Revisiting Wagner's Law for selected African Countries: A Frequency Domain Causality Analysis

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Abstract

This study examines the causal relationship between government expenditure and economic growth and tests the validity of Wagner's Law for ten African countries. Wagner's law hypothesizes that there is a one-way causality running from national income to government expenditure. We employ Granger causality tests in the frequency domain which allows us to distinguish short, medium and long run causality. The empirical results show that Wagner's law holds for Cameroon only in the medium term, for Ghana in the short, medium and long terms and for Nigeria in the long-run. The opposite view is supported for Gabon and Senegal in the short, medium and long run, and for South Africa both in the medium and short run. There is bidirectional causality between government expenditure and income for Burkina Faso over the short, medium and long run.

Keywords: Wagner's law, government expenditure, income, Frequency domain analysis.

JEL Classification: C32, E62, H50, O55.

1. Introduction

The nexus between government expenditure and economic growth is one of the most controversial issues in the macroeconomic literature. This topic has important policy implications. If government spending causes economic growth, then government expenditure could be used to promote economic growth and therefore reducing public spending could lead to a fall in real output. On the other hand, if the causality runs in the opposite direction, then budget deficit-reducing policies may be implemented without detrimental effects on economic growth. Theoretically, two conventional views describe the relationship between public spending and economic growth. First, the Wagner's law stresses that as per capita income increases the share of public spending tends to rise to meet the increased protective, administrative and educational functions of the state (Wagner, 1883). This view suggests a unidirectional causality running from national income to government expenditure. On the contrary, the Keynesian view argues that public spending is an exogenous factor and a policy instrument for increasing national income (Keynes, 1936). This line of though suggests that causality runs from government expenditure to economic growth.

An extensive empirical research has examined the validity of these two competing views. The empirical evidence from this literature is however mixed and controversial across countries, data, model specifications and econometric techniques (see Narayan *et al*., 2008; Srinivasan 2013, Samudram *et al.*, 2009; Dogan and Tang, 2006). Regarding studies on sub-Saharan African countries, Ansari *et al.* (1997) investigated the direction of causality between government expenditure and national income for Ghana, Kenya, and South Africa. They found that there is no long run relationship between government expenditure and national income. In the short-run, only Ghana shows evidence supporting Wagner's law. The results obtained by Olomola (2004), Aregbeyen (2006), Ogbonna (2012), Akonji *et al.* (2013), and Akinlo (2013) for Nigeria, Menyah and Wolde-Rufael (2012) for South Africa, Mutuku and Kimani (2012) for Kenya, and Salih (2012) for Sudan are consistent with Wagner's law. In contrast, the studies by Omoke (2009), Chimobi (2009), Sevitenyi (2012), and Muse *et al.* (2013) for Nigeria, Ebaidalla (2013) for Sudan, and Gadinabokao and Daw (2013) for South Africa provided support for the Keynesian view. Ayo *et al*. (2011) found supportive empirical evidence for both hypotheses both in the short run and long run for Nigeria. Besides, the results obtained by Frimpong and Oteng-Abayie (2009) supported neither Wagner's law nor Keynesian view for Gambia, Ghana and Nigeria.

Most of the previous studies used the standard approach to Granger causality, which requires pre-testing of unit root and cointegration. In the case of nonstationarity, variables are considered in first differences to make them stationary which cause loss of long-run information. In addition, standard approach of Granger causality ignores the possibility that the strength and direction of the causality could vary over different frequencies. The new Keynesian approach accepts that size and direction of interaction between economic variables can change over time due to rigidities in an economy. In this regard, the relation between two variables might disappear in the medium and long run, although it is strong in the short run.

This study contributes to the public expenditure-growth literature by employing the Granger causality in the frequency domain to examine short, medium and long run causality and aims to indicate whether there is a change in causality direction over time. Frequency domain analysis allows analyzing the causal relationship between economic variables in different time periods (short, medium and long terms). To the best of our knowledge, this is the first study investigating causality between government expenditure and economic growth in high and low frequencies. The empirical analysis is based on a sample of nine African countries. The remainder of the paper is organized as follows. Section 2 describes the econometric methodology. Section 3 analyses the empirical results and Section 4 concludes the study.

2. Econometric Methodology

2.1 Data description

This study uses annual time series data for a sample of nine African countries, namely Burkina Faso, Cameroon, Cote d'Ivoire, Gabon, Ghana, Kenya, Nigeria, Senegal and South Africa. The variables under study are government expenditures as share of GDP and real per capita GDP. The GDP deflator was used to express data in constant 2005 US dollars. Meanwhile, the effect of population growth was removed by using per capita values. Data cover the period from 1965 to 2013, except for Nigeria for which data cover the period 1980-2013. All data were obtained from the World Development Indicators, available online.

Table 1 reports statistics on the evolution of the two variables. The most striking feature is the low levels of the size of public sector as well as real income in most countries. Also evident from the Table is the positive association between the two variables. However, correlation does not mean causality. Our goal in this study is to find out whether this positive association implies that more government spending causes higher income or higher income leads to more public spending. It is possible that the association between the two variables is not causal in any direction, but just coincidental.

Table 1: Public expenditure and real per capita GDP over time

	Public expenditure (% GDP)				Real per capita GDP			
Countries	1965-80	1981-90	1991-00	2001-13	1965-80	1981-90	1991-00	2001-13
Burkina Faso	7.9	16.8	22.5	21.1	224.9	267.5	305.6	418.6
Cameroon	11.7	10.3	10.3	10.7	774.1	1191	837.1	925.9
Côte d'Ivoire	14.4	16.5	10.9	8.1	1492.7	1279.4	1066.8	999.9
Gabon	14.1	18.3	12.8	9.6	6566.0	7315.8	7148.9	6314.9
Ghana	12.8	8.8	11.8	12.9	457.6	355.8	412.9	567.6
Kenya	16.9	18.2	15.5	15.6	441.6	528.1	515.2	552.1
Nigeria	-	10.9	9.9	8.4	729.3	598.3	550.3	848.7
Senegal	15.9	18.7	14.5	14.1	776.7	713.2	665.5	769.2
South Africa	13.4	17.9	19.2	19.2	5042.8	5295.5	4789.4	5621.9

Source: World Development Indicators Online, World Bank

2.2 Causality test in the frequency domain

Frequency domain describes the domain for analysis of mathematical functions with respect to frequencies, rather than time. In the frequency domain, a stationary process can be expressed as a weighted sum of sinusoidal components with a frequency ω. Frequency domain causality was developed by Granger (1969), Geweke (1982) and Breitung and Candelon (2006). In this study, we follow the description in Breitung and Candelon (2006).

Let $Z_t=(X_t, Y_t)'$ be a two-dimensional vector of time series. It has a finite-order VAR representation of the form:

$$\Theta(L)Z_t = \left(I - \theta_1 L - ... - \theta_p L^p\right)Z_t = \mu_t \tag{1}$$

where L is the lag operator. The error vector μ_t is white noise with $E(\mu_t)=0$ and $E(\mu_t\mu'_t)=\Sigma$; where Σ is positive definite. Let G be the lower triangular matrix of the Cholesky decomposition, $G'G= \Sigma^{-1}$ such that $\eta_t=G\mu_t$ and $E(\eta_t\eta_t'_t)=I$. If Z_t is stationary, the MA representation is:

$$Z_t = \Phi(L)\varepsilon_t = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{pmatrix} \mu_{1t} \\ \mu_{2t} \end{pmatrix} = \Psi(L)\eta_t = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \tag{2}$$

where $\Phi(L)=\Theta(L)^{-1}$ and $\Psi(L)=\Phi(L)G^{-1}$. Using this representation the spectral density of X_t can be expressed as:

$$f_x(\omega) = \frac{1}{2\pi}\left(\left|\Psi_{11}(e^{-i\omega})\right|^2 + \left|\Psi_{12}(e^{-i\omega})\right|^2 \right) \tag{3}$$

Then, we can define the measure of causality suggested by Geweke (1982) as follows:

$$M_{y\to x}(\omega) = \log\left[\frac{2\pi f_x(\omega)}{\left|\Psi_{11}(e^{-i\omega})\right|^2} \right] = \log\left[1 + \frac{\left|\Psi_{12}(e^{-i\omega})\right|^2}{\left|\Psi_{11}(e^{-i\omega})\right|^2} \right] \tag{4}$$

To test the hypothesis that Y does not cause X at frequency ω, we consider the null hypothesis:

$$M_{y\to x}(\omega) = 0 \Leftrightarrow \left|\Psi_{12}(e^{-i\omega})\right|^2 = 0 \tag{5}$$

Breitung and Candelon (2006) show that:

$$\left|\Psi_{12}(e^{-i\omega})\right| = 0 \Leftrightarrow \left|\sum_{j=1}^{p}\theta_{12j}\cos(j\omega) - \sum_{j=1}^{p}\theta_{12j}\sin(j\omega)i\right| = 0$$

$$\Leftrightarrow \begin{cases} \sum_{j=1}^{p}\theta_{12j}\cos(j\omega) = 0 \\ \sum_{j=1}^{p}\theta_{12j}\sin(j\omega) = 0 \end{cases} \tag{6}$$

Breitung and Candelon (2006) propose a simple approach to test these linear restrictions. They consider the VAR equation for X specifies as follows:

$$X_t = \alpha_1 X_{t-1} + ... + \alpha_p X_{t-p} + \beta_1 Y_{t-1} + ... + \beta_p Y_{t-p} + \mu_{1t} \tag{7}$$

The null hypothesis $M_{y\to x}(\omega) = 0$ is equivalent to the linear restriction:

$$H_0 : R(\omega)\beta = 0 \tag{8}$$

where R=[β_1, β_2,… β_p]' and

$$R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & ... & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & ... & \sin(p\omega) \end{bmatrix} \tag{9}$$

The causality measure for $\omega \epsilon [0,\pi]$ can be tested using the standard F-test for linear restrictions. The F-statistic follows an F distribution with (2, T-2p) degrees of freedom.

3. Empirical Results

As a first step of our empirical analysis, we test for the order of integration of the series by means of unit root tests. To that end, we apply two well-known unit root tests—the PP test of Phillips-Perron (1988) and the KPSS test of Kwiatkowski et *al.* (1992). These tests have been performed under the models with constant and trend for the level series and with constant for series in first difference. The results displayed in Table 2 show that the variables are non-stationary in their level but achieve stationary status after taking the first difference.

Table 2: Results of unit root tests

Country	PP				KPSS			
	g	y	Δg	Δy	g	y	Δg	Δy
Burkina Faso	-0.981	-1.207	-8.153	-7.964	0.224	0.208	0.402	0.297
Cameroon	-2.047	-1.619	-6.559	-5.170	0.114	0.141	0.113	0.114
Cote d'Ivoire	-2.141	-2.643	-5.319	-4.499	0.157	0.106	0.196	0.202
Gabon	-2.751	-2.308	-8.114	-4.723	0.176	0.148	0.267	0.287
Ghana	-2.096	0.231	-6.167	-4.596	0.181	0.228	0.245	0.393
Kenya	-2.107	-2.968	-6.482	-6.130	0.153	0.158	0.242	0.299
Nigeria	-2.572	-1.123	-6.274	-4.937	0.077	0.151	0.071	0.198
Senegal	-4.151	-1.451	-6.816	-9.459	0.174	0.211	0.283	0.367
South Africa	-1.456	-1.638	-6.354	-4.234	0.216	0.128	0.479	0.195

Notes: Critical values at the 5% level are: for PP test -3.506 (level) and -2.925 (difference), and for KPSS: 0.146 (level) and 0.463 (difference).

Before using the frequency domain causality test, we first apply Granger causality tests in the time domain to gain first insights into the causal link between government expenditure and economic growth. To that end, we apply the Toda and Yamamoto (1995) approach. This approach does not require testing for cointegration and estimating vector error correction model and is robust to the unit root and cointegration properties of the series. While the standard Granger causality analysis requires estimating a level VAR(p), the Toda and Yamamoto (1995) procedure requires estimating a level VAR(p+d) where *d* is the maximum integration order of the variables. The null hypothesis of Granger causality is then tested by imposing zero restriction on the first *p* parameters using a standard Wald statistic. According to the results of unit root tests, the maximum integration order of the variables is one. The lag length *p* is determined using the Akaike Information Criterion (AIC). The results are shown in Table 3. They indicate that there is a unidirectional Granger causality running from income to government expenditure for only Ghana, and from government expenditure to income for only Gabon, Senegal and South Africa. There is bidirectional causality between the two variables in the case of Burkina Faso.

Table 3: Results of linear Toda and Yamamoto (1995) Granger-causality test

	Lag length *p*	Income does not cause government expenditure	Government expenditure does not cause Income
Burkina Faso	2	3.968 (0.027)*	4.825 (0.013)*
Cameroon	6	1.597 (0.186)	1.325 (0.279)
Cote d'Ivoire	2	2.590 (0.161)	2.151 (0.211)
Gabon	3	1.480 (0.240)	2.967(0.047)*
Ghana	2	3.483 (0.041)*	0.836 (0.441)
Kenya	2	0.356 (0.702)	1.013 (0.372)
Nigeria	6	2.270 (0.120)	0.876 (0.544)
Senegal	2	0.608 (0.549)	3.012 (0.061)**
South Africa	6	0.476 (0.819)	2.599 (0.041)*

Note: The lag length for the VAR(p+d) models are determined by AIC. Numbers in parentheses are the *p*-values. * and ** denote statistical significance at the 5% and 10% levels, respectively.

Table 4: Results of frequency domain Granger-causality test

	Income does not cause government expenditure						Government expenditure does not cause Income					
	Long term		Medium term		Short term		Long term		Medium term		Short term	
	ω=0.5	ω=1.00	ω=1.50	ω=2.00	ω=2.50	ω=3.0	ω=0.5	ω=1.00	ω=1.50	ω=2.00	ω=2.50	ω=3.0
Burkina Faso	3.968*	3.968*	3.968*	3.968*	3.968*	3.968*	4.825*	4.825*	4.825*	4.825*	4.825*	4.825*
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Cameroon	0.197	1.441	3.144**	0.384	1.323	1.718	0.996	2.364	0.317	0.548	0.970	0.769
	(0.821)	(0.254)	(0.059)	(0.684)	(0.283)	(0.198)	(0.382)	(0.113)	(0.730)	(0.584)	(0.391)	(0.473)
Cote d’Ivoire	2.590	2.590	2.590	2.590	2.590	2.590	2.151	2.151	2.151	2.151	2.151	2.151
	(0.169)	(0.169)	(0.169)	(0.169)	(0.169)	(0.169)	(0.211)	(0.211)	(0.211)	(0.211)	(0.211)	(0.211)
Gabon	0.654	1.274	2.086	2.201	2.218	2.220	4.357*	3.715*	3.306*	3.378*	3.471*	3.511*
	(0.527)	(0.294)	(0.142)	(0.128)	(0.126)	(0.126)	(0.021)	(0.036)	(0.050)	(0.047)	(0.044)	(0.042)
Ghana	3.484*	3.484*	3.484*	3.484*	3.484*	3.484*	0.836	0.836	0.836	0.836	0.836	0.836
	(0.040)	(0.040)	(0.040)	(0.041)	(0.041)	(0.041)	(0.441)	(0.441)	(0.441)	(0.441)	(0.441)	(0.441)
Kenya	0.356	0.356	0.356	0.356	0.356	0.356	1.013	1.013	1.013	1.014	1.013	1.013
	(0.702)	(0.702)	(0.702)	(0.702)	(0.702)	(0.702)	(0.372)	(0.372)	(0.372)	(0.373)	(0.372)	(0.372)
Nigeria	0.728	3.961**	1.902	0.244	0.881	0.764	0.242	0.118	1.656	0.953	0.254	1.150
	(0.506)	(0.054)	(0.199)	(0.787)	(0.444)	(0.491)	(0.788)	(0.889)	(0.239)	(0.417)	(0.780)	(0.355)
Senegal	0.608	0.608	0.608	0.608	0.608	0.608	3.012**	3.012**	3.012**	3.012**	3.012**	3.012**
	(0.549)	(0.549)	(0.549)	(0.549)	(0.549)	(0.549)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)
South Africa	0.111	0.620	0.103	0.124	0.650	0.573	1.106	1.871	1.131	3.620*	3.603*	3.772*
	(0.895)	(0.545)	(0.902)	(0.884)	(0.530)	(0.570)	(0.346)	(0.174)	(0.337)	(0.041)	(0.041)	(0.036)

Note: Numbers in parentheses are the p-values. * and ** denote statistical significance at the 5% and 10% levels, respectively.

To measure short, medium and long terms causal dynamics, we calculate test statistics for frequencies ω∈{0.5; 1; 1.5; 2; 2.5; 3}. The frequency (ω=2.5) corresponds to a periodicity of 2.5 years, the frequency (ω=1.5) corresponds to a periodicity of 4.2 years, and the frequency (ω=1) corresponds to a periodicity of 6.3 years. To eliminate the need for testing cointegration, we augment the VAR model by one lag and test the restrictions by using a VAR(p+1) model, so the frequency domain causality test will be robust to the cointegration property of the variables as suggested by Breitung and Candelon (2006). Table 4 presents the causality test results in frequency domain. The results suggest bidirectional causality for Burkina Faso over the short, medium and long periods. They also indicate that causality from income to government spending exists in medium term for Cameroon, and in short, medium and long terms for Ghana, and a permanent (long-term) causality for Nigeria. On the other hand, the causality from government spending to income exists for Gabon and Senegal over the short, medium and long periods, and for South Africa both in short and medium terms. Causality disappears in the long run in South Africa. There is no evidence of causal relationship between government expenditure and per capita GDP in Cote d'Ivoire and Kenya. This finding suggests that the movements of government expenditure and per capita income do not have significant impacts upon each other.

In light of these findings, we can conclude that Wagner's law holds for Cameroon only in the medium term, for Ghana in the short, medium and long terms and for Nigeria in the long-run. The Keynesian view is supported for Gabon and Senegal in the short, medium and long run, and for South Africa both in the medium and short run. Government spending in Burkina Faso follows Wagner's law and Keynesian view over the short, medium and long run. Conversely, evidence for Cote d'Ivoire and Kenya do support neither Wagner's law nor Keynesian view.

4. Conclusion

In this article, we examined Wagner's Law for nine African countries using time series data for the period 1965 to 2013. Wagner's law suggests unidirectional causality running from national income to government expenditure. The results of traditional Granger causality tests suggest that Wagner's law is supported only for Ghana, while the Keynesian view holds for Gabon, Senegal and South Africa. Burkina Faso has bidirectional causality between government expenditure and income. Since traditional causality test does not consider time varying nature of the relationship, we perform the frequency causality test. The superiority of the frequency domain causality approach is that it decomposes time periods and examines causality in different time frequencies.

The results indicate that Wagner's law holds for Cameroon in the medium term, for Ghana in the short, medium and long terms and for Nigeria in the long-run. The Keynesian view is supported for Gabon and Senegal in the short, medium and long run, and for South Africa both in the medium and short run. Therefore, these three countries can use public spending to stimulate their economies as contended by the Keynesian paradigm. Government spending in Burkina Faso follows Wagner's law and Keynesian view over the short, medium and long run. Cote d'Ivoire and Kenya do support neither Wagner's law nor Keynesian view. As a result, reduction in government final expenditure would not negatively affect economic growth for these two countries. The results of this study indicate that economists and policymakers must take account of changing causalities and design economic actions accordingly. In this regard, fiscal policies should take into consideration not only the causality direction between government expenditure and economic growth but also whether the direction of causality is temporal or permanent. The findings of the study suggest that government spending is an exogenous instrument to stimulate economic growth in Gabon and Senegal in the short, medium and short run and in South Africa only in the shorter periods.

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