Dynamic causal relationships based on wavelets between oil prices and economic growth in CEMAC countries

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Abstract:

The objective of this study is to analyse the causal relationship between oil prices and economic growth in the CEMAC. To do so, we performed a wavelet analysis on multiple time series. The results show that, in the short term, higher oil prices lead to positive economic growth in countries such as Cameroon, Chad, DRC and Gabon, while the opposite is true for Equatorial Guinea. However, in the long term, the relationship remains positive in Cameroon, Chad, the DRC and Gabon, and becomes positive in the medium term and negative in the long term in Equatorial Guinea. We therefore recommend that governments opt for economic policies that are targeted.

Keywords: Oil price; economic growth; wavelet.

JEL Classification codes : Q43, Q14, E23, C32

1. Introduction

Oil is an important resource in the CEMAC countries, and only the CAR does not produce any. Oil is considered to be the main source of export and budget revenues. In 2007, oil accounted for an average of 85% of export revenues and 69% of budget revenues in these countries.

Despite the drop in oil production in Cameroon and Gabon in 2016, the zone's production has remained significant, with the development of production in Equatorial Guinea, Congo and Chad (BEAC statistics). Most of these countries are both oil exporters and importers. However, the volume of crude oil exports remains much higher than the volume of oil product imports, because despite being an oil producer, some economies such as Cameroon, according to the African Development Bank (ADB, 2023) country report, import 21% of the world's oil refined in Russia, while oil revenues account for 20% of its GDP. Furthermore, according to the CEMAC Economic and Financial Reform Programme (PRE, 2022).

CEMAC countries imported more than CFAF 2,000 billion worth of petroleum products and derivatives in 2018. CEMAC countries are therefore affected by fluctuations in world oil prices as importers and/or exporters (Kenkouo, 2014). Crude oil accounts for a significant proportion of their total exports, i.e. 40.5% of exports in Cameroon;56.2% of exports in Congo; 67% of exports for Chad and 52% of exports from Equatorial Guinea. Cameroon, Chad, Congo, Gabon and Equatorial Guinea are ranked 11th, 12th, 6th and 9th respectively in the list of oil-producing countries in Africa.

According to a report by the African Development Bank, oil prices have an impact on economic growth because: (i) an increase in international oil prices leads to an increase in production costs and a slowdown in economic growth, (ii) an increase in oil prices leads to a deficit in the balance of trade of oil-exporting countries, followed by a reduction in household purchasing power and a transfer of wealth from importing to exporting countries, (iii) an

increase in oil prices leads to a slowdown in the demand for money, creating a slowdown in economic growth through an increase in interest rates, (iv) an increase in oil prices creates inflation which in turn increases the unemployment rate.(iiv) The relationship between consumption, investment and disposable income through the costs borne by the company.

The idea that there is a long- and/or short-term relationship between oil prices and economic growth in countries around the world in general and in the CEMAC zone in particular has been explored in the literature by a number of authors, who have reached various conclusions. For some, the impact of world oil prices on economic growth is limited in the short term (Cross & Bao H., 2017), while for others oil prices affect economic growth in both the short and long term (Olamide & Maredza, 2021).

Authors such as Fangzhi and Hua (2022) look earlier at the effect of economic growth on oil price shocks in the US and the G7 countries, concluding that there is a positive, one-sided effect. Others also argue that it is interesting to separate realised oil prices from expected oil prices in order to better understand the impact of oil prices on the population in the global market (Cross et al, 2021). Taking into account the time frequency and the model used, analyses have been carried out using linear models and VAR models for OECD countries (Abseysinghe, 2001; Jimenez-Rodrigez & Sanchez, 2005).

Recently, the causality between oil prices and economic growth has become a highly sought-after area for researchers. Oil prices have a very strong influence on the economy's real GDP. Previous studies have focused on traditional methods of time series analysis such as various cointegration analyses, Granger causality tests and linear regression techniques (Abseysinghe, 2001; Jimenez-Rodrigez & Sanchez, 2005; Lardic & Mignon, 2006), and have found that the relationship between the two variables may have (a) a unidirectional aspect from oil prices to economic growth (Binfeng & Xiaofang, 2024). (b) a unidirectional aspect from

economic growth to oil price(Fangzhi & Hua, 2022), (c) a bidirectional aspect thus an influence going in both directions(Cheng & Yonggang, 2024; Liu & Yang, 2024).

It is with this in mind that the problem of the effect of oil prices on economic growth in CEMAC member countries arises, both in terms of frequency and over time. From this problem arises the question of what is the effect over time of oil prices on economic growth in member countries of the CEMAC zone? Is there a short-term relationship between oil prices and economic growth in the CEMAC zone? Is there a long-term relationship between oil prices and growth in the CEMAC zone?

The general objective of this essay is to analyse the causal link between oil prices and economic growth in the countries of the CEMAC zone. The specific objectives are: to present the short-term causality between oil prices and economic growth in the CEMAC zone. Analyse the long-term causality between oil prices and economic growth in the CEMAC zone.

Since the hypothesis is an anticipated answer to the question posed, we have formulated as our main hypothesis that there is a dual causality between oil prices and economic growth. There is no causality between rising oil prices and economic growth in the short term; there is no relationship between oil prices and economic growth in the long term.

Our study is interesting for several reasons: firstly, we present an estimation technique that is not very widespread and, to our knowledge, has never been used on countries in the CEMAC zone with its different variables; secondly, we carry out an analysis of causality both in time and in time and frequency simultaneously using discrete wavelet analysis. In addition, MODWT performs a multi-scale wavelet decomposition on the signals, obtaining the characteristics of the signals at different frequencies. This enables a more complete analysis of the spectral content of the signals, leading to more effective noise suppression.

The rest of our essay is as follows: section 2 presents a review of the literature on long- and short-term causality; section 3 presents the data; section 4 presents the wavelets and Fourrier analysis; section 5 presents and interprets the results obtained over time and over time and frequency; section 6 presents the conclusion and recommendations…

2. Literature review

Review of the literature on short-term causality

The analysis of the relationship between oil prices and economic growth has attracted a great deal of attention from researchers in recent years. Given the important role of oil prices in the economy, Hooker (1996) explains the effect of oil prices on American economies. He bases his analysis on Granger's causality analysis of oil price shocks on US economic growth and finds that there have been major structural breaks in most variables. Its distinctive feature is that it includes oil prices, which are considered to be external, as internal variables. But it is limited to an analysis of developing countries.He is joined by Cunado and Perez (2005) who study the effects of oil prices on economic growth and inflation rates using a Granger causality test on data from developing countries (06 Asian countries) over a period of 1975-2002 (quarterly data), and find that the effects were limited in the short term, as the cointegration test was not decisive. Subsequently, Prasad and Narayan, (2007) examine the relationship between real GDP and oil prices using annual data from 1970 to 2005 for a small open economy (Fiji) with the Granger causality test. The findings indicate that oil prices have a positive effect on real GDP, however the time horizon remains limited and the Granger tests very inconclusive. Van et al (2019) analyse the impact of oil price volatility on economic growth using panel data from 17 OECD countries over 144 years.

In view of this, oil price volatility has a negative and statistically significant impact on economic growth in OECD countries, and if we take into account the heterogeneity of slopes in oil-producing countries, the effect is negative. And Sajjadur and Serletis, (2012) study the

relationship between oil price uncertainty and the level of economic activity using quarterly data from 1974-2010, using a VARMA model; GARCH -in-mean; an asymmetric BEKK model and show increased uncertainty when the variation in oil prices is associated with a lower average growth rate of real economic activity in Canada. Thus, all these analyses indicate the presence of a short-term relationship between oil prices and economic growth. But what about the long-term relationship?

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The causal relationship between oil prices and economic growth is based on a number of works, including those by Hamilton, followed by Mork (1984), who used the results of Hamilton's work to show that extending Hamilton's sample to 1988 only reflected the effect of oil prices on real GNP. To do this, he used a VAR model and found that the economy was more affected during periods of rising oil prices than during periods of falling oil prices.

He is joined by Abseysinghe, (2001) who analyses the impact of oil prices on economic growth in small economies using a VARX model and finds that oil prices have negative indirect effects even for net exporting countries and Jimenez-Rodrigez & Sanchez, (2005) show using a multivariate VAR model based on non-linear models that there is a non-linear effect of oil prices on real GDP growth in OECD Q3 countries:1972 to Q4 of 2001, the economic growth of oil prices proved to have a negative effect on the economic activities of other countries.

Fangzhi & Hua, (2022) examine whether and how unexpected economic growth could explain oil price shocks in emerging countries and China, using panel data from 1990 to 2021.They use the OLS method with heteroskedasticity robust standard errors and find that weaker than expected economic growth could lead to a real decline in oil prices after 2014; Lardic & Mignon, (2006) who study the link between oil prices and economic growth in twelve (12) European countries through an asymmetric cointegration approach using data from 1970 to 2003.They find an asymmetric cointegration relationship between oil prices and GDP in all

countries where an increase in oil prices affects the economy more than a decrease. All of these countries show a long-run relationship, but most of them are industrialised countries, and the estimation techniques used treat the process as stationary.

Following the difficulties encountered by the size of the scale between the databases, Afees, et al, (2022), using an autoregressive distributed lag model (ARDL-MIDAS), which allows mixed high and low frequency data to be included in the same prediction model, as well as the asymmetry of oil prices, present the effect of oil prices on the economic growth of Nigeria's real GDP, and conclude that a negative variation in oil prices considerably reduces economic growth, while a positive variation has no effect on it. Despite the resolution of the data scaling problem, there is still a grey area as to the frequency and magnitude of the phenomenon. Kirca et al (2020) examine the relationship between oil and gas prices and economic growth in Turkey. To do so, they first use a Granger and Toda Yamamoto causality test with structural breaks and then apply a frequency-domain causality test based on this test for a long-term analysis. From all this we see that all these authors present several estimation techniques, in various countries. But we present a set of developing countries and find it necessary to carry out a detailed analysis over time, for a better appreciation.

3. Methodology and data source

In this section, we present the various techniques used to explain the causal relationship between oil prices and economic growth in the CEMAC zone.Méthodologie économétrique

There are two types of wavelet, the mother wavelet and the father wavelet, represented as follow : $\int \varphi(t)\,dt = 1$ (wavelets Father) $\int \psi(t)\,dt = 0$ (wavelets Mother)

The father wavelet is represented by low-frequency periods, whereas the mother wavelets are high-frequency wavelets. This means that the father wavelets should behave like a small wave that loses its power as it moves forward (Ngandjon and Fouda, 2023). In this study, we have used a father wavelet because it allows a better understanding of the series studied.

Furthermore, the discrete wavelet transform decomposes the change in the function over time, i.e. the time series is decomposed into different frequencies or scales. These scales represent time series components with different frequencies, in which the low-scale components represent high-frequency signals; while the high-scale components represent low-frequency signals (Wang and Zhou, 2022). The MODWT (maximum overlap discrete wavelet transform) model is used to examine the lead/lag relationships between the dependent and independent variables. The time series can therefore be broken down into several components. Moreover, the MODWT has several advantages:(i) the MODWT is shift invariant (ii) the number of MODWT coefficients at each scale is reduced at the cost of the loss of orthogonality due to non-decomposition. In general, MODWT is defined as follows (Samejima & Sato, 2019):

$$\begin{aligned} h_{j,t} &\equiv h_{j,l} / 2^{j/2} \\ W_{j,t} &\equiv \sum_{l=0}^{L_j-1} h_{j,l} X_{t-lModT}; t = 0,\cdots,T-1 \end{aligned} \tag{15}$$

In this case : $L_j = \left(2^j - 1\right)\left(L-1\right)+1$

For j small, we have detailed short-term variations, and for j tending towards J, we have smooth long-term variations.

- **Presentation of wavelet analysis of variance tests**

Measure of variance based on wavelets, obtained by decomposing the variance of the sample into several components associated with the scale. In this case the wavelet variance is treated

as the decomposition of energy (Crowley, 2007) into the sum of two scale components (total energy) (Ramsey J. B., 2014).

- **Presentation of wavelet analysis of covariance tests**

Cornish et al (2006) define wavelet covariance as the measure of the degree of simultaneous correlation between 02 wavelet crystals for each scale. Let X_(t,T)be a locally stationary real-valued process with $\left\{h_{j,l} : j = 1,\cdots, J, l = 0,\cdots, L_{j-1}\right\}$ the MODWT wavelet filter of the jth level at scale ; $\tau_j = 2^{j-1}$ with

$$W^{X}_{j,t} \equiv \sum_{l=0}^{L_j-1} h_{j,l} X_{t-lModT}; t = 1,\cdots, T$$

The stochastic process obtained by filtering X_(t,T)with the wavelet filter $\left\{h_{j,l}\right\}$, a similar process is used to obtain $W^{Y}_{j,t}$.. The covariance is written as:

$$\gamma_{XY,t}\left(\tau_j\right) = \operatorname{cov}\left(W^{X}_{j,t}, W^{Y}_{j,t}\right) \qquad \sum_{j=1}^{J} \gamma_{XY,t}\left(\tau_j\right) = \operatorname{cov}\left(X_{t,T}; Y_{t,T}\right) \; ; \; j \in \left\{1, 2, \cdots, J\right\}$$

- **Presentation of wavelet correlation analysis tests**

Wavelet correlation highlights coincidences between the wavelet scales of two time series, and is presented as follows:

$$\rho_{XY}\left(\tau_j\right) = \frac{\gamma_{XY,t}\left(\tau_j\right)}{\sqrt{W^{X}_{j,t}} \cdot \sqrt{W^{Y}_{j,t}}}$$

$\gamma_{XY,t}\left(\tau_j\right)$ is the covariance between two series and $\sqrt{W^{X}_{j,t}}$; $\sqrt{W^{Y}_{j,t}}$ are the standard deviations of the wavelets Xand Yrespectively.

2.2 Choice of variables and data sources

In this study we use two variables: economic growth and oil prices, both taken from secondary databases. Economic growth is measured here by the GDP growth rate, taken from the WDI (2021), while the oil price comes from investing. Com. These data cover a monthly period from 1987 to 2021 for the member countries of the CEMAC zone. We then observe the evolution of oil prices and economic growth in the countries of the CEMAC zone (Cameroon; Chad; Gabon; Congo; Equatorial Guinea; Central Africa) in time series.

4. Results and interpretation

Given that the MODWT takes into account any sample size N whereas the DWT only takes into account the 2j, where "j" is a level of decomposition. Here is the decomposition of the series into different frequencies. This table will be useful for a better understanding of the results.

Table 1: Breakdown of series

W_{jt}	2^j	**Echelle**
W_{1t}	4-8	Monthly
W_{2t}	8-16	Quarterly
W_{3t}	16-32	Annual

Source: author

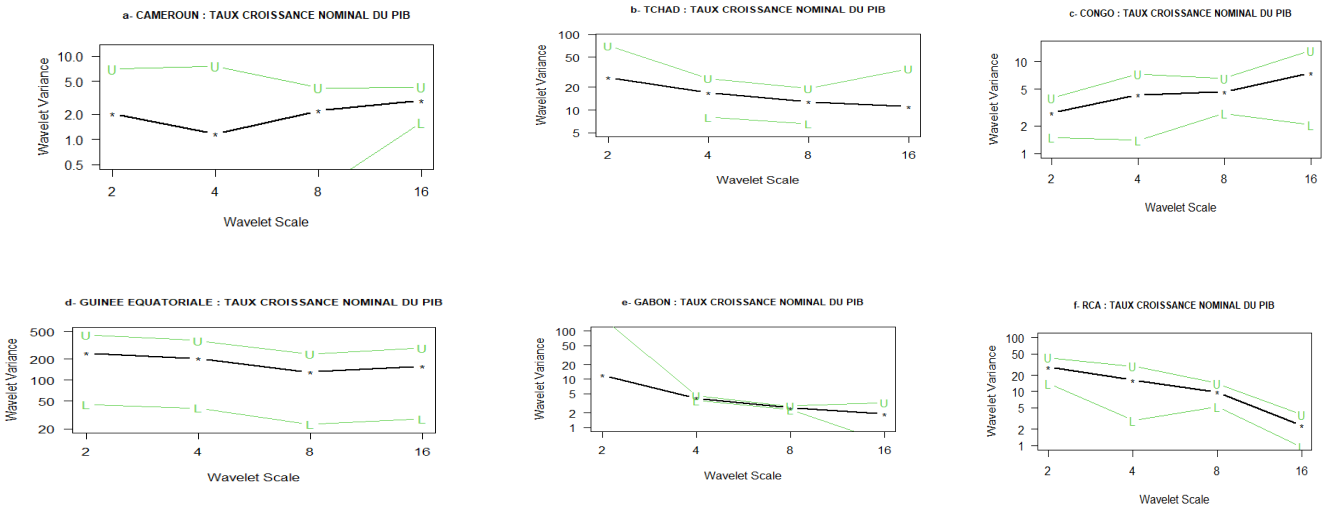
In this section, we will present the results of the wavelet analysis. First, we will perform a unit root test to confirm or deny a long-term relationship between the series. Secondly, we will carry out a wavelet analysis of variance test to check whether or not the series are stationary. Thirdly,

we will carry out an analysis of the covariance between the different wavelets. Fourthly, we will carry out a wavelet correlation analysis and finally a cross-correlation.

Wavelet analysis of variance

The aim is to assess the volatility of the series highlighted on different time scales. Using the Brent oil price series and the annual GDP growth rates of the CEMAC countries as time components.

Figure 5: Wavelet variance of growth rate by country.



Source: author

Figure 1 below shows the wavelet variances estimated at different wavelet scales for all CEMAC countries. The wavelet variance at level j is obtained using the wavelet coefficients w1 to w4.

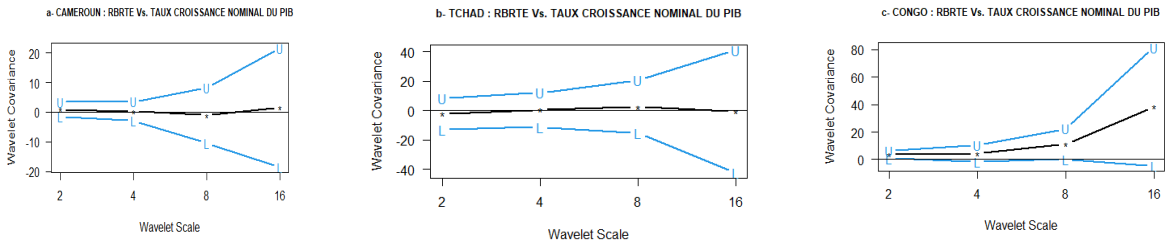
This analysis reveals that the wavelet variances tend to increase as the scale (frequency) increases for the oil price (Figure 1). In other words, volatility changes at all frequencies. With regard to growth rates, Figure 2 shows two groups of countries: the first, whose volatility decreases as the time scale increases, is made up of Chad, Equatorial Guinea, Gabon and CAR

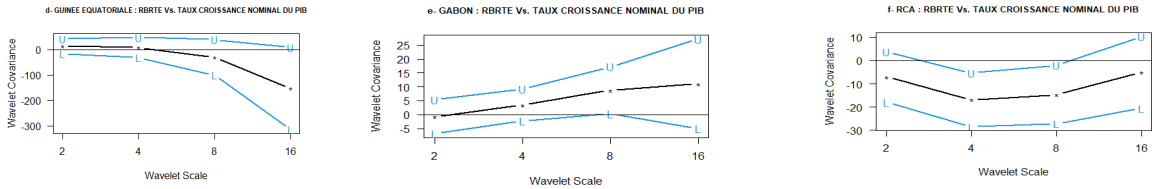
(Figure 1.b,d,e,f), and the second, whose volatility increases as the time scale increases, is made up of Cameroon and Congo (Figure 1.a,c). In particular, Equatorial Guinea shows the highest and most stable wavelet variance at all frequencies. Cameroon, Congo and Gabon show relatively low volatility at all frequencies.

Analysis of covariance

Figure 4. 6 below depicts the MODWT-based bi-variate wavelet covariance of the oil price and the annual growth rate of the CEMAC countries which shows how the two series are associated with each other. Note that a positive covariance explains that an increase in the oil price is associated with an increase in the growth rate. A negative covariance shows that an increase in the price of oil is associated with a decrease in the annual growth rate. According to these results, wavelet covariance presents three major situations. The first describes a zero covariance, the second a positive covariance, and the third a negative covariance.

Figure 2 : WAVELET COVARIANCE





Note: The dotted lines (U and L) correspond to the upper and lower limits of the corresponding 95% confidence interval.

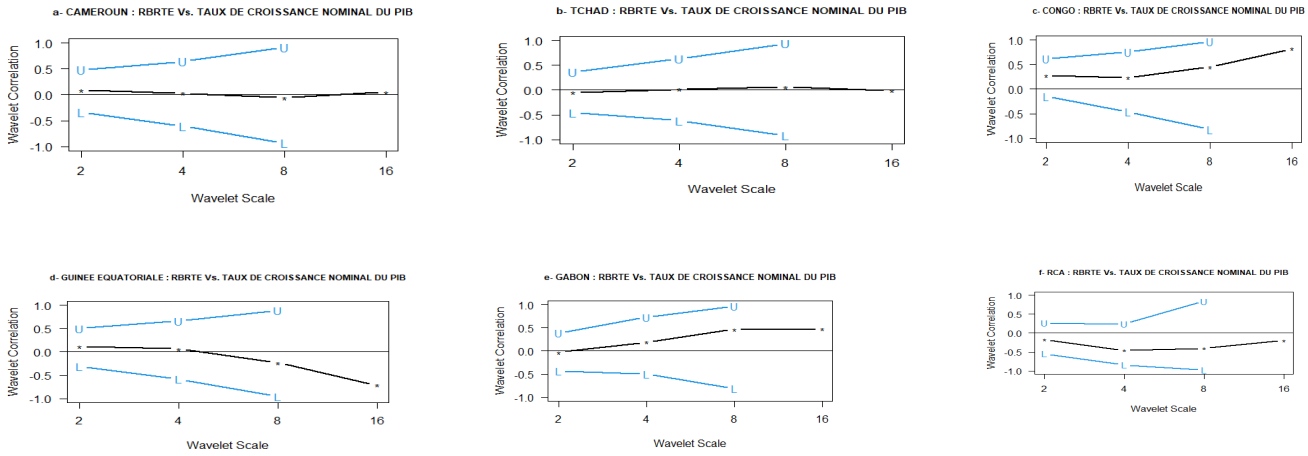
Source: author

For Cameroon (Figure 2.a) and Chad (Figure 2.b), the covariance is broadly zero. There is no evidence of a real negative or positive association between oil prices and annual growth rates for Cameroon and Chad. The second situation describes a positive covariance between the oil price and the GDP growth rate for Gabon (Figure 2.e) and the Republic of Congo (Figure 2.c). This association is weak in the short term (high frequency), strong in the medium term and even stronger in the long term (low frequency). An increase in the price of oil is associated with an increase in the annual growth rate for these two countries. The third situation describes a negative covariance between the oil price and the GDP growth rate for Equatorial Guinea (Figure 2.d) and CAR (Figure 2.f). The association is weak in the short term (high frequency), strong in the medium term and even stronger in the long term (low frequency) for Equatorial Guinea. For CAR, the association is negative on all time scales. An increase in the price of oil is associated with a decrease in the annual growth rate for these two countries.

Although there are several associations (increasing, decreasing and zero) between the price of oil and the Annual Growth Rate, it is difficult to compare the wavelet scales because of the different variability they exhibit. In this case, dividing by the variance of each series is a natural way of standardising the covariance, overcoming this influence and allowing us to compare the extent of the association between the scales. The wavelet correlation should therefore be constructed to examine the extent of the association between each series.

Wavelet correlation analysis

Figure 3: Wavelet correlation



The wavelet correlation between oil prices and growth rates in the CEMAC countries is shown in Figure 3 below.

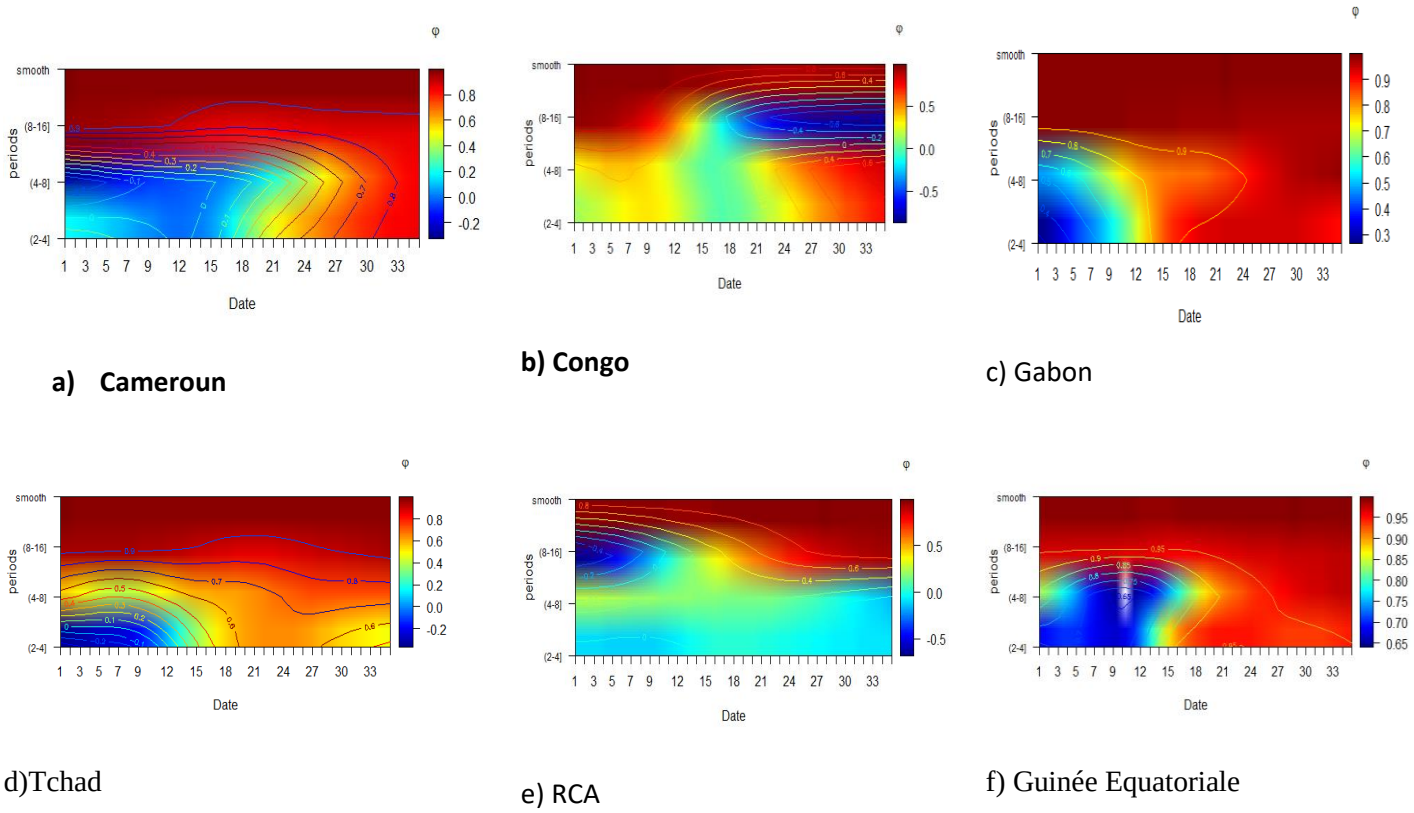
Source: author

As in the previous analysis, the results of the wavelet correlation are presented according to several situations:

No clear evidence of positive or negative correlation in the short and medium term for Cameroon and Chad. Figure 3. a , b. Clear evidence of a significant positive correlation at all frequencies for Congo (Figure 3.c), in the short and medium term for Gabon (Figure 3), and only in the short term for Equatorial Guinea. Clear evidence of a significant negative correlation at all frequencies for CAR and from the medium term onwards (Figure 3.f), for Equatorial Guinea (Figure 3.d). Overall, the correlation coefficients tend to increase with scale, although there is no significant correlation at long range.

Local Wavelet Correlation (WCL) analysis

Figure 4: Local wavelet correlation (WLC)



a) Cameroun **b) Congo** c) Gabon

d)Tchad e) RCA f) Guinée Equatoriale

Notes : Red (blue) colours signify a region with high (low) coherence. The legend (on the right of the maps) shows the strength of the coherence coefficients. The x-axis represents the years from 1987 to 2021 (35 years), the y-axis the wavelet scale.

Source: author.

Figure 4 shows that in most countries (Cameroon, Congo, Gabon, Chad and Equatorial Guinea) there is a strong correlation between oil prices and economic growth at high levels (8-16). And a strong correlation at small scales becomes high from 2001 onwards (Cameroon, Gabon and Equatorial Guinea). All this explains the procyclical nature of oil prices and economic growth in certain CEMAC countries, such as Cameroon, Equatorial Guinea and Gabon.

5. Conclusion

In this paper we study the relationship between oil prices and economic growth in the CEMAC. We find that oil prices and economic growth are related in the short and long term for high wavelet scales, but for low wavelet scales we find a correlation after 2001 for Cameroon, Equatorial Guinea and Gabon. Any policy designed to diversify the economy must therefore take account of the heterogeneity of the CEMAC.

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Appendix

Table 4.2: ADF unit root test, and PP

CER	I	T	I&T
Cameroon	I(1)	I(1)	I(1)
Tchad	I(1)	I(1)	I(1)
Congo	I(1)	I(1)	I(1)
RCA	I(1)	I(1)	I(1)
GNQ	I(1)	I(1)	I(1)
Gabon	I(1)	I(1)	I(1)

Source : author using Eviews 10 software.