (Weak Exogeneity Test)

Variable	CO_2	TI	GDPC	GDPCsq	KL	EG	POPD
LR test: $\chi^2(1)$	7.4552	2.8025	0.2253	3.3456	0.0147	0.1447	0.0026
Probability	0.0063*	0.1094	0.8807	0.1674	0.9032	0.7036	0.9590

* Denotes significance at 1% level of significance

Having identified the endogenous variable of the model using the weak exogeneity test and variables are found to have one co-integrating relation confirmed by both trace and maximum Eigen-value statistics, the following long run equation is formulated taking the first row of β' coefficients

Table 6: Normalized β' Coefficients

CO_2	TI	GDPC	GDPCsq.	KL	EG	POPD
1.0000	-0.00561	0.000264	-2.66E-6	-0.00117	0.000144	0.001161

$$CO_2 = \underset{(0.00104)}{-0.005611TI} + \underset{(0.00012)}{0.000264GDPC} - \underset{(1.2E-6)}{2.66E^{-6}GDPCsq} - \underset{(1.2E-6)}{0.001174KL} + \underset{(0.00074)}{0.00144EG} + \underset{(0.00083)}{0.001161POPD} \quad (3)$$

Figures in brackets are standard errors.

The significance tests of explanatory variables conducted using likelihood ratio (LR) test reported in table7 shows that GDPCsq which measures the technique effect of trade was found to be statistically insignificant. Once CO_2 is found to be weakly endogenous and treated as the dependent variable of the model, there is no need to make significance test for it.

Table 7: LR-Test of Zero Restrictions on the Long run Parameters (Test of Significance)

Note: * & ** denotes significance at 1% and 5% level of significance respectively

Variable	TI	GDPC	GDPCsq	KL	EG	POPD
LR Statistics:$\chi^2(1)$	4.38617	0.14709	8.1131	3.3119	4.1508	6.8417
Probability	0.0336**	0.0043*	0.7013	0.0687**	0.0141*	0.0089*

The diagnostic test of the model shows that the model does not suffer from any problem of serial correlation, hetroscedasticity and specification problems and the residual is normally distributed (Appendix , Table 2).

The autocorrelation test conducted using LM test of Breusch and Godfrey indicates no evidence of autocorrelation for the specified lag order. The Breusch-Pagan-Godfrey (BPG) Lagrange multiplier hetroscedasticity test conducted shows that there is no evidence of hetroscedasticity problem in the residuals of the model. Jarque-Bera residual normality test also suggests that the residual is normally distributed. The model specification test conducted using the Ramsey RESET test indicates the null hypothesis that the model is correctly specified was failed to be rejected at convectional significance level. This implies the model is correctly specified and there is no problem in the functional form specification of the model.

The structural break test conducted using the chow break point test taking 1991 as the possible date for structural break date following policy measures undertaken by the current government toward trade policy, indicates the null hypothesis of no structural break is not rejected at the specified year. This implies the estimated coefficients of the model remain the same throughout the study period under consideration (Appendix, Table 2).

The multicollinearity problem is tested using the correlation matrix of residuals (Appendix, Table 3). High pair wise correlation was found only between GDPC and GDPCsq which is expected. Even this does not invalidate the result; imperfect multicollinearity does not pose any problems for the theory of the OLS estimators (Stock and Watson, 2001).

The stability of model is tested using cumulative sum and cumulative sum square of recursive residuals. Both the cumulative sum and cumulative sum square of residual stays within bound indicating the model is stable at 5% level of significance. All the inverse of AR roots of characteristics polynomial of the equation lies inside the unit circle suggesting the same result i.e. stability of the model

Coming to the long run implications of estimations results of (Equation3), the normalized trade intensity coefficient is negative (Table 6) and statistically significant at 5% level of significance (Table 7). The negative coefficient of trade intensity implies there is decreasing trend between trade and per capita carbon dioxide emissions in Ethiopia. This indicates that the long run effect of trade intensity on the environmental quality is positive; one percent increase in trade liberalisation results in 0.006 percent decrease in metric tonnes of per capita carbon dioxide emission in Ethiopia.

The estimated long run coefficient of scale effect is positive (Table 6) and statistically significant at 1% level of significance (Table 7). This indicates positive relation between the scale of economic activity measured in Gross Domestic Product in per capita terms and the per capita carbon dioxide emissions.

The coefficient of GDPCsq (the technique effect of trade) is negative (Table 6) but statistically not different from zero (Table 7). The composition effect is statistically significant and is environmental friendly.

The estimated coefficient of economic growth is positive (Table 6) and significantly (Table 7) explains the long run per capita carbon dioxide emissions. The positive coefficient of economic growth shows that economic growth is positively contributing to the carbon emissions in Ethiopia and hence adversely affecting the environment. The coefficient of population density is positive and it significantly explains the environmental pollution measured in terms the level of per capita carbon emissions in air.

3.3.Estimation of the Error-Correction Model (ECM)

Estimating the long run co-integration relationship is half way to the complete model. In this section, the error-correction model (ECM) for response variable, CO_2, is estimated to understand the short run dynamics of the system in the model.

In estimating the short run dynamics of the model, the weak exogeneity test conducted by imposing restrictions on α-coefficients has important implications in identifying any simultaneity in the model. The weak exogeneity test reported in table 5 shows that the null hypothesis that "the α-coefficient of row i contains zero" was rejected for carbon dioxide only. This implies that there is single endogenous variable in the model and hence there is no problem of simultaneity in the specified equation and that we can continue with estimation of single short run error-correction model.

To estimate the short run error correction model, the general to specific approach applied by Hendry (1995) is adopted to obtain the parsimonious model. Setting one lag for all explanatory variables including the error correction term, and gradually eliminating the insignificant lagged terms, the OLS results of the model is presented in the table7.

Table 8: Short run Estimation Result

Variable	Coefficient	t-value	Sd. errors
Constant	-0.00571294	-2.26**	5.2e-5
ΔTI	-0.00121213	-2.11**	5.7e-7
ΔGDPC	$6.12234e^{-5}$	2.23**	0.00058
ΔGDPCsq	$-1.54940e-^{6}$	-2.72**	0.0016
ΔKL	$-7.15194e^{-5}$	1.97**	3.6e-5
ΔEG	0.000580863	-0.97	0.0025
ΔPOPD	0.00514872	3.21**	0.15
ECM_1	-0.789257	-5.38**	0.00019

Note: * ** indicates significance at 1%and 5% level respectively.

R^2 =0.79582   Adjusted R^2=0.759788   F (8, 32) = 7.953

$$\Delta CO2 = -\ 0.00571 - 0.00121\Delta TI + 6.12e^{-5}\Delta GDPC - 1.55e^{-6}\Delta DGDPCsq - 7.15e^{-5}\Delta KL +$$
$$(5.2e\text{-}5) \quad (5.7e\text{-}7) \quad (0.00058) \quad (0.0016) \quad (3.6e\text{-}5)$$
$$0.000581\Delta EG + 0.00515\Delta POPD - 0.789ECM\_1 \quad (4.2)$$
$$(0.0025) \quad (0.15) \quad (0.00019)$$

Where ECM_1 is the one year lagged error correction term, Δ is the first difference operator; all other variables are as defined earlier and figures in brackets are standard errors.

The error correction term has its expected negative sign and is highly significant. The coefficient of the error correction (-0.789) measures the speed of adjustment to long run equilibrium, the figure shows almost 80% of the deviations in the short run would be corrected in one year and it will completely converges to its long run equilibrium in one year and three months' time.

The t-statistic shows that all variables are individually significant at convectional significance level except economic growth and the F-statistics shows the variables are jointly significant.

The diagnostic testing of the model shows there is no problem of serial correlation, no hetroscedasticity problem and the residual is normally distributed. The Ramsey's RESET test suggests that there is no misspecification problem of the selected functional form. The value of the coefficient of determination (i.e., R^2) indicates about 80% variation in the per capita carbon dioxide emission is explained by the included variables of the model

Similar to the long run estimation result, trade intensity has negative coefficient and significant at 5% significance level.

The composition effect has negative coefficient and is significant at 5%. The short run coefficient of scale effect is positive and significant at 5% level. This is similar to the long run result. The estimated coefficient of GDPC squared is statistically significant and negative evidencing the EKC hypothesis.

Unlike the long run case, the short run coefficient of Economic growth is insignificant even though the sign is the same in both cases. The short run impact of population density on carbon emission is positive and significant at 1 percent. This is similar to the long run estimation result.

3.4.The Variance Decomposition and Impulse Responses

In this section, the study turns to perform the variance decomposition which helps us to separate the variation in an endogenous variable into the component shocks to the VAR. This provides information about the relative importance of each random innovation in affecting the variables in the VAR focusing on the forecast error variance (FEV) of individual variables. The source of this forecast error variance is the variation in the current and future values of the innovations to each endogenous variable in the VAR. The variance decomposition and impulse response is based on the Cholesky factor, altering the order of the variables in the VAR will dramatically change the variance decomposition and impulse response.

The variance decomposition and the impulse response are out of sample tests which provide us knowledge about the dynamic properties of the system beyond the sample period.

The forecast variance of carbon dioxide is displayed in table 9. A major portion of variation in carbon dioxide emission is explained by shocks in the trade intensity in long run, which explains about 49% from 16 years onwards. Population density and the composition effect (KL), explain very small variation in carbon dioxide both in long run and short run, while the variation in carbon dioxide explained by the shocks in scale (GDPC) and technique effect (GDPCsq) is relatively greater in medium term.

The response of carbon dioxide emissions to the shocks in trade openness, scale effect, technique effect, composition effect, economic growth and population density was illustrated in appendix. As it was shown in the figure, the response of CO_2 to the shocks in trade openness is negative. A shock in composition effect (KL) initially has a positive effect on carbon dioxide emission and then has negative effect after almost four years. The variations in CO_2 explained by the shocks in technique effect is relatively larger in short run to medium term (up to six years) and the effect is positive though out while the shocks in population density and economic growth have positive effect on CO_2, but the effect of economic growth up to almost four year is negative.

Table 9: Variance Decomposition of Carbon dioxide

Period	CO2	TI	GDPC	GDPCsq	KL	EG	POPD
1	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	81.03486	7.452622	4.125626	3.780525	0.813694	2.356898	0.435775
5	73.94738	6.807343	4.050342	11.46185	0.858143	2.159505	0.715437
10	64.66527	7.922838	10.06763	13.32971	0.760629	2.438245	0.815682
12	58.25551	15.70359	9.830951	12.38804	0.687625	2.392010	0.742272
16	33.92088	48.79186	6.710986	7.450159	0.407769	2.045310	0.673030
20	12.87080	76.46691	4.835415	2.861659	0.179285	1.952678	0.833250
25	3.096475	89.21079	3.890570	0.903354	0.094818	1.886131	0.917864

4. Discussions

Motivated by the growing international debate on the trade-environmental linkage, this study has analysed how trade liberalization policy can affect environment and sustainable development in Ethiopia**.**

The study found the existence of a long run co-integrating equation, indicating a valid long run relationship among the trade liberalization and environmental indicator.

Both in the long run and short run trade intensity has negative coefficient. This implies more openness and integration to the world economy is environmental friendly for Ethiopia. The result is in line with empirical findings of Alam et al (2011). This result supports the factor endowment hypothesis which states differences in factor endowment and technologies determine patterns of trade. This implies the level pollution would fall in capital scarce countries like Ethiopia and rise in capital intensive countries.

The negative coefficient of composition effect indicates the comparative advantage the country is following is environmental friendly. Theoretically, the impact of composition effect on environment depends on whether the source of comparative advantage derives from difference in factor endowment and technology which FEH states or difference in cross-country income and hence difference in environmental policy standards-the PHH view point. The result obtained here shows Ethiopia has comparative advantage in clean production indicated by negative coefficient of composition effect. The result is logical as Ethiopia has comparative advantage in agricultural production and labour intensive industries which is relatively cleaner than the northern comparative advantage in capital intensive sectors in the international trade.

The expansion in the scale of economic activity has negative effect on environment which positively contributes to carbon emission. The result is in line with empirical findings of Grossman and Krueger (1991, 1993, and 1995) and Antweiler et al (2001) and is consistent with theoretical expectations-the increase in scale of economic activity as measured by growth in output necessitates more consumption of environmental resources which would lead to more pollution emissions.

The convectional EKC hypothesis fails to hold in long run. The basic idea behind EKC as Grossman and Krueger (1991, 1993, and 1995) and other supporters of EKC argue is although growth is not good for environment at early stages of economic growth, later on it reduces pollution as countries become rich enough to pay to clean up their environments. The result obtained here does not evidence the existence of technique effect but it was found that scale effect of trade affects the environment negatively. This indicates that developing countries like Ethiopia are living through part of the Environmental Kuznets Curve in which environmental conditions are deteriorating with economic growth.

However, the short run result suggests that there is an evidence of positive technique effect which tends to reduce the adverse environmental effect of scale effect, but the scale effect is stronger than the technique effect. The result is consistent with empirical findings of Bruhetayet (2009) found in her cross country evidence in Sub-Saharan African countries. Anweiler et al (2001) in their empirical studies on cross-countries, found strong technique effect than scale effect. The result found in this study shouldn’t be surprising as the stronger scale effect in developing countries, like Ethiopia, is what is expected.

Higher population density makes the environment more polluting. Human activity either directly or indirectly contributes to the release of pollutants into the atmosphere which are a threat to the health and natural ecosystem, and hence add to the greenhouse gases Kennedy (1999 cited in Hitam et al, 2012). This suggests an increase in population density in Ethiopia results in an increase in carbon emission which adversely affects the environmental quality. Poverty related short term thinking in search for daily survival is the main cause for depletion of natural resource which has significant contribution to the greenhouse emissions in developing countries (Yale University, 2005).

The result points that the comparative advantage Ethiopia has is beneficial for environment and sustainable development. Thus, further diversification on those areas where the country has comparative advantage in international trade should be made so as to maximize the gains from trade. So, in negotiating with her trading partners, Ethiopia has to critically examine and identify her trading opportunities so as to ensure that decisions which endanger areas where the country exhibits comparative advantage should not compromised.

To achieve a sustainable development and high-quality environment, environmental costs associated with expansion in economic activity should be minimized i.e. scale effect should be kept in check. This could be made possible through the use of environmental friendly technologies especially in areas where the economy is rapidly expanding. In this regard, the role of government is crucial in making these technologies familiar and creating awareness about the use of such technology has for sustainable development and quality environment.

Economic growth is found to be positively related with environmental pollution indicating economic growth is detrimental to the environment. This demands the formulation of economic and environmental policies simultaneously so that the achievement one does not jeopardize the other. Environmental policies should be integrated into the design of sectoral development policies so that economic and environmental interdependence should not be disturbed and sectoral linkage should be recognized. The current source of economic growth in Ethiopia, which is mainly based on agriculture, should factor in the value of environment and growth should be in a way that does not harm the environment. The expansion in agricultural production can be made by improving the quality of agricultural land through conservation which can also improve the long-term prospects for agricultural development.

The government should enforce the environmental laws at all levels of governance so that there shouldn't be the transfer outdated technologies which are detrimental to environment. The processes of generating alternative technologies, upgrading traditional ones, and selecting and adapting imported technologies should be made in a way that considers the socio-economic set up and environmental conditions of the country. Moreover, environmental regulation must move beyond the usual safety regulations and environmental policy must be built effectively into prior approval procedures for investment and technology choice, and all components of development policies.

Alleviating the problem of poverty will also reduce heavy reliance on environment in search for daily life which has significant contribution to environmental damage and carbon emission.

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Appendices

Table A1: Lag Order Selection

Lag	0	1	2	3
AIC	56.474	46.407	45.721	44.786*[4]
BIC	56.776	48.820*	50.246	51.423

Table A2: Diagnostic Test for Long run Equation

Test	Testing method	Test statics	P-value
Normality	Jarque-Bera (LM-test)	χ^2 (2)=0.5656	0.7536
Hetroscedasticity	Breusch -Pagan-Godfrey (LM-test)	F(6,34)=0.9179	0.4942
		χ^2 (6)=5.7158	0.4558
Autocorrelation	Breusch –Godfrey (LM-test)	F(1,34)=2.1049	0.1560
		χ^2 (1)=2.3902	0.1221
Functional form	Ramsey (RESET test)	F(1,34)=0.1586	0.6929
		χ^2 (1)=0.1908	0.6622
Structural break Break date: 1991	Chow beak point test	F(6,29)=0.2642	0.9491
		LR: χ^2(6)= 2.1821	0.9022
		Wald: χ^2(6)=1.5852	0.9536

Table A3: The Correlation of Residual Matrix

	CO_2	TI	GDPC	GDPCsq	KL	EG	POPD
CO_2	1						
TI	0.032643	1					
GDPC	0.186051	0.223276	1				
GDPCsq	-0.177246	0.166833	0.992070	1			
KL	0.219937	0.114181	0.259379	0.414194	1		
EG	0.239670	0.505916	0.500016	0.366576	0.369549	1	
POPD	0.462134	0.313259	0.428627	0.403757	0.187430	0.293671	1

[4] * indicates the selected lag order by criterion.

Figure 1: CUSUM of Squares residual

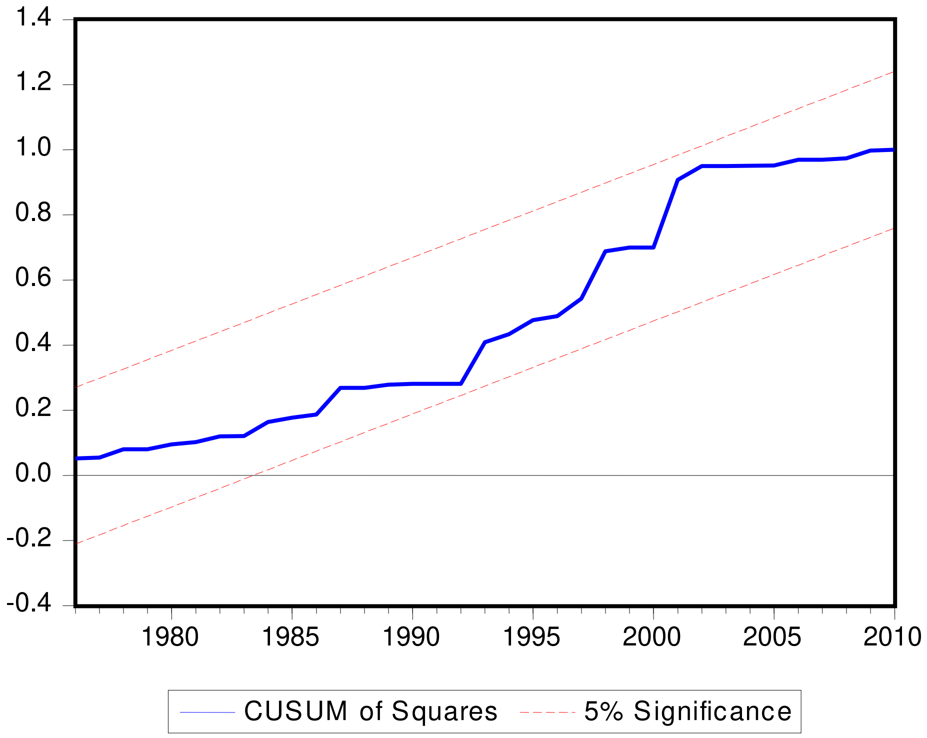

Figure 2: CUSUM of Residual

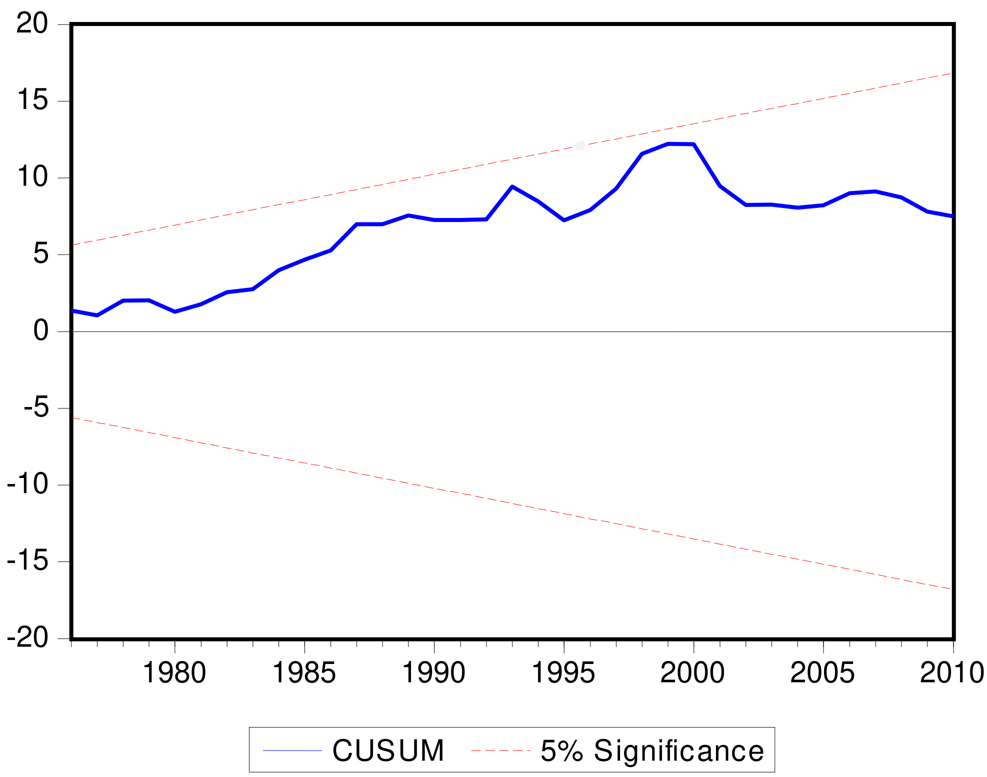

Table A4: The Short run Diagnostic Tests

Test	Testing method	test statics	P-value
Normality	Jarque-Bera (LM-test)	χ^2 (2)=2.8313	0.2428
Hetroscedasticity	Breusch -Pagan-Godfrey (LM-test)	F(7,32)=0.7581	0.6950
		χ^2 (7) =0.6528	0.5835
Autocorrelation	Breusch -Godfrey (LM-test)	F(1,32)=0.1952	0.6620
		χ^2 (1)=0.2089	0.6134
Functional form	Ramsey (RESET test)	F(1,32)=0.1866	0.6690
		χ^2 (1)=0.2035	0.5794

Figure 3: Impulse Responses of CO_2 to One-standard Deviation Shocks in Trade Openness, Scale effect, Composition effect, Technique effect, Economic growth and Population density