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Environmental Infrastructure Investment and Economic Growth in Nigeria

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Abstract

The study investigated long run equilibrium relationship between what we identified as environmental infrastructure and economic growth in Nigeria. Sustained economic growth is particularly necessary if a country is to witness development and bring about better welfare for its citizens. One way to attain sustained economic growth is for an economy to have efficient and effective infrastructure. The Autoregressive Distributed Lag (ARDL) bounds testing approach was followed using quarterly series over 1990 to 2016. The study confirmed long-run equilibrium relationship between environmental infrastructure and economic growth in Nigeria. Feedback causality was also identified between electricity and transport output. However, no causality of any form was identified between water output and economic growth in the country. Furthermore, electricity, transport and water outputs used as proxies for environmental infrastructure all have statistically significant relationship with economic growth. Therefore, it is recommended that government should raise infrastructure stock in the Nigerian economy through more investment as this hold the key to diversifying the economy, unlocking job opportunities and set the stage for the emergence of the Nigerian economy into one of the top twenty in the years ahead. As per the effects of these infrastructure on the environment, the government needs to ensure efficient transportation mix that will be friendly to the environment in terms of cutting down on carbon emission. Investment in energy infrastructure going forward, should be directed at renewable sources, while water resources in the country should be preserved because water is life as it is commonly known.

Greater access to clean water by all irrespective of location, has implication for healthy citizen and by extension, economic growth.

JEL Classification Code O40

INTRODUCTION

The preoccupation of most economies in the global theater is in respect of achieving substantial economic growth that will reflected in human development index in such economies. The challenge for many countries around the world today has to do with getting as many citizens and immigrants alike to benefit significantly from gain in Gross Domestic Product (GDP) accruable to the country (inclusiveness of economic growth). This has to be an important goal because of the tendency for the wealth of most countries (particularly the developing ones) to be in the custody of insignificant few while the larger mass wallow in one form of poverty and or deprivation or the other. The low rate of economic growth further makes the situation worse while weak infrastructural base seems to add salt to the state of injury in which most of these economies have found themselves. (Ngepah, 2017). These situations have only served to deepen inequality, insecurity and wide spread multidimensional poverty.

Furthermore, the environment, which is the respite for the majority of the people who do not benefit substantially from GDP growth seem to be caving in as a result of non-servicing by way of investments that can guarantee sustained flow of benefits from this nature gift. This implies that ultimately, the growth potential of the economy is threatened. Indeed, the literature has identified infrastructure investment as an important factor for any meaningful economics growth as evidences from developed economies suggest that infrastructure was and still remains the driving force behind the successes achieved. (Pradhan, Arvin, Norman and Bele 2014).

Accordingly, a number of issues which should worry policy makers in an economy like Nigeria's would be how to optimally engage the environment, symbiotically, for increased and sustained flow of benefits from all the available nature gifts and resources and secondly, how to reduce inequality and poverty so that the generality of the people is being made to benefit substantially from income growth. In other words, the reality of gaps in infrastructure (energy, water resources, transportation and so on) is being felt by way of high unemployment, poverty, Naira depreciation, double digit inflation to mention but a few. These go to reflect in slow pace of economic growth as the potentials in the economy are not been fully taped.

This paper therefore seeks to research into the roles which environmental infrastructure can play in bringing about inclusive and sustainable economic growth in Nigeria. Environmental infrastructure is defined in this article on one hand as that infrastructure capable of extenuating environmental degradation or enhancing the quality of the environment. This include but not limited to all government expenditure towards attaining good environmental standards, cleaning of oil spillage and efforts at ensuring that the spillage does not arise ab initio and budgetary allocations to environmental regulatory agencies. For example, investments in cleaner or green technologies both in the transport and energy industries in order to reduce carbon emission and other greenhouse gases, can be considered as environmental infrastructure. The sphere of environmental infrastructure also extends to water and sanitation facilities, waste disposal and recycling equipment as well as efforts at educating the populace on the need to be conscious of the importance of sound environmental practices given the implications on human lives, properties, plants and other animals.

The following questions will be pertinent to answer. What is the connection between environmental infrastructure and economic growth in Nigeria? What are the effects of environmental infrastructure investments on economic growth in Nigeria? What policy options can be deduced from the possible connection between environmental infrastructure and economic growth in Nigeria?
This paper is organized into six sections. The preceding was introduction and it is followed by review of some relevant literature, methodology and theoretical frame, model specification, estimation and discussion of result, conclusions in that order.

REVIEW OF LITERATURE
The review of literature for this study is approached from general to particular. Generally, the literature is suggestive of the fact that infrastructure is critically germane to economic growth and development. For example, Haughwout (2002) provide a methodology to indirectly account for the spatial implications of public capital investment when testing its effect on productivity. He shows that in general the marginal effect of infrastructure is positive but low. Infrastructure investments mainly benefit households, much less so firms, and the aggregate willingness to pay is less than the cost. Galiani, Gertler and Schargrodsky (2005) show that the p rivatization of water in Argentina has significantly reduced the incidence of child mortality due t o water borne diseases and that most of this effect has been the result of an expansion in household access to the water network.

Some contributions have looked into the issue of infrastructure's impact on development outcomes. To mention a few prominent ones, Gibson and Rozelle (2003) look at the effect of access to road in Papua New Guinea on poverty at the household level, and show that reducing access time to less than three hours where it was above this threshold leads to a fall of 5.3% in the head count index. Duflo and Pande (2007) study the effect of irrigation dams in India on agricultural production and poverty. Their Cost-Benefit analysis suggests that dams have very low rate of return and adverse distributional effects. Using Tanzanian household survey data, Fan, Nyange and Rao (2005) look at the impact of public investment and roads on household level income and poverty and find very positive effects, with a ratio of 1 to 9 in the case of public capital investment. Ilahi and Grimard (2000) show that the development of water infrastructure has a significant impact on women's time allocation in Pakistan.

The idea of environmental infrastructure can be situated within the fact that as the society pursue economic growth, pollution of the environment is inevitable. Accordingly, deliberate effort by way of policy and investment aimed at renewing the environment must be galvanized. In this respect, some studies which examined the link between environmental pollution and economic growth. There are those which focused on examining the relationship between environmental quality and growth in per capital income within the environmental Kuznets hypothesis. (Grossman & Krueger, 1995 & Copeland & Taylor, 2003).

Bilgili, Koçak & Bulut (2016) investigates the validity of the EKC hypothesis employing the dependent variable of CO_2 emissions and regressors of GDP, quadratic GDP and renewable energy consumption using a panel data set of 17 OECD countries over the period 1977–2010 and launches panel FMOLS and panel DOLS estimations. The findings support the EKC hypothesis for the panel and indicate that GDP per capita and GDP per capita squared have the impacts on CO_2 emissions positively and negatively, respectively, and that renewable energy consumption yields negative impact on CO_2 emissions.

Lau, Choong & Eng (2014) conducts a study to identify the relationship between economic growth and CO_2 emissions for Malaysia. This study attempts to examine empirically the environmental Kuznets curve hypothesis for Malaysia in the presence of foreign direct investment and trade openness both in the short- and long-run for the period 1970 to 2008.They employed the bounds testing approach and Granger causality methodology to test the interrelationships of the variables. The results of the study indicate that the Inverted-U shaped relationship exists between economic growth and CO_2 emission in both the short- and long-run for Malaysia after controlling for two additional explanatory variables, namely FDI and trade. The implication of the findings from these studies is that policies need to be tailored at ensuring that the environment, which is the basic natural infrastructure, is able to sustain economic gains not only for the present generation but also the future ones.

Achour & Belloumi (2016), considers the causal relationships between transportation infrastructure (rail and road), the transport value added, gross capital formation, transportation energy consumption and transport CO_2 emissions in Tunisia over the period of 1971–2012. The study indicates among others, the existence of unidirectional long run causality running from transport value added, road transport related energy consumption, transport CO_2 emissions and gross capital formation to road infrastructure. This finding points to the need for governments and other relevant agencies to invest in infrastructure as a way to boost economic activities.

A study on infrastructure investment and economic growth in South Africa by (Wolassa, 2012) for the period 1960-2009 used bi-variate vector auto regression (VAR) model with and without a structural break. The result indicates that there is a strong causality between economic infrastructure investment and GDP growth that runs in both directions implying that economic infrastructure investment drives the long term economic growth in South Africa while improved growth feeds back into more public infrastructure investments. This finding further confirms the submission of Canning & Pedroni (1999), with respect to the need to expand infrastructure access and promotion of productivity in an economy.

Conceptually, infrastructure helps poorer individuals and underdeveloped areas to get connected to core economic activities, thus allowing them to access additional productive opportunities (Estache, 2003). Along the same line, infrastructure access can raise the value of the assets of the poor. For example, recent research links the asset value of poor farm areas - as proxy by the net present value of the profits generated by their crops -to the distance to agricultural markets. Improvements in communication and road services imply capital gains for these poor farmers (Jacoby, 2000).

Infrastructure development can also have a disproportionate impact on the human capital of the poor, and hence on their job opportunities and income prospects. This refers not only to education, but also to health. A number of recent papers has focused specifically on the impact of expanding infrastructure services on child (and maternal) mortality, and educational attainment. This literature shows that policy changes that enhance the availability and quality of infrastructure services for the poor in developing countries have a significant positive impact on their health and or education and, hence, on their income and welfare as well.

Recent evidence on these impacts with regards to education suggests that, a better transportation system and a safer road network help raise school attendance (Brenneman & Kerf, 2002). Electricity also allows more time for study and the use of computers (Leipziger, Fay, & Yapes, 2003). Regarding health, access to water and sanitation plays a key role. Several studies have identified instances in which access to clean water has helped significantly to reduce child mortality. In Argentina, for example, a recent study by (Galiani, Gertler, & Schargrodsky, 2005),

concluded that expanded access to water and sanitation reduced child mortality by 8 percent, with most of the reduction taking place in low-income areas where the expansion in the water network was the largest. More generally, it was found that a quarter of the difference in infant mortality and 37 per cent of the difference in child mortality between the rich and the poor is explained by their respective access to water services. Allowing the poor to access safe water at the same rate as the rich would reduce the difference in child mortality between the two groups by over 25 percent. Aside from the effects of infrastructure development on aggregate income growth, a strand of recent literature has examined its effects on income inequality. The underlying idea is that, under appropriate conditions, infrastructure development can have a positive impact on the income and welfare of the poor over and above its impact on average income. This hypothesis is confirmed empirically in the study by (Lopez, 2004).
Indeed, for infrastructure expansion to reduce income inequality, it must result in improved access and/or enhanced quality particularly for low-income households. Hence the key issue is how the development of infrastructure impacts access by the poor (Estache, Gomez-Lobo, & Leipziger, 2000).

Chen, Xue, Rose and Haynes (2016) investigates the impact of high-speed rail investment on the economy and environment in China using a computable general equilibrium (CGE) model and found that rail investment in China has a positive stimulus to the economy, while the effect on CO_2 emissions generation has been large. Overall, the economic impacts of rail investment are achieved primarily through induced demand and output expansion, whereas the contribution from a reduction of rail transportation costs and rail productivity increases were modest. In addition, negligible negative impacts were found from land use for rail development and the substitution effect among other modes. Emissions reduction from substitution of rail for other modes was small and offset by output expansion due to lowered rail transport costs and induced demand.
The studies that were carried out for Nigeria on the role of infrastructure on an economy and which stressed the need for increased investment in infrastructure as a panacea to slow economic growth include; Ekpung, (2014); Ebong, Ogwumike, Udongwo, and Ayodele (2016); Ahmed, Olusola, Taiwo, and Wole (2018).

METHODOLOGY AND THEORETICAL FRAME

The neoclassical theory is a theory of the stock and spread of national product based on a society's endowment of production factors, technical conditions of production and consumer preferences (Cesaratto, 1999).The theory considers economic growth as endogenous in the sense that growth depends on the society's choice between savings and current consumption. It posits that capital comes from savings and plays very key role both in distribution theory and growth theory. The neoclassical theory posits further that aggregate economic growth comes from positive rate of profit such that if the market forces are unfettered, it is able to allocate resources most productively (Cesaratto, 1999). This will mean that labour would get its reward for contributing to output following the marginal productivity theory and is not cheated of its surplus value. Likewise, capital would be deployed for optimum productivity. The theory suggests that the government should play less role in shaping economic activities and places the bulk of the task of driving the economy at the door step of the firms who are the owners of capital. The role left to the government is mostly in respect of policy direction that will ensure that the right kind of investment is being undertaken by the players in the market system, while it intervene in sectors where incentives are low for private investors to show interest. This is necessary to guarantee sustained welfare for the generality of the people in a country.

Accordingly, theoretical and empirical literature suggests the existence of positive relationships between "environmental infrastructure investment" and sustainable economic growth (Munnel, 1992). Environmental infrastructure or efforts at improving environmental quality are capital intensive in nature as they will serve to promote further production in the economy by raising the quality of human capital, lowering cost and enhancing efficiency of other factors of production (Vivien & Nataliya, 2011). Therefore, it is on this basis that the literature has come to acknowledge "environmental infrastructure" investment (efforts at improving the quality of the environment) as a growth propeller. Within this framework, environmental infrastructure is understood as being capable of nipping in the bud issues that can frustrate the objective of attaining substantial and sustainable economic growth and or minimizing their effects. For instance, significant gap in water resources infrastructure can limit agricultural output, affect the health of the people and by implication their ability to be productively engaged in the economy. Furthermore, inadequate and inefficient transport and energy infrastructure can exacerbate environmental concerns that are capable of constraining economic growth. An understanding of this has brought to the fore, issues of green economy in the literature given the challenges of greenhouse gases and their effects on our world.

The main conjectural approaches to modeling the relationship between capital and economic growth are the Solow (1956) and Romer (2004) growth models.
The Solow model is derived from the Cob-Douglas production function given as:
$Q_t = f(A, K_t, L_t)$
Where Q_t , K_t , L_t are aggregate real output, capital and labour respectively while A is the coefficient of technical progress.
Economic growth has always been linked to accumulation of physical capital and embodied technology which allows labour to be effective and efficient. One can therefore re-affirm the endogeneity of capital and the strong positive correlation between capital and growth of output in an economy.

Given the nature of series in our model, in which they are not all integrated and we needed to tie the long run and the short run dynamics together, the Autoregressive Distributed Lag (ARDL) Model lends itself as a useful tool of analysis in this situation. In the words of Pesaran et al. (2001), ARDL model, equation (4.1), is an unrestricted error correction model and its use is based on the assumption that none of the time series in the specified model is I(2), that is, none of the series in the specification is integrated of order more than one. Unlike the Johansen co-integration, where the series must all be I(1), ARDL model permits the mixture of I(0) and I(1) series.

The earlier studies so far reviewed researched in to the roles of infrastructure in general in promoting economic growth using available econometric analytical tools. However, not much was done in the area of using infrastructure investment to address environmental issues that are capable of inhibiting economic growth in an economy. This is where this study sought to add to the existing knowledge.

THE MODEL
Relying on the Solow model and following the study by Asongu, El-Montasser & Toumi, (2016), the following ARDL model was specified to relate growth rate of gross domestic product (GDP) to environmental infrastructure outputs in Nigeria over the period 1990 to 2016 using quarterly series obtained from the Central Bank of Nigeria (CBN).

$$\Delta \dot{G}dp_t = \alpha_0 + \alpha_i \sum_0^l \Delta T_{t-i} + \alpha_j \sum_0^m \Delta E_{t-j} + \alpha_n \sum_0^s \Delta W_{t-n} + \lambda_1 T_{t-1} + \lambda_2 E_{t-1} + \lambda_3 W_{t-1} + \lambda_4 \dot{G}dp_{t-1} + \varepsilon \qquad (4.1)$$

Where:
$\dot{Gdp}_t$= Growth rate of gross domestic product
T_t = transport output
E_t= Electricity output
W_t= Water output
The values of l, m and s are determined based on Schwarz Information Criterion (SIC) model selection criterion because it is a consistent model selector.
It is assumed that: $(e_t) = 0$, $Var(e_t) = \sigma^2$, $COV(X_iX_j) = 0$,$e_t \sim N(0, \sigma^2)$
The a-priori expectations are that; $\alpha_0 > 0$, $\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_3 > 0$

ESTIMATES AND DISCUSSION OF FINDINGS

The importance of understanding the processes that led to the generation of the time series employed for this study cannot be overemphasized. Moreover, the ARDL procedure for testing for co-integration require that none of the series in the test should be I(2).Thus the stationarity properties of the series were investigated. This is presented in table 5.1

Table 5.1: Summary of Stationarity Test

Variables	T-Statistics > Phillips-Perron Critical Value 1% Staistics	I(d)	T-Stat>ADF Critical Value 1% Staistics	I(d)
Gdp	-8.5156	I(0)	-6.7694	I(1)
W	-7.2437	I(0)	-11.9224	I(1)
T	-8.8209	I(0)	-8.5588	I(0)
E	-8.3577	I(0)	-7.6315	I(0)

Source: Author's Analysis.

The result from the Phillips-Perron and ADF set of unit root tests for the series shown above indicates that none of the series is I(2) (see appendix A). In other words, they are integrated of at most order one. This is appropriate for the methodology followed in this study. The pairwise Granger causality test in table 5.2 shows that transport and electricity outputs have feedback causality with GDP growth while water output does not exhibit any form of causal relationship with GDP growth. The pair-wise correlation matrix in Table 5.3 shows that positive association exist between the series as expected and the association is not extreme such that the parameters are not indeterminate.

Table 5.2: Pairwise Granger Causality Tests

Null Hypothesis	Obs	F- Stat	Prob
T does not Granger Cause GDP GDP does not Granger Cause T	146	6.0527 3.0769	0.0030 0.0492
E does not Granger Cause GDP GDP does not Granger Cause E	146	11.9570 9.9819	2.E-05 9.E-05
W does not Granger Cause GDP GDP does not Granger Cause W	146	0.9950 0.2079	0.3723 0.8125

Source: Author's Analysis.

Table 5.3: Correlation Matrix

	GDP	T	E	W
GDP	1	0.9628	0.9704	0.5026
T	0.9628	1	0.9477	0.4163
E	0.9704	0.9477	1	0.3730
W	0.5026	0.4163	0.3730	1

Source: Author's Analysis.

The bound test procedure was followed and the estimate for Wald test shows that the value of F-statistic is 6.7579. The intercept of the specified model was not constrained, and there is no linear trend term included in the ECM.Given k = 3,the lower and upper bounds for the F-test statistic at the 10%, 5%, and 1% significance levels are [2.72 , 3.77], [3.23 , 4.35], and [4.29 , 5.61] respectively. Since the value of F-statistic is greater than the upper bound at the 1% significance level, it implies that there is sufficient evidence of a long-run relationship between economic growth as measured by growth rate of GDP and chosen environmental infrastructure in Nigeria. In addition, the t-statistic on the one period lag of GDP is -3.3958 and it is statistically significant at 1%.

The ARDL I(0) and I(1) bounds test further confirms co-integration as the F-statistic (29.01) is greater than 1% bounds critical value. (See appendix I). The Breusch-Godfrey Serial Correlation LM Test accepts the null hypothesis of no serial correlation. (See appendix F). The AR-root graph shows that the model is stable as all moduli are within the unit circle. (See appendix D)
The ARDL co-integrating long run form shows that the long-run impact of a change in each of the infrastructure on economic growth basically has no lagged-effects, the long-run changes are insignificant. However, the short run coefficients were all statistically significant with transport output significantly impacting economic growth in the Nigerian economy as feedback causality was established. A point increase in transport output led to about 14 points increase in GDP growth. This result is in conformity with the findings of Bonfatti & Poelhekke (2017). Transport infrastructure is service providing in nature and the services sector has been adjudged to have been contributing to economic growth in the country in recent time. (NBS, 201). Availability of functional and efficient transport infrastructure can further boost economic growth in the country. As the country advances towards indusrialisation, a multi-modal and energy efficient transport system will be needed to maximize the gains from industrilisation. Similarly, electricity output took on positive significant impact on economic growth in the Nigerian economy as feedback causality was also established between the two. A point in rise in electricity output boost economic growth by about 63 points. The result confirms the findings of Chakamera & Alagidede (2017); Ahmed et al, (2018). The role of power (electricity) in achieving substantial economic growth has been stressed by stakeholders at various fora. The rise in the cost of operation for firms in the country due to improvising has been responsible for shutting down of a number of firms, while others relocate to countries with better power supply. In addition, water output was found to have significant positive relationship with economic growth in the country but with no impact as causality of any form could not be established. A point increase in water output led to about 336 points increase in growth of GDP.

CONCLUSIONS

This study provides evidence on co-integration between selected infrastructure and economic growth in Nigeria following the Autoregressive Distributed lag (ARDL) bound test developed by Pesaran et al. (2001). The conclusion derivable from the findings is that the selected infrastructures have long run stable equilibrium with economic growth in the Nigerian economy. Particularly, the selected infrastructure which are regarded as connecting to the environment indirectly, have the potential to boost economic growth in the Country. Accordingly, it is recommended that the government should raise infrastructure stock by investing more in them and encourage, by way of policy, the private sector to have confidence to invest in the Nigerian economy. Infrastructure investment hold the key to diversifying the economy, unlocking job opportunities and setting the stage for the emergence of the Nigerian economy into one of the top twenty in the years ahead. As per the effects of these infrastructures on the environment, the government needs to ensure efficient transportation mix that will be friendly to the environment in terms of cutting down on carbon emission. Investment in energy infrastructure going forward, should be directed at renewable sources, while water resources in the country should be preserved because water is life as it is commonly known. Greater access to water for agricultural purposes and clean water for household uses by all irrespective of location has implications for agricultural productivity and healthy citizen and by extension, economic growth.

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Appendix A: Unit root test

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 10 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.769136	0.0000
Test critical values:	1% level	-4.058619	
	5% level	-3.458326	
	10% level	-3.155161	

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

Null Hypothesis: GDP has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.515671	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

Null Hypothesis: T has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.558779	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

Null Hypothesis: T has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.820919	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.357678	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

Null Hypothesis: E has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.631459	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

Null Hypothesis: D(W) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.92243	0.0000
Test critical values:	1% level	-4.049586	
	5% level	-3.454032	
	10% level	-3.152652	

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

Null Hypothesis: W has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-7.243738	0.0000
Test critical values:	1% level	-4.047795	
	5% level	-3.453179	
	10% level	-3.152153	

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

Null Hypothesis: RESID03 has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-10.87036	0.0000
Test critical values:	1% level	-4.048682	
	5% level	-3.453601	
	10% level	-3.152400	

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

Appendix B: VAR Estimate

Vector Autoregression Estimates
Date: 06/11/18 Time: 11:35
Sample (adjusted): 1990Q4 2016Q2
Included observations: 103 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(GDP)
D(GDP(-1))	-0.057418
	(0.01063)
	[-5.40138]
D(GDP(-2))	-0.061394
	(0.00845)
	[-7.26339]
C	74076.39
	(102549.)

	[0.72235]
D(T)	16.82630
	(3.12723)
	[5.38058]
D(E)	68.16136
	(6.00630)
	[11.3483]
D(W)	262.9965
	(27.9046)
	[9.42484]
GDP(-1)	-0.081630
	(0.03398)
	[-2.40255]
T(-1)	1.734992
	(1.72475)
	[1.00594]
E(-1)	43.95385
	(8.32201)
	[5.28164]
W(-1)	-213.3059
	(30.5260)
	[-6.98768]
R-squared	0.996393
Adj. R-squared	0.996043
Sum sq. resids	3.91E+13
S.E. equation	648138.3
F-statistic	2854.117
Log likelihood	-1519.223
Akaike AIC	29.69364
Schwarz SC	29.94944
Mean dependent	227972.9
S.D. dependent	10304086

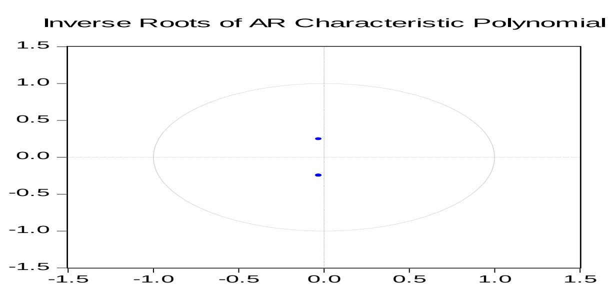
Appendix C: Optimal Lag Selection

VAR Lag Order Selection Criteria
Endogenous variables: D(GDP)
Exogenous variables: C D(T) D(E) D(W) GDP(-1) T(-1) E(-1) W(-1)
Date: 06/11/18 Time: 11:35
Sample: 1990Q1 2016Q2
Included observations: 100

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1499.253	NA	7.24e+11	30.14506	30.35347	30.22941
1	-1498.880	0.678781	7.33e+11	30.15760	30.39207	30.25249
2	-1476.436	40.39942*	4.77e+11*	29.72872*	29.98923*	29.83415*
3	-1476.379	0.101992	4.87e+11	29.74757	30.03414	29.86355
4	-1476.249	0.228921	4.95e+11	29.76497	30.07759	29.89149
5	-1476.212	0.063270	5.05e+11	29.78424	30.12292	29.92131

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Appendix D: VAR Stability test



Appendix E: Unrestricted ECM

Dependent Variable: D(GDP)
Method: ARDL
Date: 06/11/18 Time: 13:24
Sample (adjusted): 1991Q1 2016Q2
Included observations: 102 after adjustments
Maximum dependent lags: 3 (Automatic selection)
Model selection method: Schwarz criterion (SIC)
Dynamic regressors (3 lags, automatic): D(E) D(T) D(W)

Fixed regressors: T(-1) E(-1) W(-1) GDP(-1) C
Number of models evaluated: 192
Selected Model: ARDL(3, 0, 2, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(GDP(-1))	0.426210	0.098981	4.305998	0.0000
D(GDP(-2))	-0.236584	0.082927	-2.852898	0.0054
D(GDP(-3))	0.479045	0.121640	3.938232	0.0002
D(E)	63.27690	8.179683	7.735862	0.0000
D(T)	13.84212	2.026608	6.830190	0.0000
D(T(-1))	-6.335362	2.661728	-2.380169	0.0195
D(T(-2))	-8.135470	2.572223	-3.162816	0.0022
D(W)	336.2080	46.55332	7.221998	0.0000
D(W(-1))	-369.6057	95.77065	-3.859280	0.0002
D(W(-2))	254.7839	71.68520	3.554205	0.0006
D(W(-3))	-424.0058	106.6586	-3.975355	0.0001
T(-1)	2.101795	1.253351	1.676940	0.0972
E(-1)	39.54962	9.426272	4.195680	0.0001
W(-1)	-140.1002	28.44744	-4.924879	0.0000
GDP(-1)	-0.102717	0.030248	-3.395807	0.0010
C	35872.20	63192.72	0.567664	0.5717

R-squared	0.998777	Mean dependent var	230188.3
Adjusted R-squared	0.998564	S.D. dependent var	10354946
S.E. of regression	392405.3	Akaike info criterion	28.74108
Sum squared resid	1.32E+13	Schwarz criterion	29.15284
Log likelihood	-1449.795	Hannan-Quinn criter.	28.90781
F-statistic	4683.006	Durbin-Watson stat	2.007387
Prob(F-statistic)	0.000000		

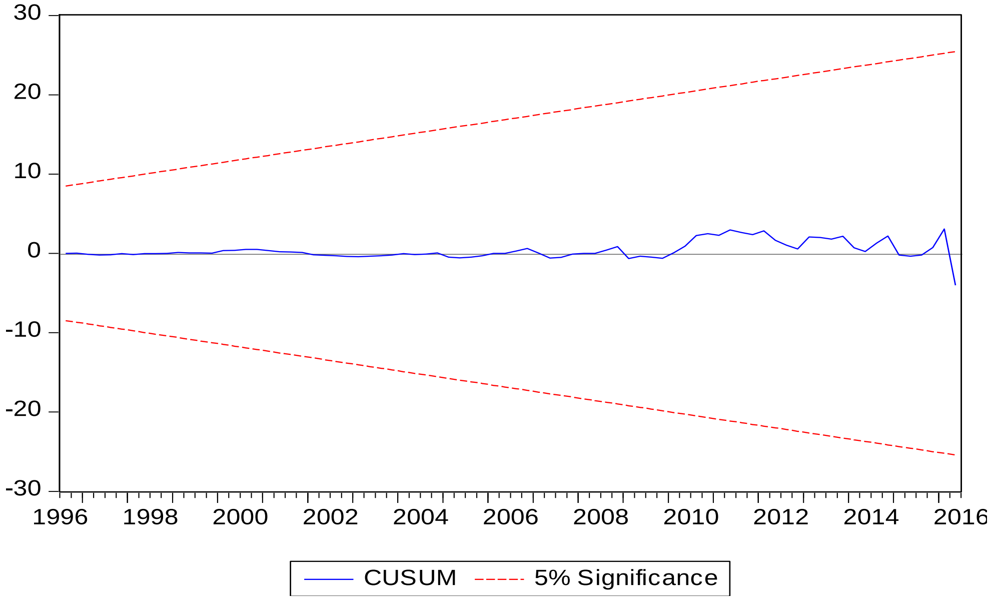
*Note: p-values and any subsequent tests do not account for model selection.

Appendix F: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.067760	Prob. F(2,84)	0.3484
Obs*R-squared	2.528840	Prob. Chi-Square(2)	0.2824

Appendix G: Stability test (CUSUM)



Appendix H: Wald Test

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	6.757967	(4, 86)	0.0001
Chi-square	27.03187	4	0.0000

Null Hypothesis: C(12) = C(13) = C(14) = C(15) = 0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(12)	2.101795	1.253351
C(13)	39.54962	9.426272
C(14)	-140.1002	28.44744
C(15)	-0.102717	0.030248

Restrictions are linear in coefficients.

Appendix I: ARDL Bounds Test

ARDL Bounds Test
Date: 06/11/18 Time: 13:32
Sample: 1991Q1 2016Q2
Included observations: 102
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k

F-statistic	29.00945	3

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Test Equation:
Dependent Variable: D(GDP,2)
Method: Least Squares
Date: 06/11/18 Time: 13:32
Sample: 1991Q1 2016Q2
Included observations: 102

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1),2)	0.906223	0.122014	7.427201	0.0000
D(GDP(-2),2)	0.291908	0.103521	2.819785	0.0060
D(T,2)	18.52487	2.507833	7.386803	0.0000
D(T(-1),2)	7.786426	3.327185	2.340244	0.0216
D(W,2)	629.2326	33.99752	18.50819	0.0000
D(W(-1),2)	-875.5932	118.1964	-7.407951	0.0000
D(W(-2),2)	-244.1130	91.66691	-2.663044	0.0092
T(-1)	4.082149	1.585768	2.574240	0.0118
E(-1)	-40.55906	16.04731	-2.527467	0.0133
W(-1)	-0.656632	58.74663	-0.011177	0.9911
GDP(-1)	0.092769	0.041486	2.236142	0.0279
C	-19887.98	81989.43	-0.242568	0.8089
D(E(-1))	25.78911	15.91815	1.620108	0.1089
D(T(-1))	4.793637	6.274980	0.763929	0.4470
D(W(-1))	1689.046	218.0259	7.746995	0.0000
D(GDP(-1))	-2.151417	0.233308	-9.221376	0.0000

R-squared	0.999329	Mean dependent var	12844.67
Adjusted R-squared	0.999212	S.D. dependent var	17927175
S.E. of regression	503385.8	Akaike info criterion	29.23920
Sum squared resid	2.18E+13	Schwarz criterion	29.65096
Log likelihood	-1475.199	Hannan-Quinn criter.	29.40594
F-statistic	8534.149	Durbin-Watson stat	1.922038
Prob(F-statistic)	0.000000		

Appendix J: ARDL Cointegrating and Long Run Form

ARDL Cointegrating And Long Run Form
Dependent Variable: D(GDP)
Selected Model: ARDL(3, 0, 2, 3)
Date: 06/11/18 Time: 13:35
Sample: 1990Q1 2016Q2
Included observations: 102

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1), 2)	-0.242461	0.180186	-1.345619	0.1820
D(GDP(-2), 2)	-0.479045	0.121640	-3.938232	0.0002
D(E, 2)	63.276902	8.179683	7.735862	0.0000
D(T, 2)	13.842115	2.026608	6.830190	0.0000
D(T(-1), 2)	8.135470	2.572223	3.162816	0.0022
D(W, 2)	336.208014	46.553323	7.221998	0.0000
D(W(-1), 2)	-254.783884	71.685204	-3.554205	0.0006
D(W(-2), 2)	424.005846	106.658620	3.975355	0.0001
D(T(-1))	2.101795	1.253351	1.676940	0.0972
D(E(-1))	39.549618	9.426272	4.195680	0.0001
D(W(-1))	-140.100211	28.447445	-4.924879	0.0000
D(GDP(-1))	-0.102717	0.030248	-3.395807	0.0010
CointEq(-1)	-0.331329	0.262927	-1.260154	0.2110

Cointeq = D(GDP) - (190.9793*D(E) -1.8976*D(T) -611.5369*D(W) + 6.3435*T(-1) + 119.3667*E(-1) -422.8436*W(-1) -0.3100*GDP(-1) + 108267.7343)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(E)	190.97926	171.973371	1.110516	0.2699
D(T)	-1.897561	15.080195	-0.125831	0.9002
D(W)	-611.5368	1364.32962	-0.448232	0.6551
T(-1)	6.343536	5.449544	1.164049	0.2476
E(-1)	119.36676	111.958143	1.066173	0.2893
W(-1)	-422.8436	336.282859	-1.257405	0.2120
GDP(-1)	-0.310015	0.298554	-1.038389	0.3020
C	108267.73	208180.167	0.520067	0.6044