A BOUND TESTING ANALYSIS OF WAGNER’S LAW IN NIGERIA: 1970-2006

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Abstract

This study tests Wagner’s Law (the tendency for government activities to expand along with economic expansion) for Nigeria using annual time series data between 1970 and 2006. It adopts the Bounds Test approach proposed by Pesaran et al. (2001) based on Unrestricted Error Correction Model and Toda and Yamamoto’s (1995) Granger non-causality tests. Empirical results from the Bounds Test indicate that there exists no long-run relationship between government expenditure and output in Nigeria. In addition, the Toda and Yamamoto’s (1995) causality test results show that Wagner’s Law does not hold for over the period being tested. Rather we found a weak empirical support in the proposition by Keynes that public expenditure is an exogenous factor and a policy instrument for increasing national income.

Keywords: Wagner’s Law, UECM, Bounds Test, Causality, Nigeria.
JEL classification: C32, H10

I Introduction

The growth of public sector spending has been a subject of extensive theoretical and empirical investigation over the past three decades. One of the theoretical explanations that have been advanced is Wagner's Law which has been used to analyze the relationship between aggregate income and public expenditure. Wagner (1890) stated that during the industrialization process, as real income per capita of a nation increases, the share of public expenditures in total expenditure increases. On the other hand, Keynes argued that public expenditure is an exogenous factor and a policy instrument for increasing national income. Therefore, he posits that the causality of the relationship between public expenditure and national income runs from expenditure to income. However, extensive empirical analysis of the Wagner’s law has produced mixed results in the literature. While some studies (Wagner and Weber, 1977; Abisadeh and Gray, 1985; Chang, 2002; Aregbeyen, 2006) have found support for the Wagner’s Law, some other studies (Ram, 1986; Afxentiou and Serletis, 1996; Ansari *et al.*, 1997; Lin, 1995; Burney, 2002; Huang, 2006) have found a non-existence or weak support for the Law.

In the case of Nigeria, Aigbokhan (1996) investigated the impact of government size (measured as expenditure share of GDP) on economic growth between 1960 and 1993 with a focus on the effects of the structural adjustment programme (SAP) introduced in July, 1986. The OLS regression analysis of a simple growth equation was estimated and augmented with the standard Granger-Causality testing approach. Empirical estimates from the Aigbokhan study reported a bi-directional causality between government total expenditure and national income. Using the Engle Granger two step procedure and standard causality tests, Essien (1997) found that the variables (public spending and real income) were not cointegrated and hence could not establish a long run relationship. In addition, causality tests performed on his models confirmed that public expenditure does not cause growth in income and there was no feedback mechanism. More recently, Aregbeyen (2006) using Johansen cointegration and standard causality tests found a unidirectional causality from national income to total public expenditure i.e. a support for Wagner's Law. There is bi-directional causality between non-transfer public expenditure and national income. In contrast, the causality from national income to non-transfer public expenditure was found to be stronger than the reverse direction following variance decomposition analysis.

However, the different sets of econometric methodologies employed in such empirical models such as single equation (Ordinary Least Square (OLS)), the Engle Granger (1987) procedure, the Johansen (1988) cointegration procedures and standard Granger causality frameworks could influence the growth-expenditure nexus. This is because there are limitations to these techniques. By way of illustration, while the Johansen (1988) multivariate cointegration method is by no means the only approach to cointegration, it has enjoyed widespread adoption since its inception. The most obvious advantage of the Johansen method is that it allows estimation of multiple cointegrating vectors where they exist. Far too often, however, practitioners fail to recognize that the application of the Johansen technique presupposes that the underlying regressors are all integrated of order one (Pesaran *et al*., 2001). This is necessary because in the presence of a mixture of stationary series and series containing a unit root, standard statistical inference based on conventional likelihood ratio tests is no longer valid. Harris (1995), for example, notes that the trace and maximum eigenvalue tests from the Johansen procedure may lead to erroneous inferences when I(0) variables are present in the system since stationary series are likely to generate spurious cointegrating relations with other variables in the model (De Vita et al, 2005).

In addition, the lack of consistent causal pattern between expenditure and economic growth in the studies on Nigeria may be due to the use of the traditional Granger causality frameworks. The use of a simple traditional Granger causality test has been identified by several studies (Engle and Granger, 1987; Toda and Philips, 1993; Toda and Yamamoto, 1995; Dolado and Lutkepohl, 1996; Zapata and Rambaldi, 1997; Tsen, 2006) as not sufficient if variables are 1(1) and cointegrated. If time series included in the analysis are I(1) and cointegrated, the traditional Granger causality test should not be used, and proper statistical inference can be obtained by analysing the causality relationship on the basis of the error correction model (ECM). Many economic time-series are 1(1), and when they are cointegrated, the simple F-test statistic does not have a standard distribution.

The primary objective of this paper is to re-evaluate the Wagner's hypothesis for Nigeria using a more robust estimation method. In this study, we use the bounds test proposed by Pesaran *et al.* (2001) which is based on the unrestricted error correction model (UECM) and the Toda and Yamamoto (1995) Granger non-causality tests. These two methodological procedures are useful because they allow tests of Granger causality between government expenditure and economic growth while accounting for the long-run information often ignored in systems that requires first differencing and pre-whitening prior to inference. In addition, the strands of the Wagner law considered by Essien (1997) and Aregbeyen (2006) are limited in scope. While Essien considered only three specifications of the model of Wagner's hypothesis, Aregbeyen considered only a single specification of the model. This study fills this gap by considering the five specifications of the Wagner's model common in the literature for Nigeria. The sequence of this paper is clear. Section II discusses the analytical framework on which the models are predicated while the estimation technique is presented in section III. Section IV discusses the empirical results from the analytical framework. Section V concludes.

II Analytical Framework

In empirical terms, Wagner Law investigates the relationship between government size and the economy. However, alternative strands of the literature have tested several specifications of Wagner's Law, using different variables to approximate the theoretical variables of government expenditure and economic growth.[1] Nevertheless, five of the specifications are predominant in the literature, since most authors test for the validity of one or more of them. Following Huang (2006), the five different versions of the Wagner's law can be expressed mathematically in a log-linear functional form, as follows:

Model 1: $RGE = f(RGDP)$ **… (1) Peacock-Wiseman:P-W (1967)**

Model 2: $RGE = f\left(\frac{RGDP}{N}\right)$ **… (2) Goffman (1968)**

Model 3: $\left(\frac{RGE}{N}\right) = f\left(\frac{RGDP}{N}\right)$ **… (3) Gupta (1967); Michas (1975)**

Model 4: $\left(\frac{RGE}{RGDP}\right) = f\left(\frac{RGDP}{N}\right)$**… (4) Musgrave (1969)**

Model 5: $\left(\frac{RGE}{RGDP}\right) = f\left(RGDP\right)$**… (5) Modified P-W (1967) version by Mann (1980)**

In this case, *RGE* = real total government expenditures, *RGDP* = real GDP, *N* = population, *RGDP/N* = real GDP per capita, *RGE/N* = real total government expenditures per capita, and *RGE/RGDP* = the ratio of real total government expenditures to real GDP. The only noticeable difference in the five models is however with respect to the measurement of government expenditure and economic output. For example, the size of government is measured by real total government expenditures (in the models of Peacock-Wiseman, 1967 and Goffman, 1968), real total government expenditures per capita (in the models of Gupta, 1967; Michas, 1975), or real total government expenditures as proportion of real GDP (in models of Musgrave 1969 and Mann, 1980). The economy is measured by real GDP (in models of Peacock-Wiseman, 1967 and Mann, 1980) or real GDP per capita (in models of Goffman, 1968; Gupta, 1967; Michas, 1975; and Musgrave, 1969). All variables are expressed in logarithm terms. The existence of long run relationship among the variables is a confirmation of the Wagner law.

III Estimation Technique

Pesaran *et al*. (2001) developed a new Auto-Regressive Distributed Lag (ARDL) bounds testing approach for testing the existence of a cointegration relationship. The approach has certain econometric advantages in comparison to other single cointegration procedures (Engle and Granger, 1987; Johansen, 1988; Johansen and Juselius, 1990). Firstly, endogeneity problems and inability to test hypotheses on the estimated coefficients in the long-run associated with the Engle-Granger (1987) method are avoided. Secondly, the long

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[1] Because there are different measures of government size and output, there are different empirical versions of Wagner's Law.

and short-run parameters of the model in question are estimated simultaneously. Thirdly, the econometric methodology is relieved of the burden of establishing the order of integration amongst the variables and of pre-testing for unit roots. The ARDL approach to testing for the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely *I*(0), purely *I*(1), or fractionally integrated. Finally, as argued in Narayan (2005), the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration (Halicioglu, 2007). The approach, therefore, modifies the Auto-Regressive Distributed Lag (ARDL) framework while overcoming the inadequacies associated with the presence of a mixture of *I*(0) and *I*(1) regressors in a Johansen-type framework.

The ARDL representation of models 1 to 5 in section II is formulated as follow:

$$\Delta RGE_t = \alpha_0 + \sum_{i=1}^{Q} \alpha_{1i} \Delta RGE_{t-i} + \sum_{i=1}^{Q} \alpha_{2i} \Delta RGDP_{t-i} + \alpha_3 RGE_{t-1} + \alpha_4 RGDP_{t-1} + \mu_t \quad (6)$$

In this case Q *stands* for the lag length for UECM while $\Delta RGDP_t$ and ΔRGE_t are the first differences of the logarithms of *RGDP* and *RGE* respectively. *RGE* represents real total government expenditures in models 1 and 2 (models of Peacock-Wiseman, 1967 and Goffman, 1968), real total government expenditures per capita in model 3 (models of Gupta, 1967; Michas, 1975), and the ratio of real total government expenditures to real GDP in models 4 and 5 (models of Musgrave, 1969; Mann, 1980). *RGDP* represents real GDP in models 1 and 5 (models of Peacock-Wiseman, 1967; Mann, 1980) and represents real GDP per capita in models 2, 3, and 4 (models of Goffman, 1968; Gupta, 1967; Michas, 1975; Musgrave, 1969).

The procedure of the bounds testing approach is based on the F or Wald-statistics and is the first stage of the ARDL cointegration method. The null hypothesis is tested by considering the UECM in equation (6) while excluding the lagged variables $\Delta RGDP_t$ and ΔRGE_t, based on the Wald or F-statistic. The asymptotic distribution of the F-statistic is non-standard under the null hypothesis of no cointegration relationship between the examined variables, without recourse to whether the underlying explanatory variables are purely I(0) or I(1). The null hypothesis of no cointegration ($H_0 : \alpha_3 = \alpha_4 = 0$) is therefore tested against the alternative hypothesis ($H_1 : \alpha_3 \neq 0, \alpha_4 \neq 0$).Thus, Pesaran *et al.* (2001) compute two sets of critical values for a given significance level. One set assumes that all variables are *I*(0) and the other set assumes they are all *I*(1). If the computed F-statistic exceeds the upper critical bounds value, then the H_0 is rejected. If the F-statistic is below the lower critical bounds value, it implies no cointegration. Lastly, if the F-statistic falls into the bounds then the test becomes inconclusive. Consequently, the order of integration for the underlying explanatory variables must be known before any conclusion can be drawn.

The concept of causality was initially defined by Granger (1969). Shirazi and Manap (2005) stated that in a bivariate framework, a time series x_{1t} Granger-causes another time series x_{2t} if series x_{2t} can be predicted with better accuracy by using past values of x_{1t} rather than by not doing so, other information being identical. The causal relationship between two series x_{1t} and x_{2t} (in such a bivariate case) can be tested on the following vector autoregressive process of order p such that:

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = \begin{bmatrix} B_{10} \\ B_{20} \end{bmatrix} + \begin{bmatrix} B_{11}(L) B_{12}(L) \\ B_{21}(L) B_{22}(L) \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \quad (7)$$

Where B_{i0} are the parameters representing intercept terms, B_{ij} (L) the polynomials in the lag operator and $\mu_t = (\mu_{1t,} \mu_{2t})$ is an independently and identically distributed bivariate white noise process with zero mean and non-singular covariance matrix. In this case, if B_{12}(L) s are statistically significantly, either in individual coefficient or a subset of coefficients but B_{21}(L) not, then it is said that x_{2t} is unidirectional Granger causal to x_{1t} . In contrast, if B_{21}(L) s are statistically significantly different from zero, either in individual coefficient or a subset of coefficients, but B_{12}(L) is not, then it is said that x_{1t} is unidirectional Granger casual to x_{2t}. Nevertheless, if both B_{12}(L) abd B_{21}(L) are statistically significantly different from zero, either in individual coefficient or a subset of coefficients in their respective equations, then there exists bi-directional causality (feedback effect) between these two variables.

However, evidence abounds in the literature (Toda and Phillips, 1993; Toda and Yamamoto, 1995; Zapata and Rambaldi, 1997) that the standard Granger causality tests still contain the possibility of incorrect inference. They also suffer from nuisance parameter dependency asymptotically in some cases. Consequently, their results are unreliable. All of these indicate that there may be no satisfactory statistical basis for using standard Granger causality tests in levels or in difference vector auto-regressive system or even in error correction models. The sequential Wald tests of Toda and Yamamoto (1995) are designed to avoid these problems. Thus, the major strength of using the Toda and Yamamoto's techniques of testing for granger causality lies in its simplicity and the ability to overcome many shortcomings of alternative econometric procedures.

Toda and Yamamoto (1995) proposed a simple procedure requiring the estimation of an 'augmented' VAR, even when there is cointegration, which guarantees the asymptotic distribution of the modified Wald statistic. The important thing is to determine the maximal order of integration *dmax* (where *dmax* is the maximal order of integration suspected to occur in the system), which we expect to occur in the model and construct a VAR in their levels with a total of (k + *dmax*) lags. Toda and Yamamoto point out that, for $d = 1$, the lag selection procedure is always valid, at least asymptotically, since $k > = 1 = d$. If $d = 2$, then the procedure is valid unless $k = 1$. Moreover, according to Toda and Yamamoto, the modified Wald statistic is valid regardless whether a series is I(0), I(1) or I(2), non-cointegrated or cointegrated of an arbitrary order (Shirazi and Manap, 2005).

By way of illustration, let us consider the simple example of a bivarite model, with one lag (k=1). That is,

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = \begin{bmatrix} B_{10} \\ B_{20} \end{bmatrix} + \begin{bmatrix} B_{11}{}^{(1)} B^{(1)} \\ B_{21}{}^{(1)} B^{(1)} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \tag{8}$$

In this case, B_{i0} are the parameters representing intercept terms and $\mu_t = (\mu_{1t,} \mu_{2t,})$ is n independently and identically distributed bivariate white noise process with zero mean and non-singular covariance matrix. In order to test that x_2 does not Granger cause x_1, we will test the parameter restriction $B_{12}{}^{(1)}$ =0. If now we assume that x_{1t} and x_{2t} are I(1), a standard t-test is not valid. We test $B_{12}{}^{(1)}$ =0 by constructing the usual Wald test based on least squares estimates in the augmented model:

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = \begin{bmatrix} B_{10} \\ B_{20} \end{bmatrix} + \begin{bmatrix} B_{11}{}^{(1)} B^{(1)} \\ B_{21}{}^{(1)} B^{(1)} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \begin{bmatrix} B_{11}{}^{(2)} B^{(2)} \\ B_{21}{}^{(2)} B^{(2)} \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \tag{9}$$

The Wald statistic will be asymptotically distributed as a Chi Square (χ^2), with degrees of freedom equal to the number of "zero restrictions", irrespective of the integrated order {I(0) or I(1)}, non-cointegrated or cointegrated of an arbitrary order. Adopting the Huang (2006) framework, we formulate the Toda-Yamamoto test of Granger causality as follow:

$$RGE_t = \alpha_0 + \sum_{i=1}^{K+d_{\max}} \alpha_{1i} RGE_{t-i} + \sum_{i=1}^{K+d_{\max}} \alpha_{2i} RGDP_{t-i} + \mu_t \qquad (10)$$

where K is the optimal lag length; $d_{\max}$ is the maximum order of integration in the system. $RGDP_t, RGE_t$ are the logarithms of *real GDP* and real government expenditure respectively. As defined earlier, *RGE* represents real total government expenditures in models 1 and 2, real total government expenditures per capita in model 3, and the ratio of real total government expenditures to real GDP in models 4 and 5. *RGDP* represents real GDP in models 1 and 5 and represents real GDP per capita in models 2, 3, and 4 respectively. This allows us to test the null hypothesis that there is no Granger causality from *RGDP* to *RGE*, that is, to test, $H_0 : \alpha_{2i} = 0$, i = 1, 2, …, K. According to Zapata and Rambaldi (1997), the benefit of this approach is that it does not require prior knowledge of the cointegration nature of the system. It has a normal limiting chi-square distribution and the usual lag selection procedure to the system can be applied even if there is no cointegration and/or the stability and rank conditions are not satisfied (Huang, 2006).

From the estimated equations 1-5, a change in any of the random innovations will immediately affect the value of the dependent variable, and make the future values of the remaining variables in the system to also change through the model's dynamic structure. Therefore it is possible to decompose the total variance of the forecast error in any of the dependent variables and determine how much of the variance is explained by the independent variables. These responses are to a-one standard deviation innovation in the factor inputs estimated using random generation of the parameters in equations 1-5 in a Monte Carlo study with 100 iterations. Since the innovations are not necessarily totally uncorrelated, the residual terms are orthogonalized using a Cholesky decomposition in order to obtain diagonal covariance matrix of the resulting innovations and, therefore, isolate the effects of each of the variable on the other.

IV The Data and Empirical Analysis

Annual time series data were collected on real GDP, real government expenditures, and population for Nigeria. The annual data covers the period 1970 to 2006. The choice of this period was guided by data availability considerations and also to make the study comparable to past studies in Nigeria. The data were obtained from the Central Bank of Nigeria Statistical Bulletin (2005) and Annual Report and Statement of Accounts (2006).

Table 1 reports the bounds test results. The computed F-statistic for five different Wagner's Law models for Nigeria all appear to be lower than the lower bounds critical values of 4.94 and 6.84 at 5% and 1% level of significance respectively. These results indicate that there exists no cointegration between *RGE* and *RGDP* in model 1, *RGE* and *RGDP/N* in model 2, *RGE/N* and *RGDP/N* in model 3, *RGE/GDP* and *RGDP/N* in model 4, and *RGE/RGDP* and *RGDP* in model 5. Consequently, these results indicate that there exists no cointegration between government size and the economy in Nigeria between 1970 and 2006. The empirical basis of Wagner's Law is the investigation of the long-run relationship between government size and the economy. We expect the cointegration relationship to exist between government size and the economy if indeed Wagner's Law holds. In contrast, empirical findings show that no such cointegration relationship exists between government expenditure and the economy in Nigeria. Thus, the validity of Wagner's Law could not be established for Nigeria.

In addition, Table 2 presents the results of the Granger non-causality tests carried out for Nigeria based on the Toda and Yamamoto (1995) approach. The Toda and Yamamoto's causality approach clearly points to the independence with respect of the causality running from output to government expenditures in most of the cases, except in model 3 where there exists a weak causality running from output to government expenditure. Rather the empirical results support the Keynesian view, which states that the fiscal policy variables are major determinants of economic growth. To Keynes, public expenditure is an exogenous factor and a policy instrument for increasing national income. Consequently, he opines that the causality of the relationship between public expenditure and national income runs from expenditure to income. The results point out there is a unidirectional relationship running from expenditure to national income in models 1 to 5.

The variance decomposition error results in Tables 3 to 7 lend credence to our argument about the Wagner's hypothesis. For example, empirical evidence from Table 3 reveals that 91.35% of future changes in government expenditure are due to changes in government expenditure itself while economic growth is responsible for 8.64%. Similarly, economic growth in Nigeria was found to explain about 87.94% changes in itself while government expenditure explains the rest 12.03%. Except for the result in Table 5 where economic growth explains about 45.70% of the future changes in real government expenditure, similar results that government expenditure and economic growth behave independently were found.

This study partly confirms the findings of Essien (1997) who could also not establish a long run relationship between government size and economic growth in Nigeria and that public expenditure does not cause growth in income and there was no feedback mechanism. The point of divergence between this study and Essien (1997) is that we found unidirectional causality from government size to national income. In contrast, our empirical results do not support the validity of Wagner's Law for Nigeria reported by Aregbeyen (2006) who found a unidirectional causality from national income to total public expenditure i.e. a support for Wagner's Law and Aigbokhan (1996) who reported a bi-directional causality between government total expenditure and national income. As earlier argued, the shortcomings of the estimation techniques employed by these studies could be held responsible for the divergence in the empirical results.

It is however worth noting that our results are consistent with Huang (2006) who found that there exists no long-run relationship between government size and the economy either in China or in Taiwan and that Toda and Yamamoto's (1995) causality test results also show that Wagner's Law does not hold for China and Taiwan between 1979 and 2002. In addition, our results are consistent with Afxentiou and Serletis (1996) in their examination of six European countries (France, Italy, Germany, Belgium, the Netherlands and Luxembourg) over the period 1961-1991, that there is no strong evidence to support Wagner's Law in relation to any of these countries. The studies of Ansari *et al*. (1997) for three African countries, Ghana, Kenya, and South Africa, could also not find a supportive evidence to support Wagner's Law. Thus, the major empirical findings from this study therefore have important implications for the governmental and economic system.

V Concluding Summary

This paper tested Wagner's Law for Nigeria using aggregate real data for the period 1970-2006 with five formulations of Wagner's Law using Bounds Test proposed by Pesaran *et al*. (2001) and Toda and Yamamoto's (1995) Granger non-causality tests. The results from the Bounds Test indicate that there exists no long-run relationship between government size and the economy in Nigeria. In addition, the Toda and Yamamoto's (1995) causality test results show that Wagner's Law does not hold for Nigeria over the period being tested. The conclusion from these results is that the postulation of Wagner's Law that there is a long run tendency for public expenditure to grow relative to national income does not have any support in Nigeria during the period 1970-2006 rather we found a weak empirical support in the proposition by Keynes that public expenditure is an exogenous factor and a policy instrument for increasing national income.

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Table 1: Bounds Testing for Cointegration Analysis

Model	Examined Variables	Lags	F -Stat	5% Critical bounds	1% Critical bounds
1	RGE, RGDP	1	2.5868	4.94 -5.73	6.84-7.84
2	RGE, RGDP/N	1	4.1200	4.94 -5.73	6.84-7.84
3	RGE/N, RGDP/N	1	4.2198	4.94 -5.73	6.84-7.84
4	RGE/RGDP, RGDP/N	1	4.0135	4.94 -5.73	6.84-7.84
5	RGE/RGDP, RGDP	1	2.3873	4.94 -5.73	6.84-7.84

Notes: The lag structure of *k* was selected based on the Schwartz criterion. The bounds critical values are obtained from Table CI(iii) Case III: unrestricted intercept and no trend for one regressor (Pesaran *et al*. 2001, Page 300).

Table 2: Granger Causality Test based on Toda and Yamamoto Test

Model	d	Null Hypothesis	Wald Statitics	ρ -value	Sum of lagged coefficients
1	1	*RGDP* does not cause *RGE*	0.819548	0.3653	1.052991
	1	RG does not cause RGDP	4.286909**	0.0384	0.889723
2	1	*RGDP/N* does not cause *RG*	1.521092	0.2175	1.179941
	1	RG does not cause *RGDP/N*	2.761886***	0.0965	0.90616
3	1	*RGDP/N* does not cause *RG/N*	2.945064***	0.0861	1.402844
	1	*RG/N* does not cause *RGDP/N*	2.745581***	0.0975	0.941053
4	1	*RGDP/N* does not cause *RG/RGDP*	0.774059	0.3790	0.948624
	1	*RG/RGDP* does not cause *RGDP/N*	2.745581***	0.0975	0.859713
5	1	*RGDP* does not cause *RG/RGDP*	0.078648	0.7791	0.754632
	1	*RG/RGDP* does not cause *RGDP*	4.286909***	0.0384	0.795229

Note: The sum of the lagged coefficients represents the summation of the lags excluding the second or third lag as discussed in Rambaldi and Doran (1996), Rambaldi (1997), Zapata and Rambaldi (1997), and Wolde-Rufael (2005).

* Significant levels at 1%; ** Significant levels at 5%; *** Significant levels at 10%.

Table 3: Variance Decomposition of RGE and RGDP

	Variance Decomposition of LAGEXP:			Variance Decomposition of LRGDP:		
Period	S.E.	RGE	RGDP	S.E.	RGE	RGDP
1	0.115757	100.0000	0.000000	0.031398	7.219967	92.78003
2	0.132486	98.38841	1.611586	0.043345	4.157973	95.84203
3	0.136754	97.27061	2.729386	0.052586	4.794905	95.20509
4	0.138200	96.24211	3.757891	0.060470	6.261103	93.73890
5	0.138983	95.27830	4.721696	0.067373	7.729083	92.27092
6	0.139642	94.38029	5.619714	0.073495	8.982770	91.01723
7	0.140295	93.54415	6.455845	0.078978	10.00287	89.99713
8	0.140950	92.76417	7.235826	0.083928	10.82310	89.17690
9	0.141599	92.03468	7.965317	0.088429	11.48447	88.51553
10	0.142232	91.35075	8.649246	0.092545	12.02263	87.97737

Table 4: Variance Decomposition of RGE and RGDP/N

	Variance Decomposition of RGE:			Variance Decomposition of LRGDP:		
Period	S.E.	RGE	RGDP/N	S.E.	RGE	RGDP/N
1	0.112465	100.0000	0.000000	0.031781	11.43093	88.56907
2	0.128462	97.08203	2.917967	0.043363	6.305497	93.69450
3	0.134700	94.40356	5.596445	0.050693	4.723578	95.27642
4	0.137828	91.83638	8.163618	0.055874	4.289351	95.71065
5	0.139826	89.60023	10.39977	0.059654	4.299708	95.70029
6	0.141311	87.77111	12.22889	0.062445	4.466753	95.53325
7	0.142484	86.33243	13.66757	0.064517	4.669573	95.33043
8	0.143419	85.22702	14.77298	0.066058	4.859995	95.14000
9	0.144159	84.38911	15.61089	0.067206	5.021876	94.97812
10	0.144737	83.75889	16.24111	0.068060	5.152780	94.84722

Table 5: Variance Decomposition of RGE/N and RGDP/N

	Variance Decomposition of RGE:			Variance Decomposition of LRGDP:		
Period	S.E.	RGE/N	RGDP/N	S.E.	RGE/N	RGDP/N
1	0.112789	100.0000	0.000000	0.031946	12.26822	87.73178
2	0.129804	94.71409	5.285907	0.044290	6.644487	93.35551
3	0.140599	86.19403	13.80597	0.052764	4.704277	95.29572
4	0.149530	77.39545	22.60455	0.058907	3.984044	96.01596
5	0.157354	70.04009	29.95991	0.063393	3.765924	96.23408
6	0.163998	64.47955	35.52045	0.066658	3.756910	96.24309
7	0.169409	60.47155	39.52845	0.069018	3.827215	96.17278
8	0.173660	57.64436	42.35564	0.070712	3.918866	96.08113
9	0.176907	55.66879	44.33121	0.071919	4.007016	95.99298
10	0.179333	54.29395	45.70605	0.072774	4.082390	95.91761

Table 6: Variance Decomposition of RGE/GDP and RGDP/N

	Variance Decomposition of RGE:			Variance Decomposition of LRGDP:		
Period	S.E.	RGE/GDP	RGDP/N	S.E.	RGE/GDP	RGDP/N
1	0.105914	100.0000	0.000000	0.031946	0.509386	99.49061
2	0.119175	98.47545	1.524547	0.044290	2.398678	97.60132
3	0.124652	95.15922	4.840783	0.052764	4.509607	95.49039
4	0.128026	91.08340	8.916596	0.058907	6.470440	93.52956
5	0.130897	87.15799	12.84201	0.063393	8.079890	91.92011
6	0.133507	83.85770	16.14230	0.066658	9.339400	90.66060
7	0.135803	81.29164	18.70836	0.069018	10.29858	89.70142
8	0.137725	79.38446	20.61554	0.070712	11.01610	88.98390
9	0.139269	78.00374	21.99626	0.071919	11.54566	88.45434
10	0.140467	77.01977	22.98023	0.072774	11.93220	88.06780

Table 7: Variance Decomposition of RGE/GDP and RGDP

	Variance Decomposition of RGE:			Variance Decomposition of LRGDP:		
Period	S.E.	RGE/GDP	RGDP/N	S.E.	RGE/GDP	RGDP/N
1	0.111501	100.0000	0.000000	0.031398	0.000695	99.99931
2	0.129633	99.84362	0.156377	0.043345	5.991824	94.00818
3	0.135713	99.80820	0.191803	0.052586	12.12937	87.87063
4	0.138442	99.56896	0.431044	0.060470	17.16552	82.83448
5	0.140005	99.17962	0.820379	0.067373	21.05098	78.94902
6	0.141112	98.70822	1.291778	0.073495	24.00974	75.99026
7	0.142011	98.20352	1.796476	0.078978	26.27811	73.72189
8	0.142801	97.69449	2.305506	0.083928	28.04234	71.95766
9	0.143521	97.19674	2.803261	0.088429	29.43775	70.56225
10	0.144193	96.71796	3.282045	0.092545	30.56037	69.43963