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Is Public Debt Detrimental to Real Economic Growth in SADC? A Wavelet Causality Analysis

Félix Euloge Pokam Kayo[1], Coulibaly A. Sandotin[2], Bosson Jean Marcelin Brou[2]

[1]Department of Economics, University Omar Bongo, Libreville, Gabon
[2]Department of Economics, University Felix Houphouet Boigny, Abidjan, Côte d'Ivoire
Email: ablosandotin22@gmail.com

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Abstract

Few researchers have addressed the issue of the causality between public deficit and economic growth. Previous work has predominantly focused on causality using Granger causality technique in time series or in panel data. The current investigation aims to study the relationship between public debt and economic growth using the wavelet transform for different SADC member countries from 2000 to 2024 with annual data. We have characterized the public debt-economic growth relationship on a time-frequency scale. The results indicate a generally strong, non-linear causal link running from public debt to economic growth in the SADC region. However, the sign (positive or negative) and intensity of this relationship vary significantly across different time scales, frequencies, and individual countries, revealing important heterogeneity in the debt-growth nexus. Finally, we can judge through the wavelet transform that this relationship is non-linear.

Keywords

Public Debt, Economic Growth, Wavelet

1. Introduction

How does public debt affect real economic growth? Is public debt detrimental to real economic growth? How? Is there a causal link between public debt and real economic growth?

Since the 2008 financial crisis, public debt has risen sharply, especially for SADC countries. Statistics are more than appealing and speak for themselves. For example, in SADC, public debt to real GDP rose from 31.47% in 2010 to 70.42% in 2020. These figures were 63.89% in 2021 and nearly 67.97% in 2023 (see IMF Financial Statistics, 2024). The above figures contrast with the evolution of real economic growth over the same period which is, 4.62% in 2010, −4.21% in 2020, 4.61% in 2021 and a decline to 2.24% in 2023.

From a theoretical standpoint, studies have shown that public debt in some cases is inflationary, see Catao and Terrones (2005) and Lin and Chu (2013); and thereby public debt has nothing to do with real economic growth.

From empirical standpoint, the link between the public debt-real economic growth relationship particularly in developing countries is even more controversial, see De Haan and Zelhorst (1990), Metin (1998), Domaç and Yücel (2005).

From either the theoretical or empirical stand, it is clear that the link between public debt and real economic growth has been analyzed using the prism of old methodologies which have shown some significant and serious inconsistencies (e.g., see Soyres et al., 2022; Barro, 1979, 1980; Eberhardt & Presbitero, 2015; Herndon et al., 2013; Kim et al., 2017; Marcelino & Hakobyan, 2014; Panizza & Presbitero, 2014; Rahman et al., 2019).

In this paper, we aim to fill this gap by focusing on the relationship between public debt and real economic growth using the wavelet transform for different SADC member countries. By so doing, we endeavor to advance research between public deficits and real economic growth from different perspectives: i) we characterize the link between public debt and real economic growth in a time-frequency scale framework; ii) we make distinction between the type of causality, i.e., linear or non-linear causality; iii) we conduct some sensitivity analyses to check whether the effects of budgetary expansion or contraction considered or adopted may be detrimental to real economic growth and/or vice versa.

The remainder of the paper proceeds as follows. Motivation of the paper appears in Section 2. In Section 3 the wavelet methodology is described in connection with causality issues. Section 4 sketches the data used in the study. Results are reported and discussed in Section 5. Some sensitivity analyses are conducted in Section 6. Section 7 concludes the paper.

2. Motivation

Much of the evidence documenting the negative relationship between public debt and real economic growth implicitly assumes that an increase in public debt causes a reduction in real GDP growth. While high levels of public debt might be detrimental to real economic growth through higher uncertainty, financial repression and crowding-out of private investment (e.g., see Elmendorf & Mankiw, 1999; Perotti, 2012; Reinhart & Rogoff, 2010), a recent strand of the literature argue that recessionary periods could increase public debt through automatic stabilizers and fiscal stimulus aimed at reversing hysteresis associated with the effects of deep recessions (e.g., see DeLong & Summers, 2012; Panizza & Presbitero, 2014). Hence, it is possible that the causal link is reversed and goes from low real growth to high public debt levels.

Another point to mention is that the estimated correlation between public debt and real economic growth is likely to reflect a mixture of both relationships. If causality has not been taken into account, all panel data analyses carried out by previous studies may become invalid. In particular, ignoring a possible reverse causality (from output growth to public debt) may explain why the strong negative relationship cited above has been recently challenged (e.g., see Minea & Parent, 2012; Pescatori et al., 2014; Egert, 2015b).

Three main reasons can be advocated to motivate the possible existence of complex causality relationships.

First, the links between public debt and real economic growth depend not only on the level of public debt, but also on its composition. Second, the links also crucially depend on the reasons behind debt accumulation, as well as whether it has been destined for consumption or investment. Third, the links might depend on a specific country's capacity to face a challenge (e.g., macroeconomic or political stability, institutional framework). Thus, there is no simple answer to the causality, if any, between public debt and real economic growth. At best, the answer should rely on a case-by-case context.

3. A Wavelet Approach and Causality

The idea is to study the behaviour of a non-stationary process in order to find results explaining whether there is a causality between the macroeconomic aggregates in question not only in a time domain but rather in a time-frequency-scale domain, which is now well documented and established.

The idea of causality is not new. This notion is often referred to as the Granger causality. It has been applied in many fields, such as finance and economics, signal processing, neuroscience, image processing, geophysics, etc. Despite its popularity, the so-called Granger causality has proven to have some important limitations. First, it does not deal with causality in variance. Second, it does not consider causality of risk, nor does it deal with causality in quantiles. Third, causality of the mean as well as of the distribution is ignored by Granger causality. In addition to these limitations, Granger causality method is unable to distinguish between long and short-term causal effects. Once causal effects are recorded and based on Granger causality, location in the frequency domain regardless of whether it is low (short term) or high frequency (long term) is difficult to analyze.

Geweke (1982) dealt with the above issues. Geweke's (1982) innovative idea was to transform causality into a frequency domain. In this context Hosoya (2001), Breitung and Candelon (2006) and Yao and Hosoya (2000) align with Geweke (1982). At this stage the research studies have found that the frequency representation of the so-called "Fourier transform" makes it possible to distinguish long-term causal effects from short-term causal effects.

An important improvement in "Granger-Geweke causality", is obtained based on "continuous wavelet transforms" to analyze time-frequency causality links. This improvement is suggested by Dhamala et al. (2008). Wavelet analysis has become widely used in empirical studies to understand the relationship between variables and more precisely the temporal fluctuations between them over different horizons. The ideas of Crowley (2007), Yogo (2008), Dhamala et al. (2008), Gallegati et al. (2011), Gençay et al. (2001), Fan and Gençay (2010) and Gallegati et al. (2011) support this approach. In this paper, we are concerned with public deficits and real economic growth relationships. The originality of this investigation lies in the fact that the research is not only speculative. In fact, the link between public deficits and real economic relationships can have implications in terms of inflation, debt sustainability, the financing of health system, and the financing of social expenditures in general. If one of the advantages of the Fourier transform (frequency representation) is that not only can long-term causal effects be isolated from short-term causal effects, but also it allows us to check whether it is the short- or long-term causal effects that modulate the correlation between the variables.

3.1. Causality of Geweke-Granger

To illustrate the two-variables (x and y), a p-order VAR model is assumed as in Breitung and Candelon (2006), Dhamala et al. (2008) or Olayeni and Philip (2015).

$$\Lambda(L)X_t = \varepsilon_t \tag{1}$$

with, $\Lambda(L)$, X_t and ε_t denote respectively, the delay polynomial, the endogenous variable of target variables and the variance-covariance matrix error term which is denoted Ω. The above system can be written more explicitly as,

$$\begin{bmatrix} I-\Lambda_{xx}(L) & \Lambda_{yx}(L) \\ \Lambda_{xy}(L) & I-\Lambda_{yy}(L) \end{bmatrix} \times \begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} \varepsilon_t^x \\ \varepsilon_t^y \end{bmatrix} \tag{2}$$

And the variance-covariance matrix involved is defined as,

$$\Omega = \begin{bmatrix} \Omega_{xx} & \Omega_{yx} \\ \Omega_{xy} & \Omega_{yy} \end{bmatrix} \tag{3}$$

If $\Lambda(L)$ is invertible, we can write,

$$X_t = \Theta(L)\varepsilon_t \tag{4}$$

The Fourier transform of the previous equation is given as,

$$X(w) = \Theta(w)\Omega\tilde{\Theta}(w) \tag{5}$$

where $X(w)$ is the spectral power of variable X in w (the frequency), $\Theta(w)$ the transfer function between variables x and y; $\tilde{\Theta}(w)$ the conjugate of $\Theta(w)$. We define $\Theta(w)$ as,

$$\Theta(w) = \begin{bmatrix} \Theta_{xx}(w) & \Theta_{yx}(w) \\ \Theta_{xy}(w) & \Theta_{yy}(w) \end{bmatrix} \tag{6}$$

Granger-Geweke causality in the frequency domain is defined as,

$$G_{y\to x}(w) = \log\left[\frac{X_{xx}(w)}{X_{xx}(w) - \left\{\Omega_{xx} - \Omega_{xy}^2 / \Omega_{xx}\right\}\left|\Theta_{xy}(w)\right|^2}\right] \tag{7}$$

The numerator in Equation (7) represents the spectral power of the variable x with frequency w. The denominator is more complex as it represents the total power minus the causal contribution which concerns the intrinsic power. Note that causality in the frequency domain allows us to reduce the time dimension to a single time point, resulting in a loss of information on time variation. However, causality content in the frequency domain is important as it informs about fluctuations in causality in the time domain by decomposing the variables into different scales (frequency). The above decomposition uses the transform into a Discrete Wavelet. The extension of Granger-Geweke causality to non-parametric time-frequency domain modeling, as well as the analysis of the power distribution of Granger causality requires the factorized spectral matrix. The factorization of the spectral matrix is obtained through the use of Wilson's algorithm (e.g., see Wilson, 1972). The necessary condition to factorize a spectral matrix is obtained by,

$$\int_{-\infty}^{+\infty} \log \det X(w) \mathrm{d}w > -\infty \tag{8}$$

The minimum phase of the spectral density factor matrix phase Γ is,

$$\Gamma = \sum_{t=0}^{\infty} \Lambda_t \exp(-2i\pi wt) \tag{9}$$

If Ω and Θ denote the noise variance-covariance matrix and the minimum phase of the spectral transfer function respectively, we get

$$\begin{cases} \Omega = \Lambda_0 \Lambda_0' \\ \Theta = \Gamma \Lambda_0^{-1} \end{cases} \tag{10}$$

The minimum phase of the spectral density factor matrix phase can now be rewritten as,

$$\Gamma = \Theta \Sigma \Theta^H \tag{11}$$

where Θ^H is the transpose obtained from the Hermitian matrix Θ. The factorization of the matrix $X(w)$ is given by,

$$X = \Gamma \tilde{\Gamma} \tag{12}$$

where $\tilde{\Gamma}$ refers to the complex conjugate of the transposed Γ.

3.2. Causality Proposed by Dhamala et al. (2008)

In Geweke-Granger causality, the factorization of the matrix spectral densities is the main disadvantage. These disadvantages have been addressed by Dhamala et al. (2008) who introduced the wavelet transformation to the Geweke-Granger approach. Therefore, Equation (7) in the Geweke-Granger causality becomes,

$$G_{y \to x}(s,\tau) = \log \left[\frac{W_{xx}(s,\tau)}{W_{xx}(w,\tau) - \left\{ \Omega_{xx} - \Omega_{xy}^2 / \Omega_{xx} \right\} \left| \Theta_{xy}(s,\tau) \right|^2} \right] \tag{13}$$

where, $W_{xx}(w,\tau)$ indicates the spectral power in Wavelet.

Turning to the wavelet transform, we note that the wavelet is a function defined on $L^2(\mathbb{R})$, noted $\psi(t)$. In general, we check the following analytical properties such as mean and integral equal to zero and normalized,

$$\begin{cases} \int_{-\infty}^{+\infty} \psi(t) \mathrm{d}t = 0 \\ \int_{-\infty}^{+\infty} \left| \psi(t) \right|^2 \mathrm{d}t < 0 \end{cases} \tag{14}$$

In addition to the continuity that has been verified in the properties explained above, the wavelet must also satisfy the following admissibility status,

$$\int_{-\infty}^{+\infty} \frac{|\Psi(t)|^2}{|w|} \mathrm{d}w < \infty \tag{15}$$

where, $\Psi(t)$ is considered by the Fourier transform of $\psi(t)$.

The projection of a series $x(t)$ through a mother wavelet function is given by the following complex coefficients,

$$W(s,\tau) = \int_{-\infty}^{+\infty} x(t) \psi_{s,\tau}^{*}(t) \mathrm{d}t \tag{16}$$

$$\text{where, } \psi_{s,\tau}^{*}(t) = \frac{1}{\sqrt{|s|}} \psi\left(\frac{t-\tau}{s}\right) \tag{17}$$

And where $x(t)$ and $\psi_{s,\tau}^{*}(t)$ denote, respectively, a series and the atom of the mother wavelet transform. In Equation (17), the parameter (s) is a scale parameter (*dilation*) $\left(s \in \mathbb{R}_{+}^{*}\right)$ and (τ) is a time location parameter (translation) $(\tau \in \mathbb{R})$. Translation and expansion allow us to determine the atom of the wavelet. Dilation is a time shift, while translation is a time location. Torrence and Compo (1998) have shown that it is possible to reconstruct the signal through the following formula,

$$x(t) = \frac{1}{C} \int_{s=-\infty}^{+\infty} \int_{\tau=-\infty}^{+\infty} \frac{1}{|s|^2} W(s,\tau) \psi_{s,\tau}(t) \mathrm{d}s \mathrm{d}\tau \tag{18}$$

3.3. Causality Proposed by Rua (2017) and Olayeni (2015)

Rua (2017) proposed a measure of the correlation by the Continuous Wavelet Transform noted $\rho_{xy}(s,\tau)$ defined as,

$$\rho_{xy}(s,\tau) = \frac{\gamma\left\{s^{-1}\left|\Re W_{xy}^{m}(s,\tau)\right|\right\}}{\gamma\left\{s^{-1}\sqrt{\left|W_{x}^{m}(s,\tau)\right|^2}\right\}\gamma\left\{s^{-1}\sqrt{\left|W_{y}^{m}(s,\tau)\right|^2}\right\}} \tag{19}$$

with γ indicating a time-scale smoothing operator. The correlation by the Continuous Wavelet Transform differs from the Wavelet Coherence noted $R_{xy}(s,\tau)$, which is given by

$$R_{xy}(s,\tau) = \frac{\gamma\left\{s^{-1}\left|W_{xy}^{m}(s,\tau)\right|\right\}}{\gamma\left\{s^{-1}\sqrt{\left|W_{x}^{m}(s,\tau)\right|^2}\right\}\gamma\left\{s^{-1}\sqrt{\left|W_{y}^{m}(s,\tau)\right|^2}\right\}} \tag{20}$$

However, the analysis proposed by Rua (2017) shows these limitations insofar as they do not integrate information on the direction between the variables. Olayeni & Philip (2015) proposed a modification of the correlation of Rua (2017) by integrating the concept of phase difference between the variables. He proposed an indicator that takes the value one if the variables are in phase and zero otherwise. The analysis is based on the phase difference circle proposed by Aguira-Conraria and Soares (2011) (see **Figure 1**).

The concept of phase difference between two variables x and y is given by,

$$\Phi_{xy}(s,\tau) = \Phi_x(s,\tau) - \Phi_y(s,\tau) \tag{21}$$

where, $-\pi \le \Phi_{xy}(.) \le \pi$. The interval $[-\pi,\pi]$ can be divided into four intervals as indicated in Table 1 and Figure 1.

Case 1: If $\Phi_{xy}(.) \in [0,\pi/2]$, $[-\pi/2,0]$: the two variables are in phase, they move in the same direction. We say that x leads to y, i.e., there is predictable information on x in the sense of Granger when $\Phi_{xy}(.) \in [0,\pi/2]$ and vice versa;

Case 2: If $\Phi_{xy}(.) \in [-\pi/2,0]$; similar to case 1.

Case 3: If $\Phi_{xy}(.) \in [\pi/2,\pi]$, $[-\pi,-\pi/2]$: the two variables are anti-phase, they move in the opposite direction. We say that y leads to x, i.e., x has predictable information on y in the sense of Granger when $\Phi_{xy}(.) \in [\pi/2,\pi]$ and vice versa.

Case 4: If $\Phi_{xy}(.) \in [-\pi,-\pi/2]$; similar to case 3.

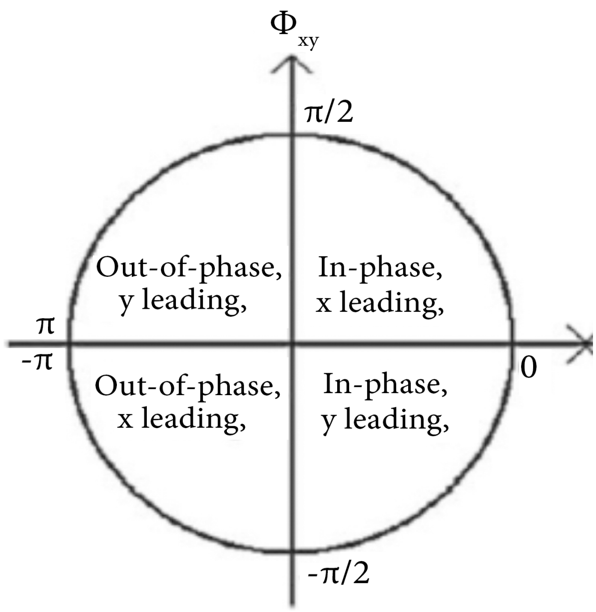


Figure 1. Phase difference circle—Conraria and Soares (2011).

Table 1. The lead-lag relationship.

	X leads y	y leads X
In-phase	$\Phi_{xy}(s,T) \in (0,\pi/2)$	$\Phi_{xy}(s,T) \in (-\pi/2,0)$
Out-of-phase	$\Phi_{xy}(s,T) \in (-\pi,-\pi/2)$	$\Phi_{xy}(s,T) \in (\pi/2,\pi)$
Total phase	$\Phi_{xy}(s,T) \in (0,\pi/2) \cup (-\pi,-\pi/2)$	$\Phi_{xy}(s,T) \in (-\pi/2,0) \cup (\pi/2,\pi)$

The indicator function proposed by Olayeni & Philip (2015) is defined as follows,

$$I_{y\to x}(s,\tau) = \begin{cases} 1, \text{ if } \Phi_{xy}(s,\tau) \in J \\ 0, \text{ otherwise} \end{cases} \tag{22}$$

where $\Phi_{xy}(s,\tau)$ denotes the phase difference function,

$$\Phi_{xy}(s,\tau) = \tan^{-1}\left(\frac{\Im\left\{W_{xy}^{m}(s,\tau)\right\}}{\Re\left\{W_{xy}^{m}(s,\tau)\right\}}\right) \quad (23)$$

And J denotes intervals: $[0,\pi/2],[-\pi,-\pi/2]$ and $[0,\pi/2]\cup[-\pi,-\pi/2]$.

4. Data

The study uses annual data covering the period 2000-2024 for SADC countries, representing a sample of 25 observations per country. While such a sample size may seem limited for conventional econometric approaches, the Continuous Wavelet Transform (CWT) offers a robust and suitable alternative. Unlike classical Granger causality tests, which are highly dependent on the asymptotic properties of large samples and the assumption of stationarity, the wavelet method allows for the extraction of complex dynamics in the time-frequency domain without these restrictive constraints. The effectiveness of this approach on moderately sized time series is well documented in recent economic literature (Rua, 2017; Gallegati et al., 2011; Fan & Gençay, 2010), confirming its ability to isolate short- and long-term cycles with high accuracy.

The data are obtained from Data Stream. Due to data availability, the following countries are considered in the econometric analysis: i) low-income countries: Angola, DRC, Tanzania, Lesotho and Zimbabwe; ii) middle and high-income countries: Botswana, Mauritius, Namibia, South Africa and Seychelles.

In our estimations, we consider two main variables: public debt and economic growth. Public debt is measured as general government gross debt in percentage of Gross Domestic Product (GDP), sourced from Datastream (series code: GGGD...). Economic growth is the annual percentage growth rate of real GDP (series code: RGDP...). All data are obtained from DataStream and cross-verified with IMF and World Bank databases for consistency.

Table 2. Descriptive statistics for SADC.

	Growth rate	Public debt
Min	−16.300	3.700
Max	19.700	199.800
Mean	3.495	53.725
Variance	21.379	1200.160
Standard deviation	4.623	34.643
CV	132.272	64.482

Table 2 reports some salient facts related to public debt and real growth rate.

The average public debt relative to GDP (53.725%) indicates that, for SADC as a whole, the average debt level is quite high. This reflects a general trend among member countries to have significant levels of public debt relative to their GDP (Seychelles (95.910%), Mauritius (67.213%), Angola (61.830%), Zimbabwe (64.133%)), which may be the result of expansionary fiscal policies, the need to finance budget deficits or to meet internal and external financing needs. This high level of public debt has been accompanied over the last 20 years by moderate economic growth averaging 3.495%. This growth is influenced by variable performances between countries, with some countries like Tanzania (6.243%), RDC (5.056%), and Angola (4.310%) showing a strong performance and others like Zimbabwe (1.143%) recording an economic contraction (see Table 3).

We observe significant variability in public debt levels across SADC countries (standard deviation = 34.643%) in Table 3. Some countries (Angola, Mauritius, Seychelles, and Zimbabwe) have very high debt levels, while others like Botswana maintain relatively low debt levels. This reflects the different approaches to debt management and the various economic challenges these countries face. The standard deviation of the growth rate (4.623%) shows significant variability in economic growth rates among SADC member countries. This variability could result from factors such as differences in economic policies, internal economic structures, productivity and exposure to external shocks.

The coefficient of variation of public debt (64.482%) shows that the debt varies significantly compared to its average. As for the coefficient of variation of the real growth rate (132.272%), it is very high, which suggests that economic growth among SADC countries is very variable compared to its average. This variability could be attributed to different economic environments, divergent economic policies, or unequal levels of resilience to external shocks (fluctuations in commodity prices).

Table 3. Descriptive statistics by Country.

	Angola		Botswana		DRC	
	Growth rate	Public debt	Growth rate	Public debt	Growth rate	Public debt
Min	−5.600	18.700	−14.100	5.900	−8.100	3.700
Max	15.000	138.700	11.900	20.900	9.800	181.600
Mean	4.310	61.830	3.676	14.576	5.056	47.943
Variance	25.574	1019.808	27.277	24.192	14.014	2670.665
Std. Dev.	5.057	31.934	5.222	4.918	3.743	51.678
CV	117.333	51.648	142.052	33.742	74.032	107.790
	Mauritius		**Namibia**		**Seychelles**	
	Growth rate	Public debt	Growth rate	Public debt	Growth rate	Public debt
Min	−14.500	48.800	−8.100	15.900	−11.700	42.500
Max	8.900	94.700	6.700	70.500	15.000	199.800
Mean	3.600	67.213	2.940	41.366	3.820	95.910
Variance	14.308	170.521	8.441	381.003	29.207	2750.023
Std. Dev.	3.782	13.058	2.905	19.519	5.404	52.440
CV	105.075	19.428	98.821	47.186	141.477	54.676

Continued

	South Africa		Tanzania		Lesotho	
	Growth rate	Public debt	Growth rate	Public debt	Growth rate	Public debt
Min	−6.000	24.000	4.500	21.700	−5.300	33.800
Max	5.600	85.700	8.500	62.000	5.100	108.700
Mean	2.086	50.190	6.243	39.583	2.080	54.506
Variance	5.182	432.494	1.092	76.379	5.948	268.942
Std. Dev.	2.276	20.796	1.045	8.739	2.438	16.399
CV	109.098	41.435	16.739	22.078	30.087	117.257
	Zimbabwe					
	Growth rate	Public debt				
Min	−16.300	33.100				
Max	19.700	100.600				
Mean	1.143	64.133				
Variance	68.043	372.409				
Std. Dev.	8.248	19.297				
CV	721.472	30.090				

Having noticed significant variations in public debt and moderate variations in real growth rate. We now ask the following question: is public debt detrimental to real economic growth? In other words, does public debt Granger-cause real economic growth? And how? Wavelet causality should provide a powerful answer.

5. Results and Discussion

We now discuss some technical background before our empirical findings.

5.1. Some Technical Background

In our study, we focus on the types of causality (linear or non-linear causality); for this reason, we interpret coherence by transforming it into a wavelet. When $\left(R_{xy}\left(s,\tau\right)=1\right)$, we can conclude that causality is linear. Before starting to interpret our results, it is essential to do the scalogram decoding. First, the color shows type of causality. The degradation of the blue color means that the causality between the two variables involved is non-linear $\left(R_{xy}\left(s,\tau\right)=0\right)$ and that the dependence between these two variables is low. The degradation of the yellow color means that the causality between the two variables involved is linear $\left(R_{xy}\left(s,\tau\right)=1\right)$ and that the dependence between these two variables is high. Second, the arrows show the direction of causality.

In our specific case:

—Upward-pointing arrows: public debt causes economic growth;

—Downward-pointing arrows: economic growth causes public debt;

—Horizontal arrows: synchronous relationships without clear causality.

The horizontal direction of the arrows indicates the phase relationship between the variables, which corresponds to the sign of their correlation. Specifically:

Right-pointing arrows ($0^\circ < \varphi < 90^\circ$ or $-180^\circ < \varphi < -90^\circ$) indicate that the variables are in phase, moving in the same direction (positive correlation).

Left-pointing arrows ($90^\circ < \varphi < 180^\circ$ or $-90^\circ < \varphi < 0^\circ$) indicate that the variables are in anti-phase, moving in opposite directions (negative correlation).

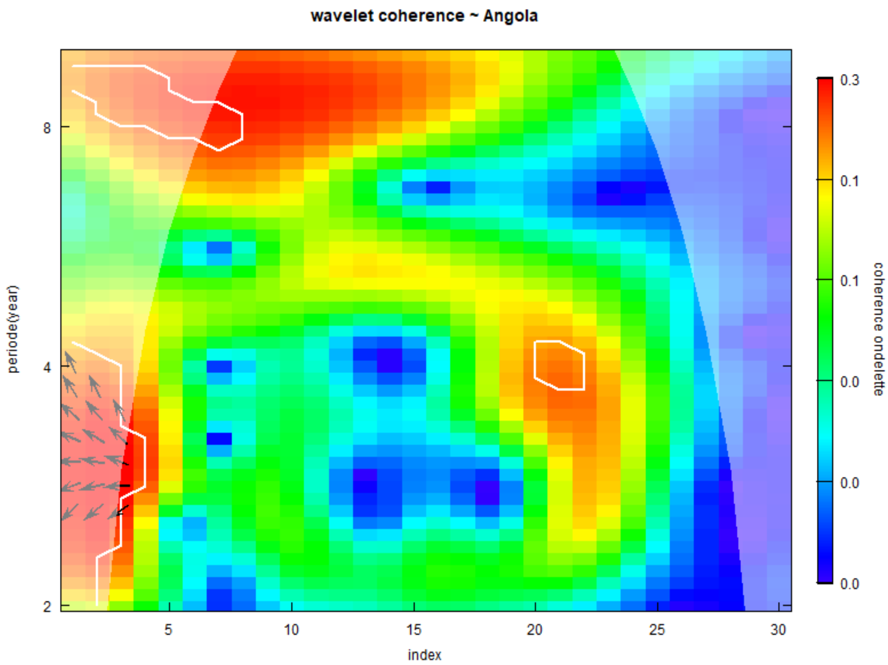
This interpretation follows the phase difference framework established by Aguira-Conraria and Soares (2011) and applied in Olayeni & Philip (2015).

5.2. Results and Interpretations

The analysis and interpretations are done based on individual case.

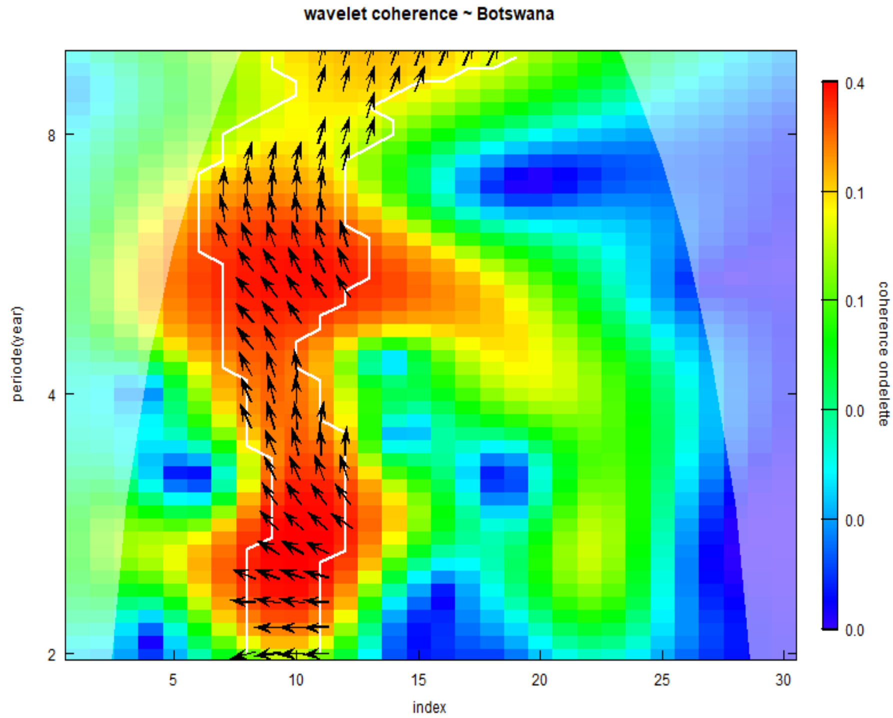
1. Angola

The relationship between public debt and economic growth in Angola is marked by specific time cycles where consistency is strong, mainly over short cycles (2 to 4 years) and at some points over long cycles (beyond 8 years). These periods often show an inverse relationship, suggesting that the accumulation of public debt can harm economic growth in certain phases. However, this relationship is not constant, and much of the time, the consistency between these two variables is weak, suggesting that public debt does not always have a direct effect on growth in Angola.



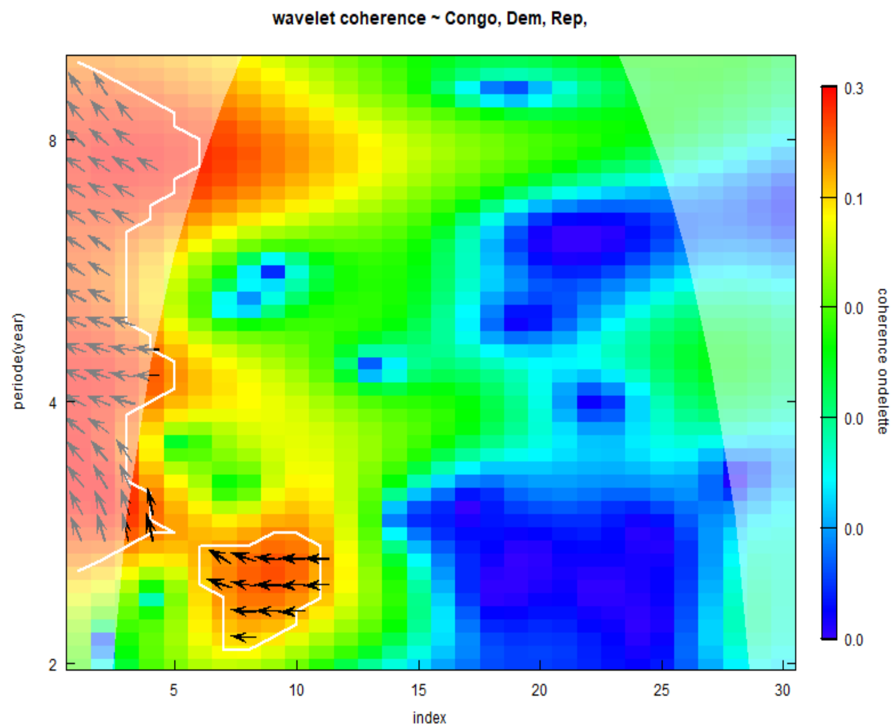
2. Botswana

Between 2005 and 2015, Botswana experienced a strong relationship between public debt and economic growth, over cycles of 2 to 8 years. This relationship suggests that debt has a positive effect on growth. This means that any increase in public debt during this period appears to have been associated with an increase in economic growth, which may indicate that the debt incurred by the country during this period was used to improve productive capacities.



3. DRC

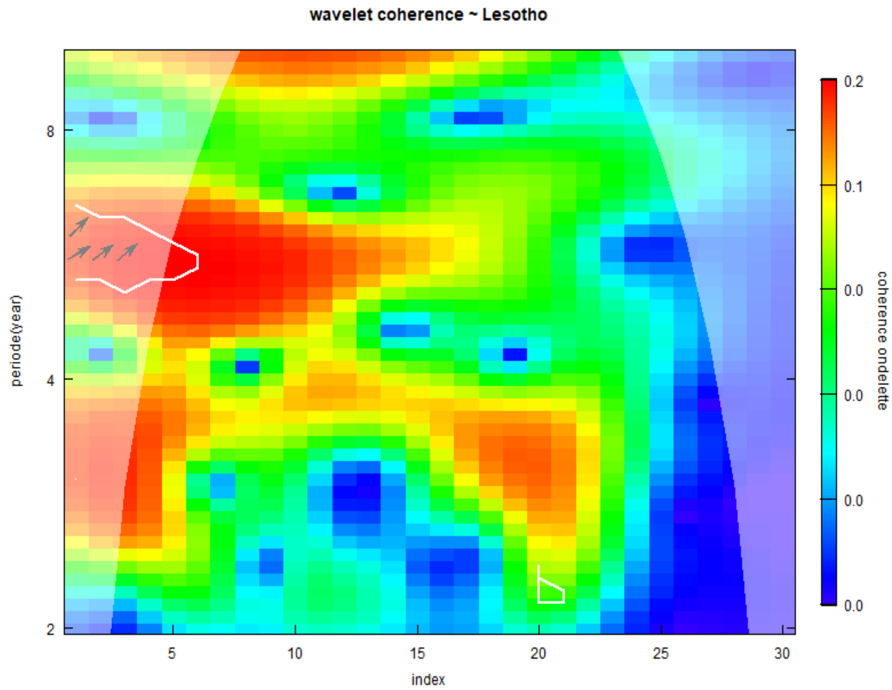
Between 2000 and 2010, the relationship between public debt and economic growth in the DRC was marked by a strong consistency, indicating that debt has a significant impact on growth. The arrows pointing to the left suggest an inverse relationship, with an increase in debt associated with a decrease in growth. This dynamic is less strong between 2005 and 2010, although a moderate inverse



relationship is still observed. In sum, public debt appears to have exerted negative pressure on economic growth in the DRC during the first years of the period studied.

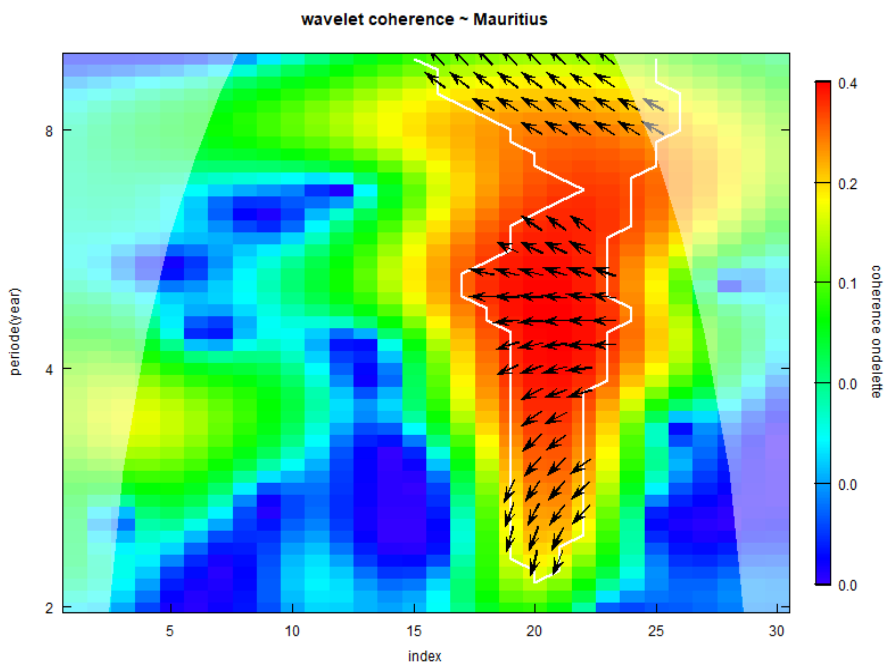
4. Lesotho

Between 2000 and 2020, public debt had a significant influence on Lesotho's economic growth. This relationship over the period 2000 to 2005 is positive, meaning that public debt and growth evolve in phase.



5. Mauritius

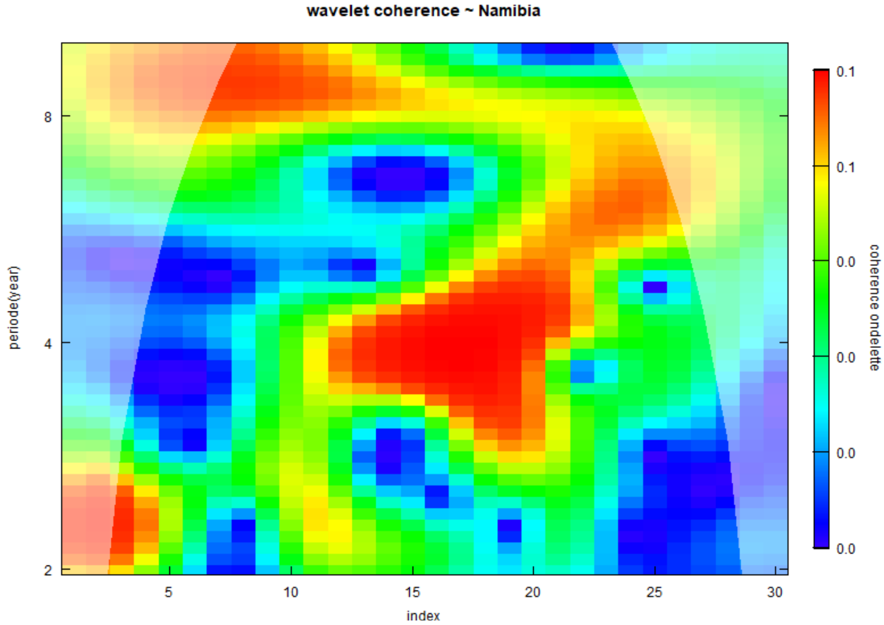
Between 2019 and 2024, the relationship between public debt and economic



growth in Mauritius is complex. Over long cycles (8 to 16 years), the two variables are in phase, showing a positive relationship. However, over medium cycles (4 to 8 years), this relationship becomes negative, indicating an inverse effect of public debt on economic growth in the medium term. Finally, short cycles (2 to 4 years) indicate that economic growth causes debt.

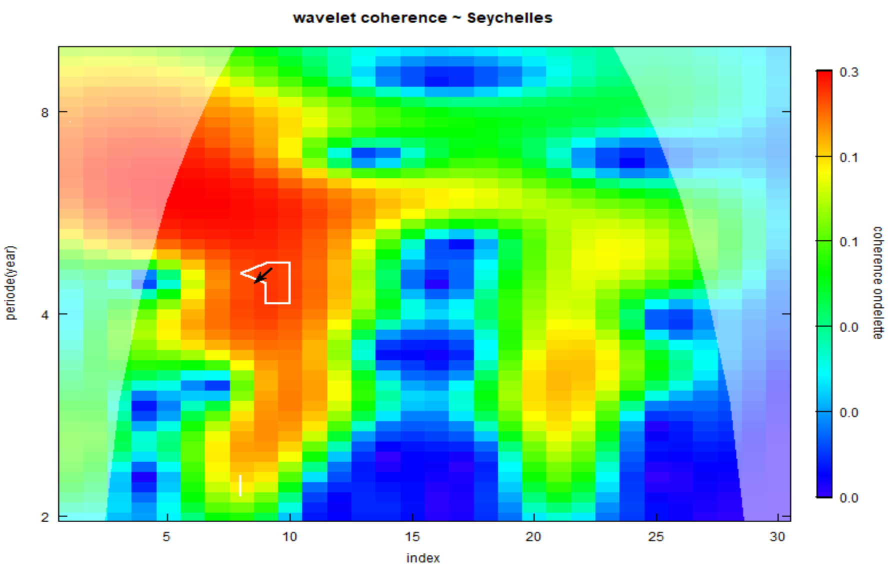
6. Namibia

In Namibia, recent periods (2015 to 2024) show a strong interaction between public debt and economic growth, particularly over 2- to 16-year cycles. Although there is no clear dephasing, the high consistency across several areas suggests that public debt has played an important role in the dynamics of economic growth.



7. Seychelles

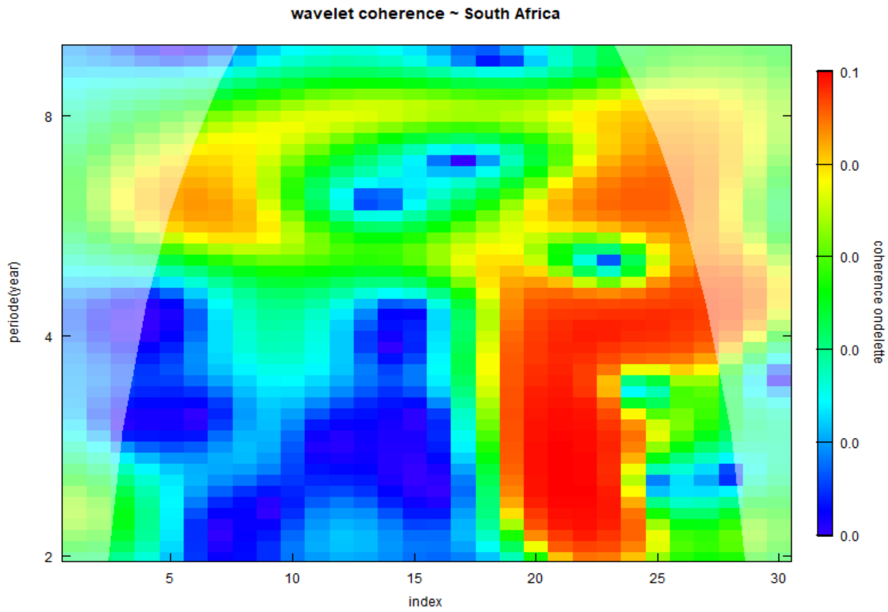
Between 2000 and 2010, public debt had a strong and direct impact on economic



growth in Seychelles, with 2 - 8 year cycles showing high consistency. More recently, between 2020 and 2024, this relationship is still present, but less markedly, with moderate consistency. The phase opposition indicated by the left-pointing arrows suggests that the accumulation of public debt had a negative effect on economic growth during this period.

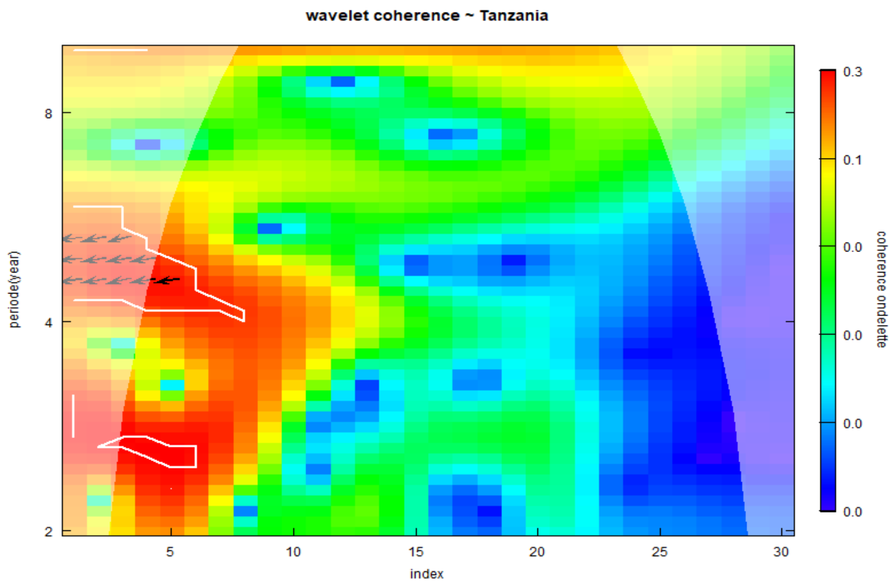
8. South Africa

Between 2020 and 2024, the relationship between public debt and economic growth in South Africa was marked by strong consistency, mainly over short- to medium-term and medium-term cycles. The absence of arrows prevents determining a clear dephasing between debt and growth.



9. Tanzania

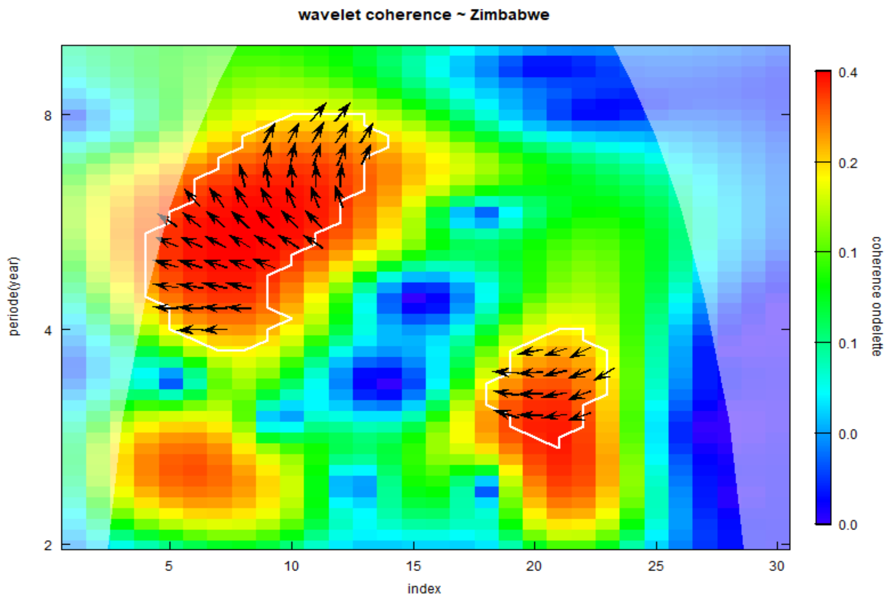
Between 2000 and 2010, the relationship between public debt and economic



growth in Tanzania is in phase opposition. Over cycles (2 to 8 years), this relationship indicates an inverse effect of public debt on economic growth in the short and medium term.

10. Zimbabwe

The relationship between public debt and economic growth in Zimbabwe varies over time. Between 2000 and 2005, although a significant relationship is present, no clear causality is determined. Between 2005 and 2015, growth appears to precede fluctuations in debt. Finally, between 2020 and 2024, public debt has a negative effect on economic growth.



5.3. Discussion

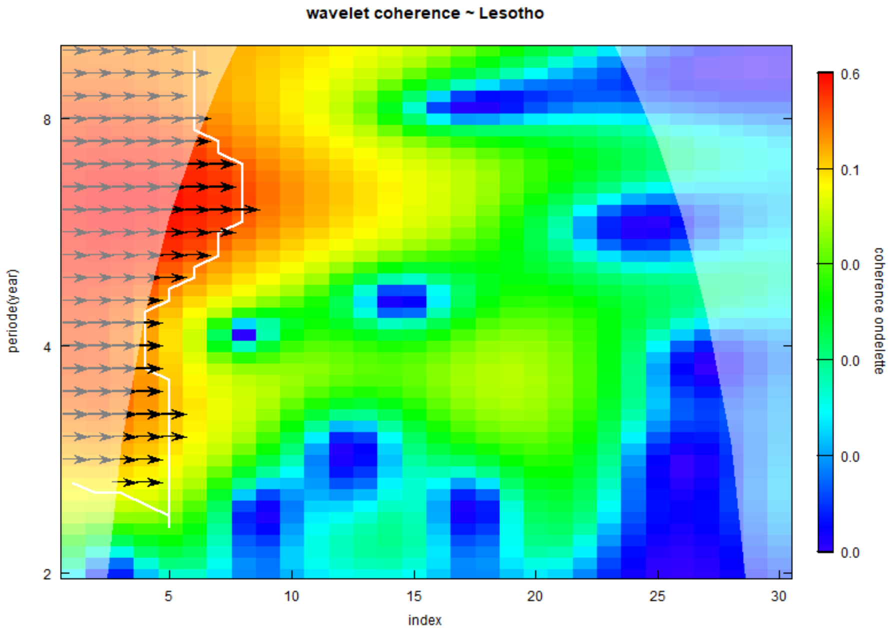
For almost all ten countries in the panel, there is a clear message: there is a strong causal link between public debt and economic growth. Although this link is not constant over time, in general (unreasonable) public debt (if not appropriately managed) has a harmful effect on economic growth. Similar results were reported by Cochrane (2011), Castro et al. (2015), and Marquez (2000).

6. Sensitivity Analyses

To assess the robustness of our results, we conduct sensitivity analyses based on simulations of hypothetical shocks to the original time series. Following macroeconomic stress test standards (Leamer, 1985; Pesaran & Shin, 1998), we apply uniform shocks of (+10% or -10%) to the public debt variable while keeping economic growth unchanged, and vice versa. The wavelet causality analysis is then fully re-estimated on these modified time series. This approach allows us to test whether the identified causal patterns are sensitive to systematic changes in the levels of the variables.

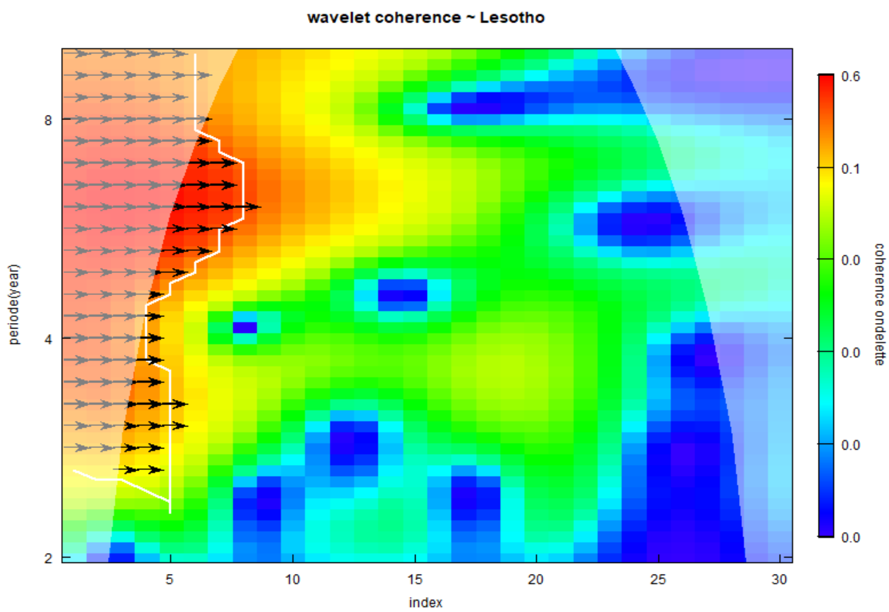
6.1. Impact of Increased Public Debt

What if public debt rises by say 10%? This rise can result from lax budget policies when countries cannot face their discretionary duty, and they are experiencing social pressures. Results can be summarized as follows: in general, a rise by 10% in public debt does not affect SADC causal relationship between public debt and economic growth with the exception of Lesotho.



6.2. What Is Public Debt Is Reduced to 10%?

Such a decision has taken place in the past where the Paris Club, the London Club, and the IMF-World-Bank were to implement such decisions and see how these decisions can boost economic growth. Results can be summarized as follows: once again a 10% reduction in public debt does not affect SADC countries except once again Lesotho.

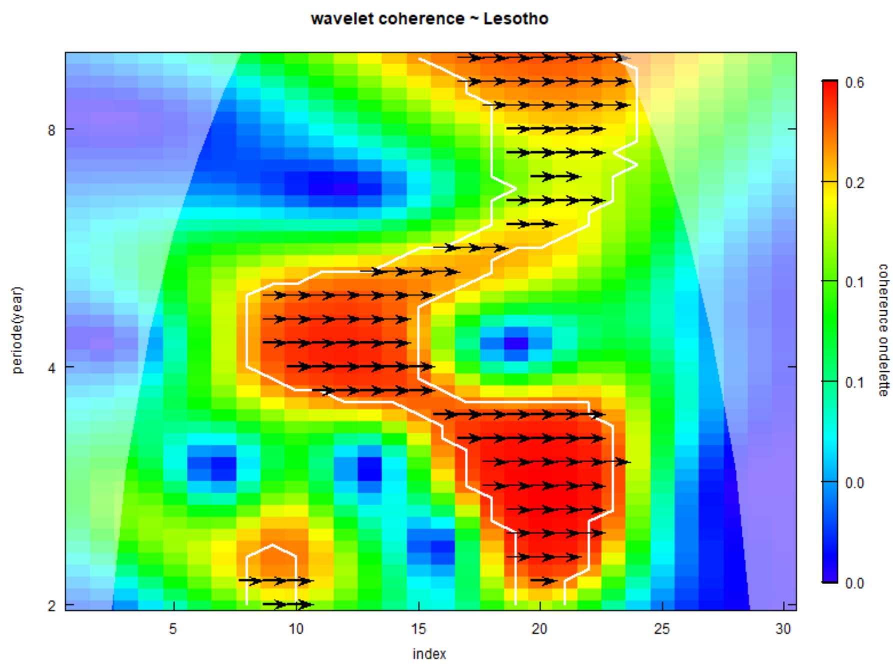


In fact, Lesotho is a landlocked country facing a tough macro-fiscal outlook due to a sharp decline in Southern African Customs Union (SACU) revenues. Significant macro-adjustments have not been operational to solve the causal link between public expenditure and economic growth.

6.3. What Is Exceptional 10% Economic Growth Is Reported?

This can happen when governments have cautionary budget policies with less social pressure.

Results obtained can be summarized as follows: again, there is no change as to the causal links previously observed except for Lesotho. The deterioration of this causal link may be explained as follows. In fact, Lesotho's economic growth has been on the decline since 2022. Inflation dropped from 8.3% in 2022 to 6.4% in 2023. Public debt fell from 60.66% of GDP in 2022 to 57.5% in 2023, mainly because of the redemption of treasury bonds. The fiscal balance is projected to deteriorate in 2024 and beyond because of high expenditures associated with the second phase of the Lesotho Highlands Water Project.



6.4. What Did the Literature Say?

In general, in developing countries, building a surplus budget is unthinkable. Rather, public debt is the rule rather than the exception. The accumulation of public debt becomes inevitable; the problem is its compatibility with economic growth.

Our results corroborate traditional view on the link between public debt and economic growth: public debt negatively affects a country's competitiveness and attractivity and consequently impedes economic growth (e.g., see Cochrane, 2011; Castro et al., 2015).

Our results are also in line with modern view on the link between public debt and economic growth: borrowing can have an adverse effect on economic growth if not managed efficiently and effectively (e.g., see Marquez, 2000).

Results obtained for SADC are in perfect harmony with discussions in the literature.

7. Final Remarks

In this study, we investigate whether public debt exacerbates a harmful effect on economic growth within the context of SADC countries. We employ the Continuous Wavelet Transforms (CWT) and Wavelet Coherence (WC) to examine the comovement between the two variables, using annual data from 2000 to 2024. This allows us to focus on the types of causality (linear or non-linear). We interpret coherence by transforming it into a wavelet. Interpretation is based on scalogram decoding.

As expected, our first important result is that for almost all SADC countries, there is clearly a causal link between public debt and economic growth. This shows that economic growth can react to economic policy. Second, predominantly, the causality link runs from public debt to economic growth. An indication that large public deficits associated with poor management can negatively affect economic growth. Similar results were reported in prior literature. Third, this causal link is in some cases unstable; similar patterns have been observed elsewhere. This is inherent to uncertainty of economic policy. Finally, for a very few countries, there is an absence of causality.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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