Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.14, 2016

Impact of Trade on the Environment: Evidence from Nigeria's Time Series

HASSAN, Anthony Emmanuel
Department of Economics, University of Abuja, P. M. B 117, Abuja, Nigeria

Acknowledgement
I wish to thank my thesis supervisors, Professor Olaniyi Oyinlola and Professor Siyan, Peter for their invaluable inputs as this study is harvested out of the thesis. The various inputs by colleagues in the department are as well immensely appreciated. I also wish to acknowledge the authors whose works were cited in this study and World Bank (World Development Index) as well as the Central Bank of Nigeria for data used for this study

Abstract
This study considers the impact of trade on the environment for Nigeria's economy. It employs Vector Autoregressive (VAR) model on Nigerian economy data over the period 1990 to 2014. It finds that within the VAR model built, trade impacts the environment mildly while the environment is also an important factor in the line of trade for a developing and natural resources driven economy like Nigeria, both over the short and the long run. The relevant authority in the Nigerian economy is hence advised to fashion policies that will explore the dynamics between trade and the environment as this can have implications for sustainability of economic growth. Given the middle low income status of the Nigerian economy and its dependence on natural resources endowments to drive economic growth, caution need to be taken not to inflict irreparable damage on the environment. Trade policies should be forward looking in relation to the environment rather than for attracting all sorts of foreign investments for immediate benefits.
Keywords: Trade, Environment and Sustainability

1. Introduction

The dearth of capital is said to have been propagated by low income and savings in the developing countries. This has been the reason why middle to low income countries seek for foreign investment and open their economies to trade. Trade theories indeed posit that advantages arise from trade under certain conditions in the event of abundant natural resources which could also confer cost plusses in some cases. However, it remains arguable whether the terms of trade between the developing economies and the developed ones are fair. In other words, does trade leaves the developing economies better-off in terms of economic gains and the opportunity cost of the trade as it relates to the effect of such trade on the environment?

An understanding of these lines of thought has been the basis for trade policies across economies and a trade-off surely exist. For instance, an indiscriminate openness of an economy to trade might mean reduction of the local economy's productive capacity and job creation as well as increase potential to inflict damage on the environment. This is particularly so, when a country's trade policy is friendly to polluting industries in an attempt to attract investment that will explore natural resources.

As it is, the Nigerian economy is arguably at the receiving end not only because the trade pattern is not in her favour and is a consumption economy, but also because the opportunity cost of trade in terms of the environment is getting pronounced by the years. The environmental consequences of liberalized trade has been a subject of debate in the academic community. The issues surrounding global warming, species extinction and industrial pollution are some of the high points of the debate as these phenomena extend beyond national borders. The consequences of global warming are manifesting faster than one can imagine with flooding, desertification and shrinking of forest reserve being experienced in the country at the moment. More so, trade libralisation and over dependence on crude petroleum and natural gas as the main income earner for the country to finance developmental projects constitute potential cost to the environment.

In addition, the emergence of Free Trade Agreement and the Uruguay round of General Agreement on Tariffs and Trade (GATT) negotiations and World Trade Oganisation (WTO), for the purpose of reducing international trade barriers in terms of tariffs, quotas and subsidies, has been the wheel upon which trade liberalization is being driven. This wheel has been severally criticized by analyst in the developing countries, where the brunt of trade has been mostly borne. The biases in favour of the advanced economies as it relates to it control, policies and gains from trade has been severally noted (Action Aid, 2003; Steger, 2009; Clapp & Wilkinson, 2010).

Research in the area of trade and the environment have increased over time with the sustained debate on the issues of climate change, species extinction and the general deteriorating state of the global environment. A strand of the literature is of the opinion that while trade is desirable, it has to be undertaken with the view to preserving the environment. Considerable number of studies suggest that tax policies should be strengthened to check the activities of polluting industries while it was quickly added by some studies that excessive tax in itself can be counterproductive, as it can hinder economic growth. This paper therefore seek to contribute to the debate by investigating the effect of trade on the environment and also extend empirical analysis to recent period in relation to the Nigerian economy.

This introduction is immediately followed by a brief review of the literature, specification of model, the data employed plus the method, result and the concluding remark.

2. Review of Literature

This section of the paper reviewed related studies from a number of perspectives. For instance, Whaley (2011) argued that trade widens the range of jointly beneficial outcomes and can be a potential facilitator of an agreed upon global climate regime. Ayres (1996) and (Daly, 1993) argued that competition promoted by free trade encourage lowering of environmental standards and wages at a global level, producing environmental deterioration, lower wages and enlargement of unemployment. Muradian and Martinez-Allier (2001) added that free competition between differing internalizing regimes is utterly unfair because it would produce a situation of ‘race’ to the bottom.

Li (2015) investigated the link between trade, capital accumulation and the environment using a two sector Ramsey model taking agriculture as being impaired by pollution form production. He noted that trade raises capital rental and encourages investment. However, he observed that under laissez faire, scale effect leads to environmental degradation in the long run, even if the economy specialises in the relatively clean sector. The study underscores the fact that in the long run, specialisation pattern is influenced by pre-trade comparative advantage. He suggested that a dynamic version of the Pigouvian tax, with a lump-sum transfer to households can lead to social optimum welfare gain.

Frankel & Rose (2005), Considered the effect of trade on a country's environment, for a given level of GDP taking specific account of the endogeneity of trade and using exogenous geographic determinants of trade as instrumental variables. They found that trade tends to reduce three measures of air pollution. Statistical significance is high for concentrations of SO_2, moderate for NO_2, and lacking for particulate matter. Their result indicates that other environmental measures are not as encouraging and that overall, little evidence exists that trade has a detrimental effect on the environment.

Hung & Tuan (2016) assesses the impact of trade liberalization on the environment in Vietnam. Their study looks at the relationship between the amount of pollution produced by the country’s manufacturing industries and the degree to which this is affected by trade liberalization policies. The study finds that trade liberalization in the country worsens industrial pollution at both the firm and industry level. They express their worries for the trade-off between liberalisation and industrial pollution given that Vietnam has recently become a WTO member and further trade liberalisation commitments are likely. The finding from this study further gives voice to the call for trade reforms that factor in the environment. Polluting industries should be made to undertake environmental clean-up while environmental agencies ensure strict enforcement of environmental standards and use of cutting-edge technologies.

McAusland and Millimet (2013), develop a theoretical model identifying channels through which trade impacts the environment. They align to the position that trade decouples some of regulation's costs from its benefits and prompt demand for stringent environmental regulations. They also posit that trade provides consumers with access to new varieties of goods; the associated income (substitution) effect raises (lowers) demand for strict regulation. In addition, they noted that international trade is more environmentally beneficial than intra-national trade due to a stronger decoupling effect, and that both intra and international trade are pro-environment unless substitution effects are sufficiently strong. Using data on intra and international trade for the US and Canada, along with several environmental outcomes, they find robust evidence that international trade has a statistically and economically beneficial causal effect on environmental quality, while intra-national trade has a harmful impact. This pattern is consistent with a moderate-sized substitution effect along with a stronger decoupling effect of international trade.

Using time series data from 1970 to 2010 (Appiah-Konadu, 2013) examines the relationship between trade liberalization and the environment in developing countries employing least squares multiple regression technique to estimate the effect of trade openness on the environment in Ghana. The study estimates composition, scale and technique effect of trade liberalization on Ghana’s environment using Carbon Dioxide (CO_2) emission and Net Forest Depletion (NFD) as proxies for environmental degradation. The results show that trade liberalization has adverse effect on emissions of carbon dioxide as a result of negative scale and composition effects of trade overriding the positive technique effect of trade. The lesson for resource rich developing economies is to accompany trade liberalization policies with strict enforcement of environmental regulations in order to avert the adverse impact of trade on the environment

Kreickemeier and Richter (2014), derive a new effect of trade liberalization on the quality of the environment. They showed that in the presence of heterogeneous firms, the aggregate volume of emissions is influenced by a reallocation effect resulting from an increase in the relative size of more productive firms. Emission intensity at the firm level determine the reallocation and scale effects. Domestic emissions decrease as a result of a unilateral tariff reduction if and only if firm-specific emission intensity decreases strongly with increasing firm productivity. As a result of the induced change in foreign emissions, domestic pollution can increase even if domestic emissions decrease.

Shen (2008), used panel techniques to evaluate the effects of scale, composition and technology on environmental degradation in China over the period 1993-2002. The results showed that the hypothesis of a factor for China is approved and that rise in exports lead to environmental degradation.

The analyses of the impact of economic growth and international trade on the level of air pollution is the aim of the study by (Kukla-Gryz, 2009) He estimates the structural equation model with two factors describing the structure of economic activity and air pollution intensity. The study assumes causal link exist between these two factors and that they are influenced by per capita income, international trade intensity and the Freedom House Index. The results show that in the developing countries analysed, both international trade and per capita income lead to changes in the structure of economic activity leading to increase in air pollution. The results further suggest that impact of economic growth on air pollution intensity varies between the developing and developed countries. In respect of developing countries, this impact occurs through the change of the structure of economic activity, while in the developed countries, this impact is mainly direct and occurs through *scale effect* and *income effect*.

This finding is in line with Dutch disease in which the booming natural resource based sector diverts attention away from other productive sectors and the income earned from the booming sector is being used for ostentatious living that are inimical to the environment. For instance, instead of raising power generation capacity for the Nigerian economy from the huge resources that have accrued to the country through crude petroleum and natural gas, air and noise polluting diesel engine power generators in addition to countless carbon consuming automobiles are being imported. This has the tendency to impact the environment negatively.

In addition, Keho (2015), employing the Pool Mean Group estimator proposed by Pesaran et al. (1999), examined the long-run impact of international trade on the environment in a panel of 11 ECOWAS countries over the period 1970-2010. They found that international trade contributed to the degradation of the environment. The income component of his study gave support to the environmental Kuznets curve hypothesis.

Furthermore, Aller et al (2015), analysed the role of the world trade network on the environment. Relying on methods developed for social network analysis to identify the most important countries in connecting trade between all the other countries in the world trade network, they estimated how the network or indirect effects from trade affect the environmental quality of a country. They posit that trade networks are endogenously determined by trade and environmental conditions and used as instrumental variables, the growth in the population of trade partners and the growth in the population of trade partners' partners to exploit exogenous variation in the world trade network. The environmental, trade, income, and network equations were simultaneously estimated using a three-stage least square procedure and found that network effects harm the environmental quality of developed countries but improve the environment of developing countries. In essence, the choice of trade partners in the international trade arena need to be an informed one.

3. Model Specification

The Keynesian model places the bulk of the task of economic reengineering at the door step of the government policies and that the activities in the real sector of the economy need to be guided as situation demands, by the so called "invisible hand". For instance, economic theory postulates that taxes and tax policies can be used to stabilise the economy just as government spending, though the latter is largely dependent on the former. How taxes and government spending are manage can to a large extent determine the pattern and outcome of trade and consequently, affecting the environment. Government policies in term of investment, for example, can either promote or discourage trade and by implication economic growth.

In addition, another critical factor that can affect trade direction and ultimately the environment is the exchange rate policy of the government. A misaligned exchange rate policy can over or under value a country's currency. It has been argued that the currencies of most economies which suffers from the so called 'Dutch disease' are in most cases over valued as the resource boom in the affected sector diverts the economy away from the long run economic growth activities. Accordingly, the prices of non-tradable (services and construction) soar. This can be a plus for the environment if the economy is of high income status and has a well-developed manufacturing sector which engages abatement technologies.

The word environment can be generic in nature, so the practice from the literature has been to employ some sort of proxies that helps drive home the point being made. In this case, we employ carbon emission (CO_2) as environmental variables. (See Budzianowski, 2012).

Base on this conjectural analysis, it can be deduced that macroeconomic policies have an indirect and a wide spread impact on a countries' resources and environment. Accordingly, the following model was specified for this paper.

$$CO2_t = \beta_0 + \beta_1 IM_t + \beta_2 EX_t + \beta_3 OPN_t + \beta_4 EXR_t + e_t \quad (3.1)$$

Where: CO_{2t} = Carbon emission

IM_t = Imports

EX_t = Exports

OPN_t = Openness of the economy to trade measured as the ratio of sum of imports and exports to gross domestic Product (GDP)

EXR_t = Exchange rate

e_t = Residual

β_i are coefficients with $\beta_0 > 0$, $\beta_1 < 0$, $\beta2 > 0$, $\beta3 > 0$, $\beta4 > 0$

A vector autoregressive (VAR) specification with p lag will be:

$$CO_{2t} = \beta_0 + \beta_i \sum_1^p IM_{t-p} + b_i \sum_1^p EX_{t-p} + c_i \sum_1^p OPN_{t-p} + r_i \sum_1^p EXR_{t-p} + e_t \quad (3.2)$$

The Akaike and Schwarz criteria ware used to determine the optimal value of p, the lag length.

4. Data and Methodology

The data employed for the study were annual series taking from both the Central bank of Nigeria and world development index (WDI) 2014 and cover the period 1990 to 2014 totaling a period of 24 years. The data were obtained in respect of all the variables described earlier. Relying on the data and the model specified earlier, the hypotheses that imports, exports, exchange rate and openness of the economy to trade do not have any significant impact on the environment as measured by carbon emission were tested. The summary statistics on the data is presented above.

The vector auto regression (VAR) methodology was used for the study because of the possibility of endogeneity among the variables and the desirability of forecasting the future trend of the relationship between the environment and the explanatory variables in the study. VAR was designed for use with non-stationary series that are known to be co-integrated. It has been found that simple, small-scale VARs without a possibly flawed theoretical foundation have proved as good as or better than large-scale structural equation systems for purposes of analyzing and forecasting macroeconomic activity and tracing the effects of policy changes and external stimuli on the economy (Bjornland, 2000). In addition to forecasting, VARs have been used for two primary functions, testing Granger causality and studying the effects of policy through impulse response characteristics. Sims (1980) first introduced VAR models as an alternative to the large scale macro econometric models. Since then the methodology has gained widespread use in applied macroeconomic research.

5. Results

Table 5.1: Summary of Stationarity Test

Variables	T-Statistics > Phillips-Perron Critical Value 1% Statistics	I(d)
IM	-11.86	I(2)
EX	-11.57	I(2)
OPN	-5.89	I(1)
EXR	-4.50	I(2)
CO2	-4.1329	I(1)

Source: Author's Analysis.

The result from the Phillips-Perron set of unit root test for the data series shown above indicates that the series are not stationary (see appendix A). In other words, they are integrated.

The general VAR (p) model has many parameters, and they may be difficult to interpret due to complex interactions and feedback between the variables in the model. As a result, the dynamic properties of a VAR (p) are often summarized using various types of structural analysis. The Granger causality test assesses the forecast power of the VAR, impulse response functions show the effects of shocks on the adjustment path of the variables and forecast error variance decomposition measures the contribution of each type of shock to the forecast error. That is, how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. These computations are useful in assessing how shocks to economic variables reverberate through a VAR system.

The Granger causality test in terms of Wald statistics for the joint significance of each of the other lagged endogenous variables are statistically significant at 1 percent for CO_2, exports and openness.

This suggests that these variables are truly exogenous. The impulse response function indicates that the cumulative response of the variables to innovations are not persistent; their effects eventually die out but slowly towards the long run. (See appendix D)

The presence of integrated variables in the VAR representation implies that shocks may be permanent as well as transitory. The roots of characteristic polynomials show that no root lies outside the unit circle meaning that the VAR satisfied the stability condition. The variance error decomposition indicated that own shock for CO_2 is about 37 percent which is largely the same over the short to long run. A shock to imports, exports, exchange rate and openness of the economy caused about 11, 1, 44 and 4 percent shock respectively to CO_2 in the short run and about 11, 3, 43 and 6 percent shock respectively to CO_2 on the long run. This implies that the impact of the shocks are relatively the same over the short and long runs. Furthermore, the impact of shock to carbon emission, exports and openness of the economy are largely the same from short to long run. However, impact of shock to imports on itself is greater in the short run than the long run, while impact of shock to exchange rate on imports is greater on the long run than the short run.

The impact of shock to CO_2 on exports is milder in the short run than the long run while the impact of imports, exchange rate and openness of the economy are largely the same over the two periods.

However, the own shock of exports is greater on the short than the long run. Shock to exchange rate whether from itself or other variables had almost the same impact over the short and the long run. This is also true of shock to openness of the economy.

6. Conclusions

Generally, VAR model shows the impact of the included variables on one another at the instances of innovations in the system and for how long (short to long run) and in what manner. The conclusions drawn from this study is that trade actually impacts the environment and that the environment as well affects trade. The impact which trade has on the environment in Nigeria over the short to the long run is largely the same as evident from the variance error decomposition. Moreover, the impact has been relatively mild. In addition, the validity of the impulse response function is contingent on the stability of the VAR system which is tied to the roots of characteristic polynomial lying inside the unit circle. Satisfying this condition in this study guarantees that shock within the VAR system will fade away, though for this study, slowly from short to the long run.

The relevant authority in the Nigerian economy will hence be advised to fashion policies that will forestall the dynamics between trade and the environment as this can have implications for sustainability of economic growth. Given that the Nigerian economy is a low income one and it depends largely on its natural resources endowments to drive economic growth, caution need to be taken not to inflict irreparable damages on the environment. Trade policies should be forward looking rather than for attracting all sorts of foreign investments that can undermine overall developmental goals. Environmental regulatory agencies should awake to strict enforcement of environmental standards to prevent grave damage on the environment.

References

Action Aid. (2003). WTO Democracy and Reform. London: *Action Aid UK*. Retrieved From, http://www.actionaid.org.uk/sites/default/files/doc_lib/54_1_wto_democracy_refor m.pdf

Aller, C., Ductor, L., & Herrerias, M. J. (2015). The World Trade Tetwork and the Environment. *Energy Economics*, *52*, 55-68.

Appiah-Konadu, Paul (2013). *The Effect of Trade Liberalization on the Environment: A Case Study of Ghana* (Doctoral dissertation, University of Ghana).

Ayres, R. U. (1996). Limits to the Growth Paradigm. Retrieved from https://flora.insead.edu/fichiersti_wp/inseadwp1996/96-18.pdf

Budzianowski, W. M. (2012). Negative Carbon Intensity of Renewable Energy Technologies Involving Biomass or Carbon dioxide as Inputs. Renewable and Sustainable Energy Reviews, 16(9), 6507-6521.

Bjornland, H. C. (2000, October 20). *VAR Model in Macroeconomic Research*. Retrieved from Statistisk Sentralbyrå: http://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner

Chang, W. W. (2014). World Trade and the Environment: Issues and Policies. *Available at SSRN 2435700* papers.ssrn.com

Copeland, B. R., & Taylor, M. S. (2013). *Trade and the Environment: Theory and Evidence: Theory and Evidence*. Princeton University Press.

Clapp, J., & Wilkinson, R. (2010). Governing poverty and inequality. In J. Clapp & R. Wilkinson (Eds.). Global governance, poverty and inequality (pp. 1-23). *Rutledge*

Cropper, Maureen and Charles Griffiths (1994). The Interaction of Population Growth and Environmental Quality. *American Economic Review Papers and Proceedings* 84(2): 250–54.

Daly, H. E. (1993). The Peril of Free Trade. . *Scientific American*, 265(5), 50-57.

Frankel, J. A., & Rose, A. K. (2005). Is Trade Good or Bad for the Environment? Sorting out the Causality. *Review of economics and statistics*, *87*(1), 85-91.

Hung, P. T., & Tuan, B. A. (2016). *The Impact of Trade Liberalization on Industrial Pollution: Empirical Evidence from Vietnam* (No. 2016042). Economy and Environment Program for Southeast Asia (EEPSEA).

Keho, Y. (2015). Long-run Effect of International Trade on the Environment: A Pool Mean Group Analysis of ECOWAS Countries, 1970-2010. *African Journal of Economic and Sustainable Development*, *4*(3), 211-217.

Kreickemeier, U., & Richter, P. M. (2014). Trade and the Environment: The role of Firm Heterogeneity. *Review of International Economics*, *22*(2), 209-225.

Kukla-Gryz, A. (2009). Economic growth, international trade and air pollution: A decomposition analysis. *Ecological economics*, *68*(5), 1329-1339.

Li, G. (2015). Trade, Capital Accumulation, and the Environment. *Capital Accumulation and the Environment (June 1, 2015)*.

McAusland, C., & Millimet, D. L. (2013). Do National Borders Matter? Intra-National Trade, International Trade, and the Environment. *Journal of Environmental Economics and Management*, *65*(3), 411-437.

Muradian, R., & Martinez-Alier. (2001). Trade and the Environment: from a 'Southern' Perspective. Retrieved from,http://ent-consulting.com/cidma/imatges/trade-ent.pdf.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association*, *94*(446), 621-634.

Shen, J., 2008. Trade, Liberalization and Environmental Degradation in China. *Journal of Applied Economics,* 40-8.

Sims, C.A. (1980). "Macroeconomics and Reality," Econometrica, 48, 1-48.

Steger, D. P. (Ed.). (2009). Redesigning the World Trade Organization for the Twenty-First Century. *Waterloo*, ON: Wilfred Laurier University Press.

Whalley, J. (2011) What Role for Trade in a Post 2012Global Climate Policy Regime*, NBER Paper No. 17498*

WDI, 2014 data. Worldbank.org/data-catalog/world-development-indicators/wdi-2014

Appendix A: Data used for the study

year	CO2	EX	EXR	IM	OPN
1990	45375.46	35.34425	8.04	17.68597	0.581588
1991	45247.11	41.70108	9.91	23.17552	0.676055
1992	64883.9	37.50938	17.3	23.5216	0.654814
1993	60061.79	33.82986	22.05	24.27999	0.562095
1994	46658.91	24.31023	21.89	17.99864	0.409893
1995	34917.17	35.76149	21.89	24.00634	0.88236
1996	40421.34	32.23857	21.89	25.45243	0.692699
1997	40190.32	41.7746	21.89	35.08539	0.744968
1998	40182.99	29.69152	21.89	36.48173	0.586788
1999	44788.74	33.86953	92.69	21.97686	0.642291
2000	79181.53	51.73036	102.11	19.65017	0.639604
2001	83350.91	45.44807	111.94	36.36478	0.682767
2002	98125.25	35.96569	120.97	27.41795	0.471165
2003	93138.13	39.7879	129.36	35.431	0.608943
2004	97047.16	30.16075	133.5	18.28738	0.577494
2005	104696.5	31.65697	132.15	19.09139	0.689488
2006	98513.96	43.11133	128.65	21.49798	0.578351
2007	95209.99	33.72852	125.83	30.73439	0.605213
2008	92621.09	39.88313	118.57	25.08984	0.689931
2009	71719.19	30.76862	148.73	31.03424	0.661724
2010	78910.17	25.26412	155.68	17.38727	0.563685
2011	87613.97	31.32981	155.89	21.4643	0.65425
2012	89362.38	31.43875	158.84	12.94139	0.594694
2013	94285.03	18.04134	159.25	12.98455	0.549698
2014	96142.31	16.1	164.88	14.1	0.586386

Source: Central Bank of Nigeria Statistical Bulletin, 2014
World Development Index, World Bank, 2014

Appendix B: Unit root test

Group unit root test: Summary
Series: FLD, CO2, OPN, EXR, OPNS, IM, EX
Date: 06/23/16 Time: 12:53
Sample: 1990 2014
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.27137	0.0116	6	144
Breitung t-stat	-3.41306	0.0003	6	138
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.58466	0.0002	6	144
ADF - Fisher Chi-square	36.5031	0.0003	6	144
PP - Fisher Chi-square	38.2237	0.0001	6	144

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Null Hypothesis: D(CO2) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.132944	0.0180
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.22E+08
HAC corrected variance (Bartlett kernel)	1.22E+08

Null Hypothesis: D(EX) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 17 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.57010	0.0000
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	61.35233
HAC corrected variance (Bartlett kernel)	10.30449

Null Hypothesis: D(IM) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-11.86179	0.0000
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(EXR) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.500167	0.0084
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: OPN has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.887144	0.0004
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: OPNS has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.797522	0.0042
Test critical values:	1% level	-4.394309	
	5% level	-3.612199	
	10% level	-3.243079	

*MacKinnon (1996) one-sided p-values.

Appendix C: VAR Estimate

Vector Autoregression Estimates
Date: 06/25/16 Time: 09:44
Sample (adjusted): 1994 2014
Included observations: 21 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
DLOG(CO2(-1))	0.638836	0.859920	0.732523	-0.319263	0.265462
	(0.19873)	(0.70631)	(0.41460)	(0.85320)	(0.23920)
	[3.21463]	[1.21748]	[1.76683]	[-0.37419]	[1.10980]
DLOG(CO2(-2))	-0.069993	-0.846558	-1.403066	-0.471486	-0.915062
	(0.17884)	(0.63564)	(0.37311)	(0.76783)	(0.21526)
	[-0.39136]	[-1.33183]	[-3.76044]	[-0.61405]	[-4.25089]
DLOG(IM(-1),2)	0.012338	-0.615293	-0.230667	0.046386	-0.261662
	(0.11144)	(0.39606)	(0.23249)	(0.47843)	(0.13413)
	[0.11072]	[-1.55352]	[-0.99217]	[0.09695]	[-1.95080]
DLOG(IM(-2),2)	0.067646	-0.056646	-0.465305	0.100162	-0.196951
	(0.10806)	(0.38407)	(0.22544)	(0.46394)	(0.13007)
	[0.62600]	[-0.14749]	[-2.06394]	[0.21589]	[-1.51421]
DLOG(EX(-1),2)	-0.058122	0.370190	-0.590335	-0.288074	0.167300
	(0.10724)	(0.38114)	(0.22373)	(0.46041)	(0.12908)
	[-0.54199]	[0.97126]	[-2.63863]	[-0.62569]	[1.29613]
DLOG(EX(-2),2)	0.194345	-0.161754	-0.149871	-0.013444	0.310075
	(0.11255)	(0.40004)	(0.23482)	(0.48323)	(0.13548)
	[1.72668]	[-0.40435]	[-0.63825]	[-0.02782]	[2.28879]
DLOG(EXR(-1),2)	0.356146	-0.341801	-0.006759	-0.619615	-0.207240
	(0.08053)	(0.28622)	(0.16801)	(0.34575)	(0.09693)
	[4.42240]	[-1.19417]	[-0.04023]	[-1.79209]	[-2.13798]
DLOG(EXR(-2),2)	0.059421	-0.134985	-0.526132	-0.190965	-0.338116
	(0.11586)	(0.41179)	(0.24172)	(0.49743)	(0.13946)
	[0.51287]	[-0.32780]	[-2.17666]	[-0.38391]	[-2.42455]
DLOG(OPN(-1))	0.276168	-0.282196	-0.791460	-0.033892	-0.903957
	(0.18902)	(0.67181)	(0.39434)	(0.81152)	(0.22751)
	[1.46105]	[-0.42005]	[-2.00703]	[-0.04176]	[-3.97321]
DLOG(OPN(-2))	-0.317008	0.260497	-0.351227	-0.146284	-0.713256
	(0.18582)	(0.66044)	(0.38767)	(0.79779)	(0.22366)
	[-1.70598]	[0.39443]	[-0.90599]	[-0.18336]	[-3.18897]
C	0.026373	0.007779	-0.012875	-0.010748	0.005068
	(0.02601)	(0.09243)	(0.05426)	(0.11165)	(0.03130)
	[1.01413]	[0.08416]	[-0.23730]	[-0.09626]	[0.16190]
R-squared	0.793978	0.753838	0.849016	0.414150	0.840488
Adj. R-squared	0.587957	0.507677	0.698033	-0.171700	0.680975
Sum sq. resids	0.129658	1.637847	0.564335	2.389931	0.187845
S.E. equation	0.113867	0.404703	0.237557	0.488869	0.137056
F-statistic	3.853860	3.062370	5.623236	0.706921	5.269103
Log likelihood	23.61976	-3.010738	8.176900	-6.978502	19.72725
Akaike AIC	-1.201882	1.334356	0.268867	1.712238	-0.831167
Schwarz SC	-0.654751	1.881487	0.815997	2.259369	-0.284036
Mean dependent	0.022403	0.002413	-0.000505	-0.009898	0.002015
S.D. dependent	0.177390	0.576782	0.432303	0.451632	0.242654

Determinant resid covariance (dof adj.)	1.73E-07
Determinant resid covariance	4.23E-09
Log likelihood	53.45746
Akaike information criterion	0.146908
Schwarz criterion	2.882562

Appendix D: Granger causality test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 06/25/16 Time: 09:37
Sample: 1990 2014
Included observations: 21

Dependent variable: DLOG(CO2)

Excluded	Chi-sq	df	Prob.
DLOG(IM,2)	0.831387	2	0.6599
DLOG(EX,2)	5.846268	2	0.0538
DLOG(EXR,2)	25.15384	2	0.0000
DLOG(OPN)	7.259374	2	0.0265
All	36.22034	8	0.0000

Dependent variable: DLOG(IM,2)

Excluded	Chi-sq	df	Prob.
DLOG(CO2)	2.348144	2	0.3091
DLOG(EX,2)	2.085534	2	0.3525
DLOG(EXR,2)	1.594468	2	0.4506
DLOG(OPN)	0.478865	2	0.7871
All	10.20467	8	0.2510

Dependent variable: DLOG(EX,2)

Excluded	Chi-sq	df	Prob.
DLOG(CO2)	14.24668	2	0.0008
DLOG(IM,2)	5.533521	2	0.0629
DLOG(EXR,2)	6.755217	2	0.0341
DLOG(OPN)	4.120934	2	0.1274
All	23.21850	8	0.0031

Dependent variable: DLOG(EXR,2)

Excluded	Chi-sq	df	Prob.
DLOG(CO2)	0.821474	2	0.6632
DLOG(IM,2)	0.063396	2	0.9688
DLOG(EX,2)	0.514294	2	0.7733
DLOG(OPN)	0.033854	2	0.9832
All	2.062342	8	0.9790

Dependent variable: DLOG(OPN)

Excluded	Chi-sq	df	Prob.
DLOG(CO2)	18.42547	2	0.0001
DLOG(IM,2)	3.814638	2	0.1485
DLOG(EX,2)	5.252603	2	0.0723
DLOG(EXR,2)	6.767886	2	0.0339
All	31.53402	8	0.0001

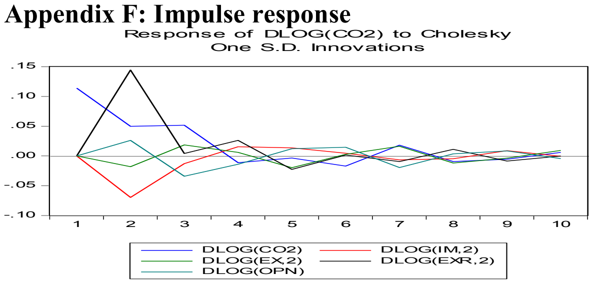
Appendix E: AR Root

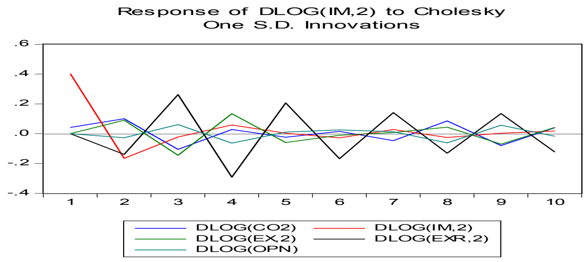
Roots of Characteristic Polynomial
Endogenous variables: DLOG(CO2) DLOG(IM,2)
DLOG(EX,2) DLOG(EXR,2) DLOG(OPN)
Exogenous variables: C
Lag specification: 1 2
Date: 06/25/16 Time: 09:46

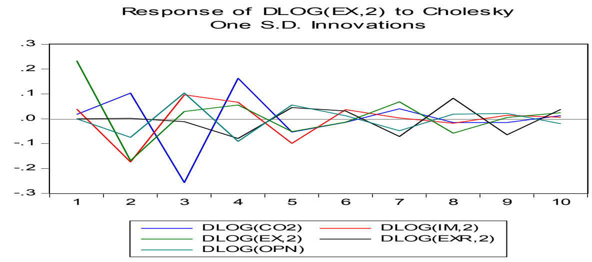
Root	Modulus
-0.341029 - 0.746470i	0.820682
-0.341029 + 0.746470i	0.820682
-0.809844	0.809844
-0.039858 - 0.698548i	0.699685
-0.039858 + 0.698548i	0.699685
-0.688532	0.688532
0.402889 - 0.341108i	0.527896
0.402889 + 0.341108i	0.527896
-0.317995 - 0.143386i	0.348827
-0.317995 + 0.143386i	0.348827

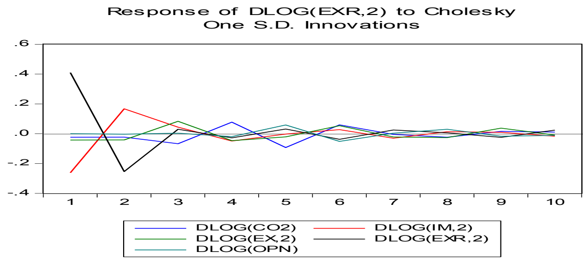
No root lies outside the unit circle.
VAR satisfies the stability condition.

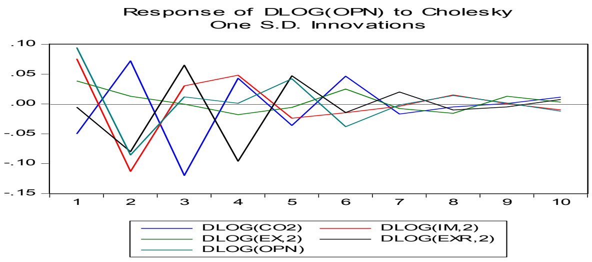
Appendix F: Impulse response











Appendix G: Variance decomposition

Variance Decomposition of DLOG(CO2):

Period	S.E.	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
1	0.113867	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.205360	36.62712	11.50772	0.777840	49.46474	1.622571
3	0.215722	38.93924	10.79178	1.440393	44.86259	3.965998
4	0.218663	38.16252	11.00287	1.478479	45.08887	4.267259
5	0.221480	37.22341	11.10161	2.229130	44.98359	4.462266
6	0.222680	37.40753	11.02430	2.220086	44.50446	4.843626
7	0.225140	37.24438	10.86966	2.691438	43.71262	5.481902
8	0.226007	37.13436	10.82887	2.949809	43.62334	5.463615
9	0.226601	37.00112	10.92636	2.960053	43.53874	5.573727
10	0.226910	36.96863	10.89745	3.115882	43.42055	5.597492

Variance Decomposition of DLOG(IM,2):

Period	S.E.	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
1	0.404703	1.095523	98.90448	0.000000	0.000000	0.000000
2	0.478812	5.208058	82.56090	3.549738	8.369662	0.311644
3	0.578237	6.870404	56.75210	8.687525	26.35891	1.331058
4	0.667697	5.330977	43.34011	10.52710	38.90907	1.892732
5	0.701760	4.938928	39.23757	10.23699	43.85018	1.736331
6	0.722696	4.704362	37.14266	9.674556	46.71525	1.763171
7	0.738535	4.903465	35.70835	9.276644	48.39179	1.719748
8	0.759161	5.911531	33.90995	9.113269	48.77136	2.293890
9	0.780363	6.636625	32.09389	9.418883	49.15526	2.695350
10	0.792578	6.694155	31.16503	9.409593	50.07315	2.658074

Variance Decomposition of DLOG(EX,2):

Period	S.E.	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
1	0.237557	0.542221	2.635666	96.82211	0.000000	0.000000
2	0.362353	8.340957	24.17608	63.20088	0.001689	4.280395
3	0.467190	35.18550	18.80102	38.40915	0.064086	7.540240
4	0.516739	38.73526	17.02892	32.55449	2.401102	9.280235
5	0.536172	36.97679	19.23618	31.16749	2.934167	9.685375
6	0.538831	36.67909	19.50791	30.92593	3.245020	9.642056
7	0.551370	35.56026	18.63432	31.08086	4.761571	9.962993
8	0.561341	34.37866	18.08134	31.05509	6.761498	9.723414
9	0.565817	33.90797	17.85814	30.57465	7.947257	9.711982
10	0.568127	33.68162	17.72499	30.50776	8.329969	9.755663

Variance Decomposition of DLOG(EXR,2):

Period	S.E.	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
1	0.488869	0.243257	28.75403	0.764161	70.23855	0.000000
2	0.577653	0.329851	28.99389	1.080271	69.59290	0.003089
3	0.589850	1.607490	28.35201	3.040454	66.99442	0.005618
4	0.599717	3.208059	28.10563	3.549192	65.02676	0.110358
5	0.610773	5.385830	27.09902	3.547849	62.95075	1.016554
6	0.619859	6.131959	26.49789	4.186657	61.49617	1.687323
7	0.621511	6.105721	26.59235	4.293228	61.32685	1.681848
8	0.623396	6.219085	26.47423	4.448191	60.96465	1.893853
9	0.625506	6.243271	26.31734	4.770803	60.70993	1.958650
10	0.626463	6.255123	26.31292	4.776545	60.67041	1.985004

Variance Decomposition of DLOG(OPN):

Period	S.E.	DLOG(CO2)	DLOG(IM,2)	DLOG(EX,2)	DLOG(EXR,2)	DLOG(OPN)
1	0.137056	13.39555	30.70434	7.983101	0.154095	47.76292
2	0.225268	15.29153	36.61141	3.285992	12.68336	32.12771
3	0.265323	31.40718	27.70512	2.368810	15.15823	23.36066
4	0.290069	28.48366	25.95741	2.359957	23.65235	19.54662
5	0.300139	28.04963	24.88140	2.240725	24.57723	20.25102
6	0.307824	28.95498	23.88021	2.797397	23.58641	20.78100
7	0.309072	29.02322	23.70273	2.834810	23.82283	20.61642
8	0.310363	28.80674	23.74412	3.062564	23.73117	20.65541
9	0.310676	28.74932	23.69659	3.229182	23.70854	20.61637
10	0.311394	28.75556	23.68863	3.224321	23.65984	20.67164

Cholesky Ordering: DLOG(CO2) DLOG(IM,2) DLOG(EX,2) DLOG(EXR,2) DLOG(OPN)