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Tax Revenues, Corruption and the Shadow Economy in Algeria: Using Asymmetric and Nonlinear Approach

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Abstract: This study examines the relationship between tax revenues, corruption, and the shadow economy, and analyzes the asymmetric impact of the GDPR on tax revenues in Algeria over the 1996Q12020Q4 period. The Z-A test and L-S test are used to test the stationarity of series. The approach also uses a non-linear model (NARDL). The results confirm that positive (negative) shocks to the GDPR have a significant (positive) negative impact on tax revenue performance. The effect is symmetrical in the short term. These results can be explained by the nature of the structure of the rental economy in Algeria. Moreover, the results of the study show that corruption negatively affects the performance of tax revenues in Algeria.

Keywords: Tax revenue; Shadow economy; Political variables; Non-linear modeling; Asymmetry.
Jel Classification Codes: O17, H20, E26, C22, C5.

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1. INTRODUCTION

In addition to efforts to fulfill its functions, through public spending in various areas such as education, health care, higher education, and others; and finance some investments, for example in the infrastructure sector, governments have a responsibility to mobilize all of their financial resources, especially those that come from taxes or tax revenues, which are considered the main and constant source of the government budget. As a petroleum country, Algeria must distinguish between two forms of tax revenues: first, ordinary tax revenues; second, oil tax revenues; The latter account for 41.93% of total tax revenue and 34.98% of total government revenues in the state budget of Algeria for the financial year 2020 and is expected to account for 37.43% of total government revenues by 2021(Finance Law 2020, 2019). The Algerian government is dissatisfied with its budget's dependence on oil tax revenues and is trying to increase its dependence on regular tax revenues to reduce its dependence on oil tax revenues, but these efforts, according to the authors, are faced with an expanding shadow economy. The size of Algeria's shadow economy as a percentage of GDP ranges from 22.96% in 2004 to 43.82% in 2011, with an average of 31.30% for the period 1999-2013. The shadow economy has received more attention from researchers since the publication of the ILO report in 1972, and from policymakers after the publication of Guttman's paper, which estimated the US subterranean economy at about 10% of GDP in 1976 (Gutmann, 1977), which was a surprise to the political class in the United States about the shadow economy's size. It has taken this attention also due to its sizable magnitude over the world, some studies estimated its size about One-third of the global GDP, and its size has sometimes exceeded 70% of the GDP (Bolivia in 2001) (Leandro & Friedrich, 2018), and

it gives an income opportunity for about 70% of the international workforce (Norman, 2016).

Several factors influence the shadow economy's size such as tax, the indirect tax is contributed in 24.3% of the shadow economy in France and 27.2% in Australia over the period 1998-2009. (Friedrich & Buehn, 2013); Moreover, the intensity of regulation is an important factor affecting the size of the shadow economy, according to (Enste, 2018), it affects the size of the shadow economy from 10% to 15%; Another important factor, the unemployment rate, which accounts for 11.8% of Australia's shadow economy (Colin C & Friedrich, 2016), (Simon, Danie, & Pablo, 1998), suggests that a smaller shadow economy is associated with lower regulation intensity; In addition, economic freedom is an important factor contributing to the expansion or decline of the shadow economy (Aziz, James, & Friedrich, 2018), concluding that economic freedom is a factor influencing the size of the shadow economy. there are economic factors, and non-economic influences such as corruption (Baklouti & Boujelbene, 2019), good governance and quality of institutions, people's trust in government institutions and agencies (Sofie & Marc, 2011)..., economic consequences have economic consequences. and non-economic impacts; The most important effect is the impact on tax revenues. A large number of studies have concluded the terrible impact of the shadow economy on tax revenues. Previous studies on estimating the size of the shadow economy using macroeconomic approaches have shown large tax revenue losses due to the shadow economy, for example (Gutmann, 1977), (Feige, 1979), (Tanzi, 1983) in the United States. In the States, the model evaluated by (Simon, Danie, & Pablo, 1998) was used to examine the relationship between the informal economy and tax revenues, and countries with smaller informal economies were found to have higher tax revenues; also (Friedrich & Colin, The Shadow Economy., 2013) argues that the large size of the informal economy can reduce tax revenues; (Ummad & Pierre-Guillaume, 2017) have shown that the size of the shadow economy has a significant negative impact on tax revenue. In addition to affecting tax revenues, the shadow economy can harm competition in the economy due to low product prices. and services in the informal economy, based on an online survey (Mróz, 2016) showing that people prefer to buy informal products due to lower prices. Another harm is the distortion that the shadow economy leaves in economic and social data, such as inflation, unemployment rate, money velocity ... Some researchers believe that the black economy has a negative impact on political and social life. (Jean, Michael, & Abhinay, 1999) have shown that the informal economy and tax evasion are associated with corruption. Other researchers argue that the shadow economy not only threatens the quality of institutions but can also threaten democracy (Dominik H, 2002) and national security (Olexander, Inna, & Oleksey, 2018). Socially, some researchers support the positive impact of the black economy, as it provides income opportunities for people on a large scale (Schneider & Enste, 2003), but others believe it can damage social stability due to some of the phenomena associated with it. such as crime (Bojan & Boštjan, 2016). The rest of the article is organized as follows: Part 2 is devoted to a literature review; in part 3 we discuss the structure and size of the shadow economy and its relationship to tax collection trends in Algeria, in section 4 the data and estimation methods are presented, in section 5 the most important part is devoted to presenting and discussing the results of the experiments.

Finally, Section 6 presents the conclusions and policy implications.

2. Literature review

Among the European Union countries, the Romanian economy is characterized by an increase in size Informal economy and tax evasion due to differences in race and religion The Roman people, as well as the impact of the 2008 global crisis, So a paper for each of Dell'Anno, R., & Davidescu, A. A. (2019) aimed at contributing to the estimation the rate of tax evasion and the size of the informal economy in Romina using quarterly data for the period 1999-2017, Where the methodology of Multiple Indicator Multiple Cause (MIMIC) was used with the aim of measuring the value of the informal economy as a percentage of the GDP, and the use of the currency demand approach in order to estimate the size of tax evasion, The results of the study showed that high values of tax evasion are due to the fact that the institutional framework is characterized by instability and poor quality of the legal framework, an inefficient and unfair tax system, meaning that tax evasion is the result of low income and high taxes, While the most important cause of the informal economy is the unemployment rate, the self-employment rate, capital taxes, indirect taxes and the weak effectiveness of the government (the quality of public services). Moreover, there is also an inverse relationship between the informal economy and tax evasion, especially after the beginning of the Great Recession in 2008, as they are characterized by their high values for example; in 2012, the informal economy recorded 48.5%, while tax evasion was recorded in the same year 30.2% (Dell'Anno & Davidescu , 2019).

Due to the high size of the informal economy in some developing countries in Asia, a research paper by Huynh, C. M., & Nguyen, T. L. (2020) comes to measure the impact of taxes, government spending, and corruption on the development of the informal economy in 24 Asian countries using the Panel method for the period 2002-2015, and the use the methodology of Multiple Indicator Multiple Cause (MIMIC) to estimate the size of the informal economy, in addition to feasible generalized least squares (FGLS) and two-step generalized method of moments (SGMM). The researchers found several results, the most important of which were the positive effects of taxes (direct and indirect) and corruption on the size of the shadow economy due to corruption and burden. Taxes increase the size of the informal economy. is a negative impact of government spending on the size of the shadow economy, since government spending can reduce the size of the informal economy due to its contribution to economic growth. In addition to taxes (direct and indirect) and government spending, corruption has a profound effect on the shadow economy, as the size of the informal economy can be controlled using broad fiscal policy instruments, finding the right mix of direct and indirect taxes (tax cuts) and government spending (increasing taxes) on control conditions and corruption (Huynh & Nguyen, 2019).

Corruption remains an important impediment to growth in many developing countries, limiting fiscal capacity to generate sufficient resources as development economies require financing to cover development costs, in this case Tido Boone, A., Dell'Anno, R., and Schneider, F. (2018) analyze the impact of economic and political variables affecting tax collection in the BRICS countries (Brazil, Russia, India, China and South Africa) over the

period 1996-2017 using conventional least squares (FMOLS), the explanatory variables were reversed to investigate long-term effects. The results show that economic development, open trade and the fight against corruption are factors that improve the income of the BRICS, while the agricultural sector impedes the realization of tax revenues. Even so, the size of the shadow economy in the BRICS undermines the production impact of fighting corruption and improving the income-generating economy. Based on the results obtained, it is recommended to control corruption. Reasonable tax administration, increased penalties for tax violators, and legitimate shareholder monitoring will be beneficial for capacity building and tax collection; In addition, the BRICS countries should focus on monitoring the agricultural sector and try to formalize it to generate additional income (Buehn, Dell'Anno, & Schneider, 2018).

As the Algerian case, the Nigerian economy is characterized by the dependent on oil rent, the high size of the shadow economy, and the bad ranking by transparency international. The paper of Omodero, C. O. (2019) is aimed to explore shadow economy and corruption's effect on tax revenue in Nigeria, by using the Ordinary Least Squares method (OLS method) to estimate a model that allows the examination of nexus among the three latter variables. The researcher was based on annual data covering the period 1996-2018, and he concluded that the shadow economy and corruption have negatively affected tax revenues in Nigeria, with a stronger effect of corruption on tax revenue. The author recommended that the government address the causes of the shadow economy (unemployment, tax burden ...) to reduce its size and that the government should fight corruption to gain the confidence of the public, especially taxpayers (Omodero, 2019).

Several papers study the interaction effect among growth, inflation, and the shadow economy, but Baklouti, N., & Boujelbene, Y. (2019) papers studied that firstly in global and secondly with the distinction between developing and developed countries. Researchers studied the relationship between economic growth, inflation and, the shadow economy, by exploring the causal relationship between them. They selected a sample of 47 countries, 33 developed countries (OECD countries) and 14 developing countries (MINA countries). They used the Seemingly Unrelated Regressions method (SUR method), in addition to the Dynamic Simultaneous-Equation models by using the Three-Stage Least Square method to estimate three models. For the entire sample, the pilot study concluded: First, economic growth was negatively affected by inflation and the shadow economy. Second, inflation was positively affected by the shadow economy, and negatively affected by economic growth. Third, the shadow economy has been positively affected by inflation and negatively affected by economic growth. The most interesting result is the different interaction effect noticed between the three variables among developed and developing countries, whereas in the case of developing countries, economic growth had a positive effect on inflation and shadow economy, but it was not significant effect; and an insignificant negative impact of the shadow economy on inflation in the case of developed countries. Researchers attributed this difference to political instability, which is an influential factor that helps spread the

underground economy in developing countries and hurts tax revenues (Baklouti & Boujelbene, 2019).

3. RESULTS AND DISCUSSION

3.1. Data description and model specification

This article uses quarterly time series data for the period 1996-2020 In Algeria. The data for this study was obtained from several sources. Fiscal Revenue (TR) as a percentage of GDP, Real Gross Domestic Product (RGDP) at constant prices derived from the World Development Index (WDI) database. One of the political variables represented in the control variable for corruption is also used and expressed as CC. This policy variable is derived from the World Governance Index (WGI) and ranges from -2.5 to 2.5; A positive value for this variable indicates a high degree of control over corruption, while a negative value indicates a very low level of control over corruption (Neog & Gaur, 2021). It reflects the size of the shadow economy in Algeria and is taken from the Medina and Schneider (2018) database. Due to the small sample size, we decided to convert the time series from annual to quarterly. series by the quadratic method (100 observations). In studying the relationship between corruption, tax collection, and the shadow economy, we draw on the theoretical foundations developed by Neog Y. and Gaur A. (2021). The equation can be formulated as follows:

$$TR_t = a + b_1\, RGDP_t + b_2\, Corru_t + b_3\, SE_t \qquad (1)$$

3.2. Methodology: The NARDL cointegration model developed by Shin et all (2014)

In this study, we employ the standard linear ARDL (Pesaran and Shin, 1999; Pesaran et al., 2001) and the nonlinear ARDL (Shin et al., 2014) cointegration methodologies. with four variables series. We will focus more on the nonlinear model which allows predicting asymmetries in the short and long run. Clive W.J. Granger (2002) introduced the concept of "Hidden Cointegration" and explained that the long-run relationship among the purposed variables could be established from their positive and negative components.

The asymmetric cointegrating regression model (NARDL) of Shin et al is as follows (Shin, Yu, & Greenwo, 2014):

$$TR_t = \theta + \theta^+\, RGDP_t^+ + \theta^-\, RGDP_t^- + \mu_t \qquad (2)$$

Where μ_t is a stationary zero-mean error process that represents deviations from the long-run equilibrium, θ^+, and θ^- are the associated asymmetric long-run parameters and x_t is the vector of regressors decomposed as (Shahzad, Nor, Ferrer, & Hammoudeh, 2017):

$$RGDP_t = RGDP_0 + RGDP_t^+ + RGDP_t^- \qquad (3)$$

where $RGDP_0$ is an arbitrary initial value and $RGDP_t^+$ and $RGDP_t^-$ denote partial sum processes which accumulate positive and negative changes in x_0, respectively, and are defined in the equation as follows (Driouche, Manel, Moussa, & Mohamed, 2020):

$$RGDP_t^+ = \sum_{j=1}^{t} \Delta\, RGDP_j^+ = \sum_{j=1}^{t} \max(\Delta\, RGDP_j\,, 0) \qquad (4)$$

$$RGDP_t^- = \sum_{j=1}^{t} \Delta RGDP_j^- = \sum_{j=1}^{t} \min(\Delta RGDP_j, 0) \qquad (5)$$

Shin et al. (2014) extend the symmetric ARDL bounds testing developed by Pesaran et al. (2001) to investigate the joint issues of nonlinearity and asymmetric effects using the partial sum decompositions specified in equations (4) and (5) (Kumar, Kumar, Kumar, & Stauvermann, 2020). By integrating Equation (2) with the linear ARDL specification, the following asymmetric error correction model can be applied:

$$\begin{aligned}\Delta TR_t = a_0 &+ \partial TR_{t-1} + \theta^+ RGDP^+_{t-1} + \theta^- RGDP^-_{t-1} + \gamma\, Corru_{t-1} + \delta\, SE_{t-1} \\ &+ \sum_{j=1}^{p} \lambda_j \Delta TR_{t-j} + \sum_{j=1}^{q} \eta_j \Delta Corru_{t-j} + \sum_{j=1}^{q} \kappa_j \Delta SE_{t-j} \\ &+ \sum_{j=0}^{q} \left(\pi_j^+ \Delta RGDP^+_{t-j} + \pi_{j-}^- \Delta RGDP^-_{t-j}\right) + D_t + u_t \qquad (6)\end{aligned}$$

Δ is the first difference operator and u_t is white noise. In Equation (6), λ , η, κ, π^+, π^+ denote short-run coefficients, while ∂ , θ^+, θ^-, γ, δ denote long-run coefficients. Dt is a dummy variable that is employed to apprehend the impact of the structural break date (t), which is determined by Zivot and Andrews (1992) unit root tests. Previous to proceeding with the results of NARDL and ARDL, certain pre-tests are needed. The order of integration has to be I (0), I (1) for applying the NARDL model; therefore, the order of integration of these series must be checked. We recollect that a short-run analysis is considered to assess the immediate impacts of external variables changes on the dependent variable. seen against, a long-run analysis is used to compute the reaction time and speed of the adjustment towards an equilibrium level (Shahbaz, Hoang, Mahalik, & Roubaud, 2017).

In the NARDL model, short-run and long-run symmetrical or asymmetrical cointegrating relationship between Corruption, Tax Revenues, and the Shadow Economy in Algeria, can be confirmed if the value of F statistics is greater than upper bound and lower-bound critical value, therefore, its implementation is similar to ARDL model. But, NARDL is having the ability to break down every independent variable into its partial sums of positive and negative shocks as we mentioned earlier (Tabash, Sheikh, & Asad, 2020). This statistic (F statistics) refers to the joint null hypothesis of no co-integration $H_0: \rho = \theta^+ = \theta^- = 0$ against the alternative of cointegration $H_0: \rho \neq \theta^+ \neq \theta^- \neq 0$ in equation (6).

Next, the existence of long-run and short-run asymmetries is discovered by using the Wald tests; we investigate for long-run symmetry as follows: $H_0: \theta^+ = \theta^-$ and also short run asymmetrical relation is estimated: $H_0: \sum_{j=0}^{q-1} \pi_j^+ = \sum_{j=0}^{q-1} \pi_j^-$ (Shahbaz, Shahzad, Alam, & Apergis, 2018).

Finally, the asymmetric cumulative dynamic multiplier effect of a unit changes $RGDP^+_t$ and $RGDP^-_t$ on TR_t is investigated as (Shahzad, Nor, Ferrer, & Hammoudeh, 2017):

$$m_h^+ = \sum_{i=0}^{h} \frac{\partial TR_{t+i}}{\partial RGDP_t^+} \quad , \quad m_h^- = \sum_{i=0}^{h} \frac{\partial TR_{t+i}}{\partial RGDP_t^-} \quad , \quad h = 0, 1, 2, \dots \qquad (7)$$

$h \to \infty$ so $m_h^+ \to \beta^+$ et $m_h^- \to \beta^-$, β^+ et β^- are the positive and negative asymmetric coefficients in the long-term; respectively, where $\beta^+ = -\theta^+/\partial$ and $\beta^- = -\theta^-/\partial$. Examining the adjustment path and duration of disequilibrium, specify a positive or negative shock, gives useful information about the long and short-run patterns of asymmetric adjustment.

3.3. Descriptive statistics and correlation matrix

A summary of descriptive statistics and correlation matrix of some variables appears in Table 01:

Table 1. Descriptive statistics and correlation matrix

Variable	Panel A: Descriptive statistics						
	Mean	**Max.**	**Min.**	**Std. Dev.**	**Skew.**	**Kurt.**	**J-B stats**
TR_t	13.66	20.89	9.45	2.93	0.81	3.18	11.28 (0.003)
$RGDP_t$	2.95	7.42	-9.05	2.43	-1.81	10.02	260.03 (0.000)
$Corru_t$	-0.65	-0.46	-0.94	0.14	-0.94	2.67	15.16 (0.0005)
SE_t	34.22	47.71	24.21	5.36	0.19	2.69	1.01 ∗ (0.606)

	Panel B: Correlation matrix			
	TR_t	$RGDP_t$	$Corru_t$	SE_t
TR_t	1.00	---	---	---
$RGDP_t$	-0.22 (0.0277)	1.00	---	---
$Corru_t$	-0.008 (0.93)	-0.22 (0.02)	1.00	---
SE_t	0.22 (0.02)	-0.32 (0.001)	-0.17 (0.07)	1.00

Note: This table reports the main descriptive statistics, including the mean, maximum, minimum, standard deviation, skewness, kurtosis, and Jarque-Bera test statistics of the variables.

The table shows the descriptive and correlation analysis for some variables in the Algerian economy. In this study, four variables were used. To test for normal distribution, the study adopted the Jarque Bera test statistic. The Jarque–Bera test shows that there is an issue of non-normality in some series. Such scenarios require the utilization of asymmetric techniques as employed in this research work (Shahbaz, Hoang, Mahalik, & Roubaud, 2017). We can see that the correlation values are less than 0.3. All the P-values in the Five diagnostic tests above are insignificance just one is insignificance.

3.4. Unit root test with structural break: Z-A tests, L-S test

Classical stationarity tests such as ADF or PP can deceptively prove that variables must be integrated of the first order or second order when there are one or more breaks in the series (Ullah , Zhao , Kamal , & Zheng, 2020). First, in the study, the Zivot and Andrews (1992) unit root tests and Lee Strazicich LM unit root test results were conducted on the sample to confirm the orders of integration of the variables analyzed.

Table 2. Zivot and Andrews test for unit roots with one structural break

Variables	Level			First Difference		
	A	**B**	**C**	**A**	**B**	**C**
TR_t	-3.41 (4)	-2.26 (4)	-2.67 (4)	-3.83 (4)	-3.86 (-4)	-4.72 (4)
TB	2014.Q2	2005.Q2	2004.Q2	2017.Q1	2016.Q2	2014.Q2

$RGDP_t$	0.40 (4)	-1.18 (4)	-1.30 (4)	-4.26 (4)	-4.88 (4) *	-4.92 (4) ***
TB	2017.Q1	2017.Q2	2017.Q2	2009.Q2	2017.Q1	2017.Q1
$Corru_t$	-4.91 (4) ***	-4.20 (4) ***	-3.86 (04)	---	-4.52 (4) **	-5.55 (4)
TB	2002.Q4	2005.Q3	2004.Q2	---	2001.Q3	2005.Q2
SE_t	-2.74 (4)	-2.68 (4)	-3.25 (4)	-4.40 (4)	-3.71 (4)	-4.38 (4)
TB	2002.Q1	2003.Q3	2007.Q2	2011.Q2	2017.Q1	2011.Q2

Note: **TB** is the time of the break, **( )**, *, ** and *** Indicate that the unit-root hypothesis is rejected at the 10%, 5%, and 1% levels, respectively

Table 2. provides the Zivot-Andrews (1992) unit root test with a single structural break. Through the results, we note that some of the series are stationed after the first difference $(\mathrm{RGDP_t}, \mathrm{Corru_t})$, while others did not stationary even after taking the first difference $(\mathrm{TR_t}, \mathrm{SE_t})$. For this reason, we relied on another most advanced test, which is the test presented in the following table.

Table 3. Lee Strazicich LM unit root test with two structural breaks

Variables	**Level**	**First Difference**	**I(..)**
	A	**A**	
$\boldsymbol{TR_t}$	-5.88 (6)	-6.34 (7) **	**I(1)**
TB_1	2004.Q3	1999.Q3	
TB_2	2015.Q3	2017.Q4	
$\boldsymbol{RGDP}$	-4.27 (5)	-6.25 (7) **	**I(1)**
TB_1	2000.Q1	2000.Q4	
TB_2	2017.Q2	2017.Q4	
$\boldsymbol{Corru_t}$	-5.35 (6)	-5.48 (7) ***	**I(1)**
TB_1	2004.Q1	2001.Q3	
TB_2	2014.Q3	2005.Q4	
$\boldsymbol{SE_t}$	-5.82 (7)	-6.92 (7)	**I(1)**
TB_1	2003.Q3	2010.Q3	
TB_2	2011.Q3	2014.Q1	

Note: TB is the time of the break, **( )**: is the optimal lag length, **A**: Model Break (C) , *, ** and *** Indicate that the unit-root hypothesis is rejected at the 10%, 5%, and 1% levels, respectively.

Table 3. presents the Lee and Strazicich (2004) unit root tests with two structural breaks. The results of this test confirm that all the variables are non-stationary in the level, but stationary in the first difference. These findings do not create any problem in the implementation of the NARDL approach since this approach allows the inclusion in the long-run equilibrium relationship of variables with the same orders of integration (I(1)). The existence of several structural breaks in the time series data offers an early indication of a time series asymmetric behavior over time, and hence the possibility of asymmetric short- and long-run relationships between the variables (Shahzad, Nor, Ferrer, & Hammoudeh, 2017).

Lee and Strazicich's (2003) test find significant breaks as 2004Q3 and 2015Q3 for the Tax revenue (TR). The breaks generally represent the positive short-run effects especially with the beginning of the recovery of oil prices, the improvement of the State's hard currency revenues, and the start of the implementation of a set of economic programs (economic recovery, support, and promotion of economic growth). As for the period, 2015Q3 reflects the period following the 2014 crisis and the emergence of the effects of the fall in oil prices on public revenues, which affected all macroeconomic indicators. We include these breaks in the NARDL lag estimate model (Rezitis, 2019).

3.5. NARDL models for Short and Long-run analysis

3.5.1. The BDS test for nonlinearity

The appositeness of the linear or nonlinear ARDL model is furthermore established by the BDS testing approach (Brooks, 1996; Kim et al., 2003). BDS test is employed by several research articles to confirm that whether the time series data are identically distributed and independent (Tabash, Sheikh, & Asad, 2020). This section deals with testing for nonlinearity within time series by using this test of nonlinearity as follows:

Table 4. The BDS test for nonlinearity

Variables	Dimensions				
	m = 2	**m = 3**	**m = 4**	**m = 5**	**m = 6**
TR_t	0.176	0.289	0.358	0.396	0.213
$RGDP_t$	0.141	0.215	0.252	0.267	0.283
$Corru_t$	0.185	0.311	0.393	0.444	0.473
SE_t	0.141	0.227	0.278	0.306	0.319

*, ** and *** indicate the significance at 10%, 5%, and 1% level of significance, respectively.

The BDS test findings of the variables applied in this study are offered, in Table 4. which indicates that the calculated BDS test statistics for each variable is significant at 1 % level as the corresponding p-value. Table 4. confirms that the NARDL model is an appropriate choice for estimating these models. The null hypothesis of the BDS test is rejected for tax revenue, real gross domestic product, corruption control, and shadow economy which confirms the evidence of nonlinearity within time-series data (Brock et al., 1996). The null hypothesis is rejected as the value of BDS test statistics is greater than critical values.

3.5.2. Results of asymmetric cointegration

We proceed to investigate the cointegrating relationship using the symmetric and asymmetric bounds test which is shown in the following table:

Table 5. Asymmetric/symmetric bounds test with structural breaks

Test	**Model 1:** $TR_t = f(RGDP_t, Corru_t, SE_t)$	
	Model symmetric: ARDL	**Model asymmetric: NARDL**
F_{PSS}	1.39	6.71 *
t_{BDM}	-2.23	-5.49 *
Decision	No Cointegration	Cointegration
Test	**Model 2:** $TR_t = f(RGDP_t, Corru_t, SE_t, D_1, D_2)$	
	Model symmetric: ARDL	**Model asymmetric: NARDL**
F_{PSS}	2.89	6.41 **
t_{BDM}	---	-5.30 **
Decision	No Cointegration	Cointegration

Note: F_{PSS} shows the statistics from the Pesaran et al. (2001) bounds test. T_{BDM} shows the statistics from Banerjee et al. (1998).

Table 5. explain the bounds test for both linear and non-linear co-integration with F_{PSS} and t_{BDM}. The findings of the symmetric co-integration test (ARDL) in two models show that the values of the test statistics (F_{PSS} and $t_{BDM)}$ are less than the minimum critical value of the bounds calculated by Pesaran et al. (2001) at a 5% level of significance. Therefore, the null hypothesis of no cointegration between the variables is accepted, this means, the absence of a long-term relationship between them (for linear models).

While, the results of the asymmetric cointegration test (NARDL models) indicate that the values of the test statistics (F_{PSS} and t_{BDM}) exceed the upper critical value of the bounds calculated by Pesaran et al. (2001) at 1% and 5% levels of significance, sequentially. Therefore, the alternative hypothesis of cointegration between the variables is accepted, suggesting that a valid long-run relationship (cointegration) exists between all these variables.

3.5.3. Results of Tests for long and short-run asymmetry

The NARDL (Shin et al. 2014) results are shown in Table 6:

Table 6. The results of NARDL estimation

ECM form with Δ TR$_t$ as an Endogenous Variable		
Variables	**Model 1**	**Model 2**
	Coefficient	**Coefficient**
Panel A : Short run		
C	3.376 *	3.771 *
$Trend$	0.085 *	0.081 *
$\Delta TR_t(-1)$	0.601 *	0.609 *
$\Delta TR_t(-2)$	0.378 *	0.387 *
$\Delta TR_t(-3)$	0.165 ***	0.171 ***
$\Delta TR_t(-4)$	-0.446 *	-0.447 *
$\Delta TR_t(-5)$	0.368 *	0.367 *
$\Delta TR_t(-6)$	0.242 **	0.249 **
$\Delta RGDP_t^+$	-0.131	-0.124
$\Delta RGDP_t^-$	-0.043	-0.013
ΔSE_t	-0.013	-0.009
$D_{2004.Q3}$	---	-0.139
$D_{2015.Q3}$	---	-0.213
ECT_{t-1}	-0.241 *	-0.257 *
R^2	0.68	0.68
R^2 Ajusted	0.64	0.63
Panel B: Long run model		
$RGDP_t^+$	-0.72 *	-0.61 *
$RGDP_t^-$	0.66 *	0.60 *
$Corru_t$	0.08 **	2.08
SE_t	- 1.16 *	0.07 **
Panel C: Symmetry tests		
W_{LR}	35.008 * (0.000)	17.61 * (0.001)
Conclusion	Asymmetry	Asymmetry
W_{SR}	0.35 (0.55)	0.52 (0.47)
Conclusion	Symmetry	Symmetry
Panel D: Diagnostics tests of the estimated model		
LM test	$x_{SC}^2 =$ 2.66 (0.26)	$x_{SC}^2 =$ 3.80 (0.14)
ARCH	$x_{FF}^2 =$ 1.05 (0.59)	$x_{FF}^2 =$ 1.07 (0.58)
Nor- test	$JB =$ 34.35 (0.00)	$JB =$ 33.22 (0.00)
Ramsey RESET	$F =$ 4.08 (0.14)	$F =$ 3.95(0.21)
CUSUM	Stable	Stable
CUSUM squares	Stable	Stable

Notes: *, ** and *** indicate the significant at 10%, 5% and 1% level of significance, respectively.

After finding the presence of long-run asymmetric cointegration in our study, and results are announced in Table 6. In Model 1, real gross domestic product (RGDP), control of corruption (Corru), and shadow economy (SE) are statistically significant. But in Model 2, after introducing the structural breaks in the estimation of this model, it appeared that the corruption variable was not significant. We note that the level of positive shock of real GDP is negative and statistically significant in model 1. As for the negative shock in real GDP, it is statistically significant and positive, as it contributes to raising tax revenues. The negative result for the positive shock and positive findings for negative shock can be explained by the nature of the structure of the Algerian economy. Which depends on its exports of oil. Since oil revenues represent about 45% of real GDP, the rise in the prices of the latter (a positive shock) contributes to the increase in oil tax revenues on the one hand, and on the other hand, we notice a decline in regular taxes. But the results were very weak. In Model 1, we notice that the effect of corruption control is positive and significant, but very small. Whereas in model 2 the result is insignificant. As is known, the size of the shadow economy restricts the government from collecting taxes and controlling corruption. On the other hand, the large size of the shadow economy can help reduce tax revenue, which was observed in Model 1, where the result was negative and statistically significant. The results in the short term are not much different from the results in the long term.

In Table 6. (Panel C), W_{LR} indicates the Wald test statistic for long-run symmetry, and W_{SR} indicates the Wald test statistic for short-run symmetry. For model 1. The null hypothesis for long-run symmetries (WLR=35.008 * (0.000)) is rejected in favor of long-run asymmetries. An RGDP variation has then a long-run asymmetric effect on tax revenue and the result is significant at 1%. The same for model 2, the null hypothesis of symmetries was rejected in the long and short-run (WLR=17.61 * (0.001)).

To test the short-run asymmetry, from model 1 the Wald statistic W_{SR} is equal to 0.35 and which corresponds to the probability of 0.55; hence, this probability is greater than 0.01. Thus, the null hypothesis of symmetry is accepted and the effect of RGDP shocks on tax revenue is symmetric in the short term. The findings of the Wald test in the model 2 reveal the same conclusions of model 1, where the symmetric effect exists in the short-run.

From Panel D of Table 6. we investigate the effect of autocorrelation using the LM test as we find the models don't suffer from autocorrelation in two models, we continue our diagnostic by addressing the heteroscedasticity problem using (ARCH test) when the residual diagnostic test is confirmed that these two models were had no problem of heteroscedasticity. The residuals of these models are not normally distributed (Normality test of JB). For stability we show that the CUSUM and CUSUMSQ plot is within the 95% confidence level, signifying the stability of the estimated models. Consequently, the two models are reliable for decision-making and forecasting.

The coefficients of "Error Correction Mechanism" (ECM) in both models are -0.241 and -0.257 respectively and are very significant, which point out that tax revenue adjusts to its equilibrium with a speed of 24.1% and 25.7% in one quarter and the presence of other

mentioned variables. in other words, it takes almost one year (1/0.241 = 4.14 quarters; 1/0.257= 3.89 quarters) to eliminate the disequilibria.

4. CONCLUSION

This study aimed to investigate the long-run relationship between tax revenue performance, corruption, and shadow economy in Algeria covers the time of 1996–2020. As a first stage, we tested the stationary of time series using fairly recent unit roots tests with structural breaks in these series. We utilized two tests: Zivot and Andrew (1992) test and Lee Strazicich LM test (2003). Developed unit root tests suggest that all the variables contain unit root at level format and become stationary at first difference.

To examine the linear dependence, we applied the BDS nonlinearity test. This test rejects the null hypothesis of independent and identically distributed residuals across various dimensions. Our findings are commensurate with the BDS test with the test of Shin et al. Employing the nonlinear ARDL (NARDL) of Shin et al we confirm the asymmetric cointegration between TR, RGDP, Corru, and SE in the two models. From it, we conclude that are the relationship between all variables is asymmetric in the long-run. Concerning real GDP, its effect was the opposite of what was expected, and it had a long-term asymmetric effect on tax revenues. We note that the effects of shock positive of real GDP are negative, as, for the negative shock in real GDP, it is positive as it contributes to raising tax revenues. these results can be explained by the nature of the structure of the Algerian rentier economy. Also, the results of the study revealed that corruption negatively affects the performance of tax revenues in Algeria.

These results indicate significant complementarities between corruption, the shadow economy, and tax collection, which indicates that reducing corruption will lead to a reduction in the size of the shadow economy and will also reduce the negative effects of corruption on economic growth and therefore on the volume of regular tax revenues by limiting the size of the underground economy.

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