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Do Climatic Conditions Affect Tax Revenues in Cameroon? Evidence From the Ardl Quantile Approach

İklim Koşulları Kamerun'daki Vergi Gelirlerini Etkiliyor Mu? Ardl Kantil Yaklaşımı Buguları

Bybert Moudjare Helgath [a] & Sabine Nadine Ekamena Ntsama [b,*]

[a] University of Garoua (Higher School of Economic and Commercial Sciences, University of Garoua), Garoua, Cameroon
ORCID : 0000-0001-7125-0603
[b] Lec. Dr., Ondokuz Mayıs University, Terme Vocational School, Department of Foreign Trade, 55100, Samsun/Türkiye
ORCID: 0000-0002-6099-0160

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ÖZ

Bu çalışma, Kamerun'daki iklim değişikliği ile vergi gelirleri arasındaki kantil eşbütünleşme ilişkisini incelemektedir. 1980-2015 dönemi için Kantil Otoregresif Dağınık Gecikmeli (QARDL) modeli kullanılmıştır. Sonuçlar, değişkenler arasındaki ilişkinin kantillere bağlı olduğunu göstermektedir. Bu nedenle, iklim değişikliği daha yüksek kantillerde vergi gelirlerindeki iyileşmeye olumsuz katkıda bulunmaktadır. Ayrıca, tarım belirli kantillerde vergi gelirlerindeki artışa olumsuz katkıda bulunmaktadır. İklim değişikliğindeki (sıcaklık ve yağış) ve vergi gelirlerindeki değişimler, tarımdaki geçmiş ve mevcut değişikliklerden sorumludur. Sonuçlar, sıradan en küçük kareler yöntemiyle bulunanlarla uyumludur. Bu bulgular, Kamerun bağlamında hükümetler ve diğer paydaşlar için önemli politika çıkarımlarına sahiptir. Vergi gelirlerinin seviyesini iyileştirmeye ve mükemmel bir çevre politikası uygulamaya yardımcı olacaklardır.

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A B S T R A C T

This study examines the quantile cointegration relationship between climate change and tax revenues in Cameroon. The Quantile Autoregressive Distruted Lag (QARDL) model is used, over the period 1980-2015. The results indicate that the relationship between the variables depends on the quantile. Thus, climate change contributes negatively to the improvement in tax revenue at higher quantiles. In addition, agriculture contributes negatively to the increase in tax revenue at certain quantiles. Variations in climate change (temperature and precipitation) and tax revenues are responsible for past and current changes in agriculture. The results are in line with those found by the ordinary least squares method. These findings have important policy implications for governments and other stakeholders in the Cameroonian context. They will help to improve the level of tax revenues and implement an excellent environmental policy.

Introduction

Taxes, an important source of public revenue, are characterised by their stability and predictability, unlike mining revenues, which are highly volatile, and development aid, which is often conditional (Ongo Nkoa and Song, 2022). As such, they help to strengthen states and reduce public deficits, poverty and inequality through service provision, aid dependency and reduced vulnerability (Asongu et al., 2021). Despite the relative increase in tax revenues in Africa, which reached an average of 11.5% of GDP in 1980 and 16.6%

* Sorumlu yazar/Corresponding author.
e-posta: nadia_ekamena@yahoo.fr

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in 2021, Cameroon's tax mobilisation remains below the African average of 14.2% in 2021.

Meeting the challenge of raising sufficient tax revenue, particularly in the face of tax evasion, informality and poor institutional quality, requires a climate-sensitive approach to taxation. Similarly, the geophysical factors used in economic studies can be divided into non-random time-scale factors, such as latitude and altitude, and average stochastic factors, such as climatic conditions or soils (Nordhaus, 2006). With this in mind, the analysis of the link between climate and tax revenues can be based on two transmission channels. The direct channel is based on the idea that the tax revenue collected depends on the behaviour of citizens, which varies according to the climate zone (Mutascu, 2014). As a result, unlike people living in hot spots, people living in cold regions are characterised by honesty, pragmatism, independence, personal initiative and strong will (McDougall, 2005). Furthermore, Mutascu (2014) argues that tax compliance is a dimension of human behaviour, therefore, climate can affect the level of tax revenues through the intensity of tax compliance. The indirect channel we study is based on the impact of climate conditions on tax revenues through a series of socio-economic factors (such as economic growth, trade openness, agriculture, etc.), which can play an important role in the expansion of tax revenues. Tax bases in specific climates.

Empirical studies on tax revenues suggest two categories of determinants: modern determinants such as public-private partnerships, institutional quality and ICTs (Shita et al., 2021), and traditional and non-conventional determinants such as GDP/capita, trade openness, direct investment (FDI), natural resources, gender and climate change (Asongu et al., 2021). Moreover, there is little literature in this area on the tax revenues that are affected by climate conditions. Recent studies have examined the need for climate change mitigation and adaptation policies, highlighting that climate change can lead to negative supply shocks that trigger lower global economic growth (Kahn et al., 2021; Botzen et al., 2019; Krogstrup and Oman, 2019). A review of the literature by Krogstrup and Oman (2019) shows that the loss of GDP varies between 0% and 3% for each 3°C of global warming. Other research has shown that the effects of climate change and vulnerability vary from country to country. In particular, developing countries tend to be the most disadvantaged due to global warming, poor initial macroeconomic conditions and higher levels of poverty and income inequality (Acevedo Mejia et al., 2018).

However, the pioneers in the study of this subject were Montesquieu (1750) and Smith (1776), In any case, the fiscal implications of climate change remain an open question. To our knowledge, the only study is by Mutascu (2014). He examines the impact of climatic conditions on tax revenues in 123 countries around the world, using temperature as a measure of climate change over the period 1996-2010. His findings show that temperature has a negative effect on tax revenues in countries in the warm zone, while tax revenues improve in temperate countries.

This paper develops the literature in this area by focusing on the impacts of climate change on the economy and finding new evidence on the determinants of tax revenues collected. Furthermore, within this continuity of theoretical background and empirical methodology, the purpose of this study is to analyse the impact of climate change on tax revenues in Cameroon. With this in mind, this article contributes to the empirical literature in two ways. Firstly, we use all the indicators for measuring climate change: temperature and precipitation. Secondly, assume the impact of climate change on tax revenues. Given that climate change is cyclical, this document could help governments adjust their tax policies to take account of the cyclical nature of climate change.

In addition, analyses must be carried out using quantile modelling to assess the impact of policy parameters on the set of policy variables of interest. We analyse the impact of climate change on tax revenues over the period 1980 to 2015. In addition, we specify and estimate the ARDL quantile cointegration model using the method of Cho et al. (2015) in Cameroon. Similarly, the ARDL quantile approach tests the stability of long-term relationships between quantiles and provides a more flexible econometric framework. This method can simultaneously describe the relationship between several quantile time series conditional on several quantiles. In addition, we show that the effects of explanatory policy parameters differ in terms of the magnitude, nature and timing of responses. Designing a robust policy requires assessing the different impacts of the descriptive policy parameters on the set of target policy variables, and this is achieved by applying the QARDL approach. In addition, this approach explains the asymmetric response of tax revenues to climate change. On the other hand, capturing the impacts of climate change with a single variable may not reflect the right scenario, which is why two climate change indicators have been chosen from a policy perspective: temperature and precipitation. Inclusion of these indicators has given the study the flexibility to describe scenarios in great detail, so that the expected results of the tests can be reproduced in other emerging economies around the world, with the Cameroonian situation suggesting a more or less realistic outcome. This approach can be seen as an analytical contribution to the research. The results of this study show that climate change reduces tax revenues at higher quantiles.

The article is structured as follows. Section (1) presents the methodology and data. Section (2) presents and discusses the results. The conclusion discusses policy recommendations.

1. Research methodology

In that section, we present the data and their sources. Well before that, we justify and specify the choice of model and present the various stages in estimating the model.

Justification, specification of the choice of model and estimation procedure

This paper explores the cointegrating relationship between climate change and tax revenues with the Quantile Autoregressive Distributed Lag (QARDL) model developed by Cho et al. (2015). One of the advantages of this model is its ability to accommodate the long-run quantile equilibrium manipulation exercise (He et al.2021) of climate change, agriculture and tax revenues in Cameroon. In addition, QARDL has more strengths than the non-linear Autoregressive Distributed Model Lag (NARDL) of Shin et al. (2014), due to its ability to assess the equilibrium of the long-run quantile relationship and creates flexibility in the econometric framework. In addition, the explanation of the Asymmetry of the response on one variable to the variables of another variable is easier with the latter.

In the same vein, Luqman et al (2021) argued that QARDL first allows simultaneous long-term association between variables over a large quantile. This facilitates short-term dynamics with the conditional distribution of independent variables. Secondly, it improves the fluctuation of quantile cointegration coefficients concerning the different shocks. Finally, the asymmetric situation in which the parameter relies on the positions of the dependent variable regarding their conditional distributions. In addition, QARDL evaluates the quantile effects of the variables on the dependent variable. In addition, the model evaluates the non-linear relationship of all the variables in the study, as opposed to the traditional linear approach, allowing a linear association between the means of the regressed results (Jahanger et al.2022; Shahzad et al.2020). Clearly, it considers both non-linearity and asymmetry in a tax revenue mobilisation environment. In the same sphere, Shahzad et al (2020) argue that the QARDL model, which takes into account the cointegrating relationship of the quantiles of the dependent variable, is an extension of the ARDL model and has all the strengths of the ARDL model. We can therefore specify the ARDL model as follows:

$$TAX_t = \alpha + \sum_{i=1}^{p} \varphi_i TAX_{t-i} + \sum_{i=0}^{q_1} \omega_i CC_{t-i} + \sum_{i=0}^{q_2} \theta_i AGRI_{t-i} + \varepsilon_t (1)$$

Where TAX_t is the logarithm of tax revenues in period t. Similarly, CC_t is climate change in t. It is measured using temperature indicators (MAT) and precipitation indicators (MAP). $AGRI_t$ is population growth in t. ε_t is the error term, measured as follows: $TAX_t - TAX[TAX_t - F_{t-1}]$, F_{t-1} with the smallest $\boldsymbol{\sigma}$ calculated as follows : $\{CC_t, AGRI_t, TAX_{t-1}, CC_{t-1}, AGRI_{t-1}, ...\}$, p, q_1, q_2 are order shifts on the Schwarz information criterion (SIC).

In another sphere, we abound in the same vein as Cho et al. (2015), which transforms the ARDL model into a QARDL model, incorporating quantiles. We obtain the following form:

$$Q_{TAX_t} = \alpha(\tau) + \sum_{i=1}^{p} \varphi_i(\tau) TAX_{t-1} + \sum_{i=0}^{q_1} \omega_i(\tau) CC_{t-1} + \sum_{i=0}^{q_2} \theta_i(\tau) AGRI_{t-1} + \varepsilon_t(\tau) \quad (2)$$

Where $\varepsilon_t(\tau) = TAX_t - Q_{TAX_t}(\tau / F_{t-1})$ and $Q_{TAX_t}(\tau / F_{t-1})$ is the τ^{th} sub-quantile of TAX_t the given information set F_{t-1} defined as above. We reformulate equation (2) to arrive at the modified form of the QARDL model as follows:

$$Q_{TAX} = \alpha(\tau) + \sum_{i=1}^{q_1-1} \delta_{CC_i}(\tau) \Delta CC_{t-1} + \gamma_{CC}(\tau) CC_t + \sum_{i=1}^{q2-1} \delta_{AGRI_i}(\tau) \Delta AGRI_{t-1} + \gamma_{AGRI}(\tau) AGRI_t + \varepsilon_t(\tau) \quad (3)$$

Where , $\gamma_{CC}(\tau) = \sum_{i=0}^{q_1} \omega_i(\tau)$, $\delta_{CC_t}(\tau) = -\sum_{j=i+1}^{q_1} \omega_i(\tau)$ and $\gamma_{AGRI}(\tau) = \sum_{i=0}^{q_1} \theta_i(\tau), \delta_{AGRI_t}(\tau) = -\sum_{j=i+1}^{q_1} \theta_i(\tau)$

The parameters in equation (3) below capture short-term dynamics. In order to take into account the long term dynamics in the relationship between climate change, tax revenues, agriculture, equation (3) is modified as shown in equation (4) below:

$$Q_{TAX_t} = \mu(\tau) + X_t^{'} \beta(\tau) + M_t(\tau) (4)$$

Where in equation (4), $X_t^{'}$ is a vector $K*1$ of integrated regressors of order I (1). However, the K variables are not integrated by themselves. With $X=[CC, AGRI]$ and where $\beta_{CC}(\tau)=\gamma_{CC}(\tau)\left[1-\sum_{i=1}^{p}\varphi_{CC_i}(\tau)\right]^{-1}$, and $M_t(\tau)=\sum_{j=0}^{\infty}\partial_{CCj}(\tau)\Delta CC_{t-1}+\sum_{j=0}^{\infty}\theta_{CC_j}(\tau)\Delta\varepsilon_{t-1}$ with $\mu(\tau)=\alpha(\tau)\left[1-\sum_{i=1}^{p}\varphi_i(\tau)\right]^{-1}$ and $\partial_j(\tau)=\sum_{l=j+1}^{\infty}\pi_l(\tau).\beta_{AGRI}(\tau)$.

Where $\{\theta_0(\tau),\theta_1(\tau),...\}$ and $\{\pi_0(\tau),\pi_1(\tau),...\}$ are defined as follows :

$$\sum_{i=0}^{\infty}\theta_i(\tau)L^i=\left(\frac{\sum_{i=0}^{q_1}\omega_i(\tau)L^i}{1-\sum_{i=1}^{q_1}\omega_i(\tau)L^i}-\frac{\sum_{i=0}^{q_1}\omega_i(\tau)}{1-\sum_{i=1}^{q_1}\omega_i(\tau)}\right)$$

By simplifying the model, we avoid the problems associated with serial correlation. The model is as follows:

$$Q_{\Delta TAX_t}=\alpha+\rho TAX_{t-1}+\varphi_{CC}CC_{t-1}+\varphi_{AGRI}AGRI_{t-1}+\sum_{i=1}^{P}\varphi_i\Delta TAX_{t-1}+\sum_{i=0}^{q_1-1}\omega_i\Delta CC_{t-1}+\sum_{i=0}^{q_2-1}\theta_i\Delta AGRI_{t-1}+\upsilon_t(\tau) \quad (5)$$

Taking into account equation (5) above, we introduce a correlation υ_t between ΔCC_t and $\Delta AGRI_t$. We apply the projection υ_t in ΔCC_t , and $\Delta AGRI_t$ in the form: $\Delta\upsilon_t=\gamma_{CC}\Delta CC+\gamma_{AGRI}\Delta AGRI_t+\varepsilon_t$.

However, ε_t is not correlated with ΔCC_t, and $\Delta AGRI_t$. We introduce the previously defined projection into equation (5). Next, we generalise the quantile regression environment, leading to the QARDL Error-Correction Model, as follows:

$$Q_{\Delta TAX_t}=\alpha(\tau)+\rho(\tau)\left(TAX_{t-1}-\beta_{CC}(\tau)CC_{t-1}-\beta_{AGRI}(\tau)AGRI_{t-1}\right)+\sum_{i=1}^{p-1}\varphi_i(\tau)\Delta TAX_{t-1}+\sum_{i=0}^{q_1-1}\omega_i(\tau)\Delta CC_{t-1}+\sum_{i=0}^{q2-1}\theta_i(\tau)\Delta REN_{t-1}+\varepsilon_t(\tau) \quad (6)$$

The impact of past tax receipts on current tax receipts is measured by $\varphi^*=\sum_{j-1}^{p-1}\varphi_j$.

Thus, $\varphi^*=\rho$. In the same vein, the cumulative short-term impacts of tax revenues on climate change and agriculture are given by: $\omega^*=\sum^{q_1-1}\omega_j$, and $\theta^*=\sum^{q_2-1}\theta_j$. In addition, the cumulative long-term cointegration parameters for climate change and agriculture are calculated as follows : $\beta_{CC*}=-\frac{\varphi_{CC}}{\rho}$ and $\beta_{AGRI*}=-\frac{\varphi_{AGRI}}{\rho}$.

The long-term and short-term cointegration parameters are calculated using the delta method. In addition, we note that the EMC of the parameter ρ^* should be significantly negative. We apply the Wald test statistic to assess the asymmetric and non-linear impact of climate change on tax revenues. This test allows us to test for zero and follows a chi-square distribution, with the null and alternative hypotheses for the short- and long-term parameters respectively. φ^*, ω^*, β^* and ρ^*.

$H_0^{\omega}: F\varphi^*(\tau)=s$ versus $H_1^{\omega}: F\varphi^*(\tau)\neq s$

$H_0^{\omega}: F\omega^*(\tau)=s$ versus $H_1^{\omega}: F\omega^*(\tau)\neq s$

$H_0^{\omega}: F\beta_i^*(\tau)=s$ versus $H_1^{\omega}: F\beta_i^*(\tau)\neq s$

$H_0^{\omega}: F\rho^*(\tau)=s$ versus $H_1^{\omega}: F\rho^*(\tau)\neq s$

For the null and alternative hypotheses, F and f are the specific matrices, respectively of $h^*\rho s$ and h^*1. However, S and s are the pre-specified matrices of h^*s and h^*1 , in which h refers to certain restrictions (Cho et al. 2015) and i for climate change (CC) and agriculture (AGRI).

In addition, our study tests the null hypothesis for each parameter ρ^*, i.e

$$H_0 : \rho^*(0.05) = \rho^*(0.10) = \rho^*(0.20) = \rho^*(0.30) = ... = \rho^*(0.90) = \rho^*(0.95)$$
$$H_1 : \rho^*(0.05) \neq \rho^*(0.10) \neq \rho^*(0.20) \neq \rho^*(0.30) \neq ... \neq \rho^*(0.90) \neq \rho^*(0.95)$$

The same hypotheses are tested on β_{CC}, and β_{AGRI} on the three cumulative short-term variables φ^*, ω^* and θ^*.

1. 2 Data

Our objective is to assess the impact of climate change on tax revenues in Cameroon. Using quantile cointegration, our study covers the period 1980-2015. The choice of this study period and sample is due to the tax revenue database. Indeed, the tax revenues come from studies by Caldéira et al (2019), confirmed by FERDI, and cover the entire study period. For the sake of data harmonisation, we have decided to select this period. In the same vein, the choice of Cameroon is due to its low tax revenue and high temperatures and rainfall. We back this up with the floods that occurred in the 2000s. In addition, the climate change variables, which are our variables of interest, come from https://climateknowledgeportal.worldbank.org. The agriculture variable, on the other hand, is taken from the World Development Indicators (WDI, 2022).

2. Empirical results and discussion

This section is devoted on the one hand to the presentation of descriptive statistics, correlation of variables and unit root tests, and on the other hand to the estimation of the relationship between climate change and tax revenues.

Descriptive statistics, correlation of variables and unit root tests

We report the descriptive statistics for tax revenues, climate change and agriculture in table [1]. The descriptive statistic shows that the average tax revenue is lower, but contributes positively in the same way as temperature, precipitation and agriculture. Precipitation data follows a strong variation compared to tax revenue, temperature and agriculture. However, all our data show little variation. This gives us confidence that the results are unbiased. Finally, the Shapiro-Wilk test statistic shows that all our variables are normally distributed, except for the temperature and agriculture variables.

Table [1]: Descriptive statistics and Shapiro-Wilk normality test

Variables	Mean	Standard deviation	Minimum	Maximum	Shapiro-Wilk test
TAX	15.680	3.021	8.866	22.920	0.285
MAP	975.450	50.433	849.04	1082.37	0.419
MAT	21.166	0.3779	21	22	0.000
AGRI	18.714	4.852	13.095	28.677	0.0022

Source: Authors.

Table [2] below shows little interdependence between the dependent variable (tax revenue) and the independent variables (temperature, rainfall and agriculture). This result suggests the absence of multicollinearity problems between the dependent and independent variables.

Table [2] : **Correlation table of variables**

	TAX	MAP	MAT	AGRI
TAX	1			
MAP	0.012	1		
MAT	-0.154	-0.074	1	
AGRI	-0.189	-0.521*	-0.099	1

Source : Authors

Table [3]: Results of unit root tests

Variables	ADF		PP		ZA		Decision
	Level	Difference	Level	Difference	Level	Difference	
TAX	-2.232	-6.258***	-2.232	-6.258 ***	-5.756	-7.979***	I(1)
MAP	-4.938***	-12.744***	-4.938 ***	-12.744 ***	-8.428***	-8.151***	I(0)
MAT	-5.778***	-9.798***	-5.778***	-9.798***	-7.339***	-8.163***	I(0)
AGRI	-2.128	-7.380***	-2.128	-7.380 ***	-5.788	-8.378***	I(1)

Note: The numbers in the table indicate the empirical value of the statistical test for stationarity. The asterisks ***,**,* indicate rejection of the null hypothesis of unit root at the 1%, 5% and 10% significance level respectively. The critical values of ZA are -5.57 (1%), -5.08 (5%) and -4.82 (10%). Source: Authors.

Before estimating the QARDL model, it is necessary to determine the order of integration of the time series of all our variables. We used the Augmented Dickey-Fuller (ADF) test (1979), the Phillip-Perron (PP) test (1988) and the Zivot-Andrews (1992) (ZA) test. The advantage of the ZA test is that it takes account of a break in the structure of the data. The results show that all the time series are I(1), with the exception of climate change (precipitation and temperature), which is I(0). All the variables are therefore stationary, since the ADF, PP and ZA tests reject the null hypothesis of the unit root of climate change at the 1% significance level, respectively. The results indicate that the QARDL model is the appropriate model for this research.

2.2. Results of the impact of climate change on tax revenues

Using the QARDL method of Cho et al. (2015), the objective of this research is to examine the relationship between climate change and tax revenues in Cameroon. We use two indicators of climate change measures namely: rainfall (MAP) and temperature (MAT).

Considering rainfall as a proxy for climate change in Table [4], the OLS estimation results confirm the linear cointegrating relationship between this variable, tax revenue (dependent variable) and agriculture. The speed of adjustment coefficient is negative and significant for the case of Cameroon, thus justifying a long-run cointegration relationship (Shahbaz et al.2018). Thus, the long-run linear cointegration parameters between agriculture and rainfall are found to be significant, explaining the linkage of these variables to tax revenue in the long run.

In addition, the results in Table [4] of the QARDL approach confirmed the measurement parameter of the error correction model (ECM) ρ^*. The parameter ρ^* is negatively significant in all quantiles, which supports the presence of aversion in the long-term equilibrium between rainfall, tax revenue and agriculture. Furthermore, the results support that β_{MAP} is negatively significant at the 80th, 90th and 95th quantiles, showing a downward trend in rainfall levels. The possible economic justification for this finding is timely, given that Cameroon has been facing its worst climate change crisis in recent years. Human activities, through greenhouse gas emissions, play a decisive role in the occurrence of extreme precipitation. We are witnessing severe soil erosion, an increase in agricultural losses and widespread flooding. The environmental policies initiated by the Cameroon government have not been effective. The results are consistent with the findings of Bachner and Bednar-Friedl (2019), who find a significant negative relationship between climate change and tax revenues in Australia.

With regard to the association between agriculture and tax revenue, the results show that β_{AGRI} is also a significant negative relationship between tax revenue and agriculture at the lower quantiles (20th and 30th), the middle quantile (50th) and the upper quantiles (70th, 80th and 95th). This suggests that tax revenues are vulnerable under all agricultural conditions. The results of this study are consistent with those found by Albimana and Hemedb (2022). This is explained by the strong presence of substance agriculture to the detriment of industrial agriculture. This highlights the shortcomings of agricultural policies in Cameroon's development process.

Table [4]: Results of OLS estimates and ARDL quantile regressions with the precipitation indicator

Result of the MCO estimate							
α_*	ρ_*	β_{MAP}	β_{AGRI}	φ_1	ω_1	θ_1	
11.646*	-0.255*	**-1.493***	-0.227*	-0.072	-0.790	0.155	
(6.017)	(0 .132)	**(0.850)**	(0.125)	(0.189)	(0.576)	(0.242)	
Result of the ARDL Quantile estimate							
(τ)	$\alpha_*(\tau)$	$\rho_*(\tau)$	$\beta_{MAP}(\tau)$	$\beta_{AGRI}(\tau)$	$\varphi_1(\tau)$	$\omega_1(\tau)$	$\theta_1(\tau)$
0.05	-0.121	-0.480***	0.238	-0.123	0.213	0.070	0.345
	(0.168)	(0.144)	(1.551)	(0.168)	(0.210)	(0.720)	(0.960)
0.10	-0.121	-0.480***	0.238	-0.122	0.212	0.069	0.345

	(10.747)	(0.147)	(1.541)	(0.146)	(0.214)	(0.743)	(0.981)
0.20	-5.334	-0.554***	1.106	-0.300*	0.190	0.373	0.254
	(11.752)	(0.229)	(1.692)	(0.151)	(0.225)	(0.694)	(0.882)
0.30	0.337	-0.603***	0.347	-0.400***	0.246	0.164	0.332
	(10.449)	(0.231)	(1.503)	(0.152)	(0.229)	(0.759)	(0.813)
0.40	5.313	-0.298*	-0.582	-0.618	0.004	-0.069	-0.618
	(9.023)	(0.221)	(1.269)	(0.842)	(0.188)	(0.687)	(0.842)
0.50	9.204	-0.324*	-1.091	-0.272*	-0.044	-0.236	-0.560
	(8.129)	(0.182)	(1.134)	(0.135)	(0.188)	(0.690)	(0.773)
0.6	7.655	-0.305*	-0.892	-0.225	-0.100	-0.256	-0.612
	(7.866)	(0.158)	(1.110)	(0.142)	(0.183)	(0.565)	(0.647)
0.7	11.950	-0.456***	-1.424	-0.294***	-0.059	-0.522	-0.769
	(8.532)	(0.151)	(1.229)	(0.137)	(0.164)	(0.593)	(0.602)
0.8	16.430*	-0.390***	**-2.111***	-0.255*	-0.131	-1.445***	-1.083
	(8.170)	(0.175)	**(1.208)**	(0.133)	(0.193)	(0.659)	(0.672)
0.9	21.867*	-0.526***	**-2.856***	-0.224	0.165	-1.485	-1.019
	(10.580)	(0.188)	**(1.490)**	(0.153)	(0.316)	(1.156)	(0.726)
0.95	24.607***	-0.391**	**-3.241****	-0.374**	0.043	-1.500	-1.114
	(10.818)	(0.183)	**(1.522)**	(0.163)	(0.316)	(1.154)	(0.721)

Notes: Standard errors are in brackets. ***, ** and * indicate significance at 1%, 5% and 10% respectively. The lags p and q in equation [6] are selected using the information criterion of Schwarz, p = 6 ; q = 1. $\alpha^* = \alpha$ et $\rho^* = \rho$.

Source: authors.

The results of the Wald test (see Table 5) show that parameter constancy or zero linearity for the speed of the adjustment parameter is largely rejected for the Cameroonian economy. Moreover, the null hypothesis of parameter constancy across quantiles for the long-run integration parameter β_{MAP} shows a significant Wald test value.

This would claim that the parameter cointegration between tax revenue and rainfall is dynamic across different quantiles for the Cameroonian economy. Furthermore, the results in Table 4 also predict that the null of parameter constancy across the relevant quantiles β_{AGRI} is accepted. The estimated parameters are significant for all quantiles.

Table [5] : Wald test

Quantiles	Parameter values
ρ_*	16.38*** [0.000]
β_{MAP}	12.65*** [0.000]
β_{AGRI}	29.63*** [0.000]
φ_1	11.86***[0.000]
ω_1	1.34 [0.260]
θ_1	3.00** [0.0112]

Notes: probabilities are in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% thresholds respectively.

Source: authors from stata.

If we consider temperatures as a measure of climate change (see table [6]), the estimates obtained are in line with those in table [4]. Thus, the analysis made for precipitation is more or less the same as that made for temperature.

Table [6]: Results of OLS estimates and ARDL quantile regressions with the temperature indicator

Result of the MCO estimate							
α_*	ρ_*	β_{MAT}	β_{AGRI}	φ_1	ω_1	θ_1	
7.612	-0.319	**-2.065***	-0.120	0.037	-0.829	0.110	
(5.934)	(0.136)	**(1.972)**	(0.108)	(0.185)	(1.372)	(0.229)	
Result of the ARDL Quantile estimate							
(τ)	$\alpha_*(\tau)$	$\rho_*(\tau)$	$\beta_{MAT}(\tau)$	$\beta_{AGRI}(\tau)$	$\varphi_1(\tau)$	$\omega_1(\tau)$	$\theta_1(\tau)$
0.05	6.915	-0.674*	-1.410	-0.313	0.041	-0.241	0.383
	(8.796)	(0.358)	(2.696)	(0.226)	(0.325)	(1.963)	(0.979)
0.10	9.581	-0.520	-2.373	-0.353*	0.097	-0.772	0.353
	(7.987)	(0.378)	(2.516)	(0.191)	(0.324)	(2.019)	(0.970)
0.20	10.555*	-0.529	-2.636	-0.401**	0.074	-0.986	0.350
	(6.114)	(0.371)	(1.927)	(0.195)	(0.283)	(1.610)	(0.913)
0.30	9.898	-0.447	-2.617	-0.252	0.108	-0.548	-0.874
	(5.976)	(0.374)	(1.879)	(0.198)	(0.257)	(1.733)	(0.906)
0.40	8.858	-0.418	-2.334	-0.211	0.110	-0.548	-0.874
	(5.797)	(0.366)	(1.928)	(0.212)	(0.198)	(1.733)	(0.906)
0.50	9.269*	-0.382	-2.511	-0.197	0.127	-0.630	-0.957
	(5.208)	(0.285)	(1.757)	(0.222)	(0.235)	(1.348)	(0.976)
0.6	10.559**	-0.458	-2.908	-0.144	0.103	-1.184	-1.061
	(4.850)	(0.273)	(1.715)	(0.211)	(0.288)	(1.245)	(0.835)
0.7	13.090***	-0.530*	**-3.669****	-0.136	0.072	-2.216	-1.057
	(4.039)	(0.260)	**(1.371)**	(0.204)	(0.290)	(1.535)	(0.942)
0.8	16.496***	-0.584***	**-4.675*****	-0.192	-0.003	-2.292	-1.436*
	(4.709)	(0.235)	**(1.611)**	(0.157)	(0.263)	(1.752)	(0.780)
0.9	19.155***	-0.620***	**-5.507*****	-0.190	-0.058	-2.175	-1.957***
	(4.023)	(0 .197)	**(1.344)**	(0.147)	(0.249)	(1.471)	(0.598)
0.95	13.833***	-0.505**	**-3.946*****	-0.097	-0.158	-1.450	-1.620**
	(3.928)	(0.192)	**(1.321)**	(0.149)	(0.252)	(1.492)	(0.596)

Notes: Standard errors are in brackets. ***, ** and * indicate significance at 1%, 5% and 10% respectively. The lags p and q in equation [6] are selected using the information criterion of Schwarz, p = 6 ; q = 1. $\alpha^* = \alpha$ et $\rho^* = \rho$.

Source: authors.

Similarly, the results of the Wald test in table [6] are in line with those obtained in table [4]. The analyses carried out in this respect are the same as those above.

Tableau [4] : Test de Wald

Quantiles	Valeurs des paramètres
ρ_*	206.31*** [0.000]
β_{MAT}	10.27*** [0.000]
β_{AGRI}	11.48*** [0.000]
φ_1	426.18*** [0.000]
ω_1	9.29*** [0.000]
θ_1	21.18** [0.0112]

Notes: probabilities are in brackets. ***, ** and * indicate significance at the 1%, 5% and 10% thresholds respectively.

Source: authors from stata.

Conclusion and policy implications

This study has given a new direction to the development process of the Cameroonian economy. We use the QARDL cointegration model to assess the long-term relationship between climate change and tax revenues over the period 1980-2015. The model estimates lead to important results in the presence of short- and long-term dynamic impacts between different measures of climate change (temperature and rainfall), agriculture and tax revenues. We find a negative and significant association between the various climate change measures and tax revenues at the higher quantiles. Similarly, the results show a negative and significant association between agriculture and tax revenues at certain quantiles. In addition, the Wald test validates the asymmetric cointegration of the short- and long-term relationship between variables at different quantiles.

In addition, the summary of this study supports the guidelines needed by the State authorities to improve economic policies. More specifically, the research results provide the tools needed to combat climate change and low tax revenues. In this way, the Cameroonian government can achieve its Millennium Development Goals by modernising tax structures and controlling human actions to combat climate change. In addition, the Cameroonian government must promote new green technologies, while educating the population on the need to combat climate change and involving them in the mobilisation of tax revenues. Then, fiscal and environmental policies must be improved to encourage national and international investors to participate in the country's development. In addition, the study suggests that a significant increase in the tax revenue collected, without a major negative reaction from taxpayers, can easily be achieved by the public authority.

Finally, our study does not take into account the different components of tax revenue in the analysis. In addition, a study of the countries of the Gulf of Guinea is necessary, as this area represents the world's second largest forest reserve after the Amazonia. In the same vein, a comparative analysis of the effects of climate change on tax revenues depending on the zone is important.

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