



Co-integration between Corruption and Economic Growth through Investment Channels: Empirical Evidence using the ARDL Bound Testing Approach for the Tunisian Case

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ABSTRACT

This study examines the relationship between corruption and economic growth in Tunisia from 1992 to 2018 by focusing on the role of the discretionary power and the distortion of the public spending. To explore the relationship between the variables of interest, the ARDL Bound testing co-integration approach of Pesaran and Shin (1999) was used. The empirical results showed that corruption negatively affects the long-term economic performance by suggesting that large-scale public investment is not necessarily desirable in an environment characterized by corruption as this leads to the waste of public funds. However, the estimation of an ECM model of short-term dynamics shows that corruption is associated with the increase of the real GDP per capita. Therefore, these results support the idea that corruption undermines long-term economic performance and call for institutional reforms to improve the quality of governance as a pre-condition for any broad-based economic growth.

Keywords: Corruption, Economic Growth, Investment, Co-integration, ARDL, ECM

JEL Classifications: D73, O4, E22, C12, C15

1. INTRODUCTION

In this paper, we focus on the effect of corruption on economic growth in Tunisia through the investment channel over the 1992/2018 period, using the ARDL Bound testing approach of Pesaran and Shin (1999). Therefore, the basic hypothesis is that corruption has a negative effect on economic performance since, on the one hand, it acts as a tax that increases indirect production costs and consequently, it negatively affects the volume of production factors and, on the other hand, it is associated with the decrease of efficiency in the allocation and use of the production factors. To empirically validate this relationship, we used two different cointegration techniques; the Engle-Granger's two-step cointegration technique, which shows that there is no cointegrating relationship, which implies that nothing can be said about the long-term relationship between corruption and economic growth.

This result is not surprising given the small sample size (relatively short period) and the low power of the test.

To cope with the problem of the relatively short study period, the ARDL, we applied the Bound Testing approach of Pesaran and Shin (1999), which shows that there is no cointegrating relationship between the variables and therefore, it makes it possible to estimate such a relationship in the long and short term. In fact, the choice of the model describing the long term was made on the basis of the Schwartz Bayesian Criterion and Akaike Information Criterion.

Furthermore, the estimation results show that corruption has a negative impact on long-term economic growth. This can be explained by the fact that, on the one hand, it can harm private sector investment because it increases the indirect production costs by acting as an indirect but uncertain tax on investment and, on the

other hand, it negatively affects the volume of productive public investment by diverting public funds to unproductive activities and mega public infrastructure projects. In this way, corruption has a negative effect on the efficiency of public investment because corrupt officials give priority to projects that bring them significant private material and political gains at the expense of projects that generate significant social benefits. Therefore, a corrupt State devotes most of its resources to large public infrastructure projects in order to maximize the opportunities for the misappropriation of public funds.

On the other hand, in the short term, the estimation of an error correction model (ECM) shows that corruption positively affects economic growth. This result is not surprising since corrupt decision-makers will speed up the implementation of short-term projects that bring them gains in a very short time. As for the rest of the article, it is organized as follows. The second section reviews the main theoretical and empirical findings, the third describes the model and the estimation methods, the fourth presents the results of the study, and the fifth and final section concludes the work.

2. THEORETICAL AND EMPIRICAL LITERATURE REVIEW

According to Ndikumana (2007), the main causes of corruption are the concentration of power, the discretionary power for public spending, the structure of the tax system, low wages in the public sector, attempts to divert fungible external debt and development aid, and the lack of transparency in international contracts, particularly for natural resource extraction.

In this study, we limit ourselves to the role of discretion and distortion in public spending. In this context, Acemoglu and Verdier (2000), stated that corruption is linked to State intervention. In this case, policy makers have discretionary power to determine the type, the size, the composition and the location of projects and service delivery. This may raise the risk of funding misappropriation which, according to Reinikka and Svensson (2005), is characterized by fund leakage during the transfer of public funds from the central decision point to the end-users of public services. In this respect, Mauro (1998) pointed out that public capital expenditure is easier to divert, and therefore, it is generally found to be larger than current expenditure, such as the employees' wages.

Regarding the relationship between corruption and economic growth, most of the studies on this topic, including Tanzi (2002), Svensson (2005) and Gyimah-Brempong (2002), support the view that poor governance, particularly corruption, is detrimental to growth. In fact, this is not surprising given that countries with lower governance standards and high levels of corruption have a slower growth.

The question that arises is to know the channels through which corruption weakens economic growth.

For Mauro (1995), Tanzi and Davoodi (2002a), the most important channel is investment. In fact, corruption increases the cost of

production and the uncertainty about the profitability of the invested capital, which discourages investment. In this regard, it should be noted that corruption acts like a tax although it differs from it in the sense that it is unpredictable and therefore difficult to internalize.

Empirically, Pellegrini and Gerlagh (2004) pointed out that when corruption falls by one percentage point, private investment and GDP increase by 2.5 and 0.35 percentage points, respectively, while for Mauro (1995), almost a third of the effects of corruption on economic growth passes through the private investment channel.

In reality, corruption is detrimental to public investment since it induces a preference for mega-projects that can lead to a considerable fund misappropriation by corrupt decision-makers, which reduces the effectiveness of the investment. Moreover, in a study of State-owned electricity companies in countries with high levels of corruption, Dal Bó and Rossi (2007) found that these companies are overcrowded and less efficient than similar companies in well-governed countries.

For their part, Mauro (1998), Tanzi and Davoodi (2002b) noted that corruption is associated with a distortion in favour of new debt-financed investment projects, which generates higher gains for corrupt decision-makers at the expense of current expenditure financed by current revenues.

3. THE MODEL AND THE ESTIMATION METHOD

3.1. The Model and the Data

- The model

In this study, the modified Solow model, which has been used to analyse the effect of political stability on economic growth, is written as follows:

$$Y = AK^\gamma L^{1-\gamma} \quad (1)$$

with Y ; the real GDP,
 A ; technical progress, which is neutral in the sense of Hicks,
 K ; physical capital,
 L ; the number of workers,
 γ ; the share of physical capital in production,
 $1-\gamma$; the share of labour in production.

In fact, if we divide the two terms of the equation by L , we get:

$$\frac{Y}{L} = \frac{AK^\gamma L^{1-\gamma}}{L} = A \left(\frac{K}{L} \right)^\gamma \Leftrightarrow y = Ak^\gamma \quad (2)$$

with y ; the real GDP per unit of labour, and k ; the physical capital per unit of labour.

$$\ln y = \ln A + \gamma \ln k \quad (3)$$

On the other hand, adding the logarithmic operator to both equality terms gives: $\ln y = \ln A + \gamma \ln k$

Now, we will incorporate political stability into the above specification. In fact, North (1990) argued that a country's institutions, which determine its long-term economic performance, refer to political stability, government quality, independent judiciary system, political and property rights, etc. Therefore, corruption can directly affect economic growth through its impact on the country's total productivity of the factors, which is represented by the letter A.

Let us suppose that A is a function of corruption C and of time t .

$$A(C) = A_0 e^{\alpha t + \beta C} \quad (4)$$

According to equations 1 and 2, we will have:

$$\ln y_t = \ln A_0 + \alpha t + \beta C + \gamma \ln k_t \quad (5)$$

Let $\ln A_0 = \alpha_0$, therefore, the previous equation can be written as follows:

$$\ln y_t = \alpha_0 + \alpha t + \beta C_t + \gamma \ln k_t \quad (6)$$

In fact, β is the coefficient that measures the direct effect of corruption on economic growth. It is worth noting that it is sometimes difficult to estimate such a structural equation since the use of a pure time series is characterized by non-stationarity in the data. Therefore, the estimation in this structural form can lead to a misleading regression if there is a lack of co-integration between the variables.

- The data

The variables used in this study are:

y_t : The real GDP per capita used as a proxy for GDP per unit of labour is a measure of economic performance;

k_t : Investment as a percentage of the real GDP used as a proxy for investment per employee;

$corr_t$: The corruption variable.

This study covers the period from 1992 to 2018 and the data are annual. We are limited to this period because the data on corruption are available only from this date, while those relative to y_t et k_t are taken from the Penn World Table (version 7.0) by Heston et al. and finally, the data for the $corr_t$ were collected from the Political Risk Services (PRS) group of the International Country Risk Guide (ICRG). This index is based on a scale of 0 to 6, implying that corruption is considered high if the index is zero. Therefore, to have an easy interpretation, we have reversed this index.

3.2. Methodology

In fact, most of the time series for the economic variables are non-stationary therefore, the estimates based on them generally lead to a misleading regression. However, these variables can be transformed into stationary ones through differentiation after determining their order of integration. However, the disadvantage of this method is that it lacks long-term information. Therefore,

this co-integration method can help overcome this problem since the regression in level will be possible if the variables are additionally co-integrated besides, it helps test the existence of a long-term relationship.

In fact, there are several approaches for the testing of this long-term relationship, including the following:

- The two-step method of Engle and Granger (1987)
- The Bound Testing Approach of (Pesaran and Shin, 1999; and Pesaran et al., 1996; 2001)
- Cointegration test: Engle-Granger's 2 step procedure.

Economically speaking, we can say that two or more variables are cointegrated if there is a long-term equilibrium relationship between them. In other words, testing the cointegrating relationship is like trying to find out if there is a long-term relationship between the variables that can be under the structural form represented by equation(6). This method helps estimate the short-term imbalance relationship at the same time.

After verifying that the variables are integrated in the same order, we perform the Engle and Granger (1987) test using the following regression:

$$\ln y_t = \alpha_0 + \alpha_1 \ln k_t + \alpha_2 corr_t + u_t \quad (7)$$

With

- y_t : The real GDP per capita
- k_t : The investment as a percentage of the GDP
- $corr_t$: Corruption
- u_t : The error term.

This method consists first in estimating equation (7) using the ordinary least squares (OLS) method and then testing the stationarity or the unit root existence of the residual term, which is expressed as follows:

$$u_t = -\alpha_0 + \ln y_t - \alpha_1 \ln k_t - \alpha_2 corr_t \quad (8)$$

The null hypothesis H_0 : u_t in non stationary and therefore, there is no cointegration relationship between the variables.

However, the frontier distribution of the t-test does not follow that of Dickey-Fuller's used in the unit root test. Although the Engle and Granger (1987) test initially provided critical values for a regressor, it was later extended by Engle and Yoo (1987) besides, the table suggested by MacKinnon (1999, 2010) is now considered the most complete one.

Moreover, if the null hypothesis of no cointegration H_0 has been rejected, the following log level equation can be estimated and therefore will not be misleading:

$$\ln y_t = a_0 + \alpha t + \beta C_t + \gamma \ln k_t + \varepsilon_t \quad (9)$$

To capture the short-term dynamics, the following ECM error-correction model can be estimated

$$\Delta \ln y_t = \beta_0 + \beta_1 \Delta \ln k_t + \beta_2 \Delta \text{corr}_t + \beta_3 t + \beta_4 \text{ECM}_{t-1} + \varepsilon_t \quad (10)$$

$$\text{ECM}_{t-1} = \varepsilon'_{t-1} = \ln y_{t-1} - \beta'_1 \ln k_{t-1} - \beta'_2 \text{corr}_{t-1} - \beta'_3 (t-1) \quad (11)$$

With

- ECM_{t-1} : the error correction term at time $t-1$,
- $\Delta \ln y_t = \ln y_t - \ln y_{t-1}$
- t : Is the time trend.
- The ARDL bound testing approach

In the ARDL bound testing approach, the lagged dependent and independent variables can be introduced into the model. Moreover, the term “autoregressive” means that the lagged dependent variable can determine the present dependent variable while the term “distributed lag” refers to the lag of the independent variables. Therefore, this technique can be used even if the independent variable does not cause an instantaneous variation of the dependent variable, as provided in the theoretical model. However, to apply the ARDL bound testing method, it is necessary to make sure that there are no I(2) variables. In fact, according to Ouattara (2004), the critical F statistics are not valid in this approach in the presence of an I(2) variable. Similarly, one should be cautious about using critical values when the sample size is small. Therefore, the critical values from Narayan (2004) will be used in this study since the sample size is small.

Moreover, the ARDL bound testing approach is preferred to other co-integration techniques for several reasons. First, according to Pesaran et al. (2001), this approach is better suited for small sample sizes, whereas Johansen’s approach requires a large sample to obtain a valid result (Ghatak and Siddiki, 2001). Then, this methodology can be applied if the used variables are all I(1), all I(0), or mixed. On the other hand, the ARDL model concedes a convergent estimator of long-term coefficients regardless of whether the underlying regressors are purely I(0), I(1) or mutually cointegrated according to Pesaran et al. (2001).

According to Pesaran and Shin (1995), the ARDL approach requires a simple reduced equation form, whereas in other methods, an equation system is required. In fact, the ARDL bound test enables the use of different lags for the regressors as opposed to the cointegration VAR models where mixed lags for the variables are not allowed (Pesaran et al., 2001). Therefore, to apply the ARDL bound testing approach, we have used the reduced form of equation (6) below because the normal equation 6 cannot be used.

$$\ln y_t = \alpha_0 + \alpha_1 \ln k_t + \alpha_2 \ln \text{corr}_t \quad (12)$$

With

- y_t : The GDP per capita
- k_t : The investment as a percentage of GDP and
- corr_t : The corruption index.

The reasons for defining the model in this way can be summarized as follows:

- If the variables are expressed in a logarithmic form, the non-normality problem can be reduced (Wooldridge, 2006)

- In the bound testing approach, if there is a cointegrating relationship, the presentation of the long-term relationships often requires regressors made up of lagged dependent and independent variables, which is not the case in the Engle-Granger representation of long-term relationships
- According to Wooldridge (2006), this technique, which is used to look for a long-term relationship, has an advantage as it can solve the endogeneity problem by adding lagged dependent variables as regressors
- However, it is not necessary to introduce many explanatory variables into the model since the lagged dependent variables can substitute the omitted ones, if needed. In our case, the unrestricted error-correction version of the ARDL model can be formulated as follows:

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta \ln y_{t-i} + \sum_{i=0}^p \gamma_i \Delta \ln k_{t-i} + \sum_{i=0}^p \delta_i \Delta \ln \text{corr}_{t-i} + \theta_1 \ln y_{t-1} + \theta_2 \ln k_{t-1} + \theta_3 \ln \text{corr}_{t-1} + \eta_t \quad (13)$$

On the other hand, the lag can be chosen based on the techniques of the Akaike information criterion (AIC) as well as the Bayesian information criterion (BIC) since the model does not exhibit AutoRegressive Conditional Heteroskedasticity (ARCH) and non-normality. In this respect, Pesaran and Shin (1999) recommended using a maximum of 2 lags for annual data. Moreover, the estimation can be carried out using the OLS method, then, an F-test will be carried out to test for the existence of the long-term relationship:

- $H_0: \theta_1 = \theta_2 = \theta_3 = 0$, all these coefficients are nil, which implies that there is no cointegration relationship between the variables of interest
- $H_1: \theta_1, \theta_2$ and θ_3 , are not simultaneously nil.

On the other hand, the asymptotic distribution of the F-statistics is not standard. This depends on the number of regressors and variables I(0) and I(1) and the inclusion of the the trend and the constant. Since we have a relatively small sample size, the critical values reported by Narayan (2004) are used in this study. In fact, Narayan proposed for each sample size two critical values; a lower critical value (lower bound), which assumes that the variables are purely I(0), and an upper critical value (upper bound), which assumes that the variables are purely I(1). Therefore, if the calculated F-statistics exceeds the upper bound, then the null hypothesis of no cointegration can be rejected, implying that there is a long-term relationship between the underlying variables. On the other hand, if the calculated F-statistics is below the lower limit, the null hypothesis of no cointegration cannot be rejected and therefore, the long-term relationship between the variables cannot be confirmed. However, the inference is inconclusive if the calculated statistics is between the lower and upper bounds.

Moreover, it should be noted that even if there is a cointegrating relationship between the variables, the result will be unimportant, especially when the parameters are not stable throughout the study period. In fact, instability in a parameter occurs due to structural breakdowns, therefore, it is important to check whether the parameters are stable or not so as to make the inference totally reliable. In this context, Pesaran and Pesaran (1997) recommended

applying the cumulative sum of the recursive residuals (CUSUM) test of Brown et al. (1975) to test the consistency of the parameter. As a consequence, if a cointegrating relationship exists, then the long term model and the error correction version of the ARDL model to be estimated can be formulated as follows:

$$\ln y_t = \alpha_0 + \sum_{i=1}^p \beta_i \ln y_{t-i} + \sum_{i=0}^p \gamma_i \ln k_{t-i} + \sum_{i=0}^p \lambda_i \ln corr_{t-i} + u_t \quad (14)$$

$$\Delta \ln y_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta \ln y_{t-i} + \sum_{i=0}^p \gamma_i \Delta \ln k_{t-i} + \sum_{i=0}^p \lambda_i \Delta \ln corr_{t-i} + \delta (ECM_{t-1}) + \varepsilon_t \quad (15)$$

With

$$ECM_{t-1} = \ln y_{t-1} - \alpha_0 + \sum_{i=2}^p \beta_i \ln y_{t-i} + \sum_{i=1}^p \gamma_i \ln k_{t-i} + \sum_{i=1}^p \lambda_i \ln corr_{t-i} \quad (16)$$

with $-1 \leq ECM_{t-1} \leq 0$ et $\delta \pi 0$

The absolute value of δ determines how quickly the equilibrium will be established.

- The unit root test

Before performing the cointegration test firstly, we have to perform the unit root. It should be noted that the Engle-Granger cointegration method requires that all variables be integrated in the same order, while the ARDL bound approach requires that the order of integration of each variable should exceed the unity.

In this paper, we will use the Dickey-Fuller unit root test.

Let us consider the following stochastic process:

$$y_t = \theta y_{t-1} + u_t \quad (17)$$

u_t is a white noise

Therefore, if $\theta=1$ then, there is a unit root and the process becomes a drift-free random walk which is a non-stationary stochastic process.

This equation can also be written as follows:

$$\Delta y_t = (\theta - 1) y_{t-1} + u_t \quad (18)$$

On the other hand, on considering the drift and the trend, the following two models can be written as:

$$\Delta y_t = \theta_0 + \theta_1 y_{t-1} + u_t \quad (19)$$

$$\Delta y_t = \theta_0 + \theta_1 y_{t-1} + \theta_2 t + u_t \quad (20)$$

As for the Dickey-Fuller (DF) test, which assumes that the error terms are uncorrelated with one another. In fact, this test consists firstly in estimating one or both of the above equations using the OLS method to calculate the estimated value of θ_1 , and the associated standard error. Then, by comparing the t-statistics resulting from the estimation with the appropriate critical value from the Dickey-Fuller table, we can then decide whether to accept or reject the null hypothesis H_0 according to which $\theta_1 = 0$.

In case the CUs are correlated, the augmented version of the Dickey-Fuller test (ADF) will be used. It consists in adding lagged dependent variables. The optimal number of lags is often empirically decided. The idea is to include enough lags terms so that the error terms will not be correlated.

4. THE ESTIMATION RESULTS

4.1. The Unit Root Test Results

To perform the Dickey-Fuller unit root (ADF) test, we followed the procedures described by Enders (2004). The results are presented in Table 1.

Table 1 shows that all the variables are not stationary, although they become stationary in first difference. Therefore, the conditions required to perform the cointegration test using the Engle-Granger method and the Bound testing approach are met.

4.2. Engel and Granger's Co-integration Test Results

Moreover, Engel and Granger's co-integration test consists first in estimating equation (7) using the OLS method, whereas Engle-Granger's augmented test is performed on the estimated residuals of the previous equation. In fact, it is a test of the null hypothesis according to which there is no cointegrating relationship.

On the other hand, it should be noted that Engle-Granger's augmented test is the same as the ADF test, except that the critical values are different. Besides, this test is performed without any trend or constant, and the lag lengths have been chosen so that the error terms will not be self-correlated.

Therefore, by comparing the calculated statistics using the critical values in Table 2, we can conclude that the null hypothesis of no co-integration cannot be rejected even at a significance level of 10%. Consequently, equation (6), which describes the long-term relationship between the variables in level cannot be estimated. For this reason, we proceeded with the cointegration approach of bound testing which, although it cannot estimate the exact theoretical model, it can bring back long term information if there is a cointegrating relationship between the variables.

4.3. Cointegration Results: Bound Testing Approach

To proceed with the bound test approach, it is necessary to specify an unrestricted general ARDL model and then select its reduced form while respecting the criteria of absence of autocorrelation, ARCH and normality (equation (7)). The reduction is made by removing the least significant lag from the model while keeping the constant and the shape variables expressed in level. Moreover, the

Table 1: Unit root ADF test results

Variable	Model with a trend and a constant		Model with a constant		Model with neither a trend nor a constant		Cointegration order
	Coefficient	Number of lags	Coefficient	Number of lags	Coefficient	Number of lags	
$\ln y_t$	-0.40*▲	2	-	-	-	-	I(1)
$\Delta \ln y_t$	-4.54***	1	-	-	-	-	
$\ln k_t$	-3.21	3	-1.52	3	1.23	3	I(1)
$\Delta \ln k_t$	-4.15*	1	-	-	-	-	
$corr_t$	-1.43	2	-1.43	2	0.62	2	I(1)
$\Delta corr_t$	-4.12*	1	-	-	-	-	
$\ln corr_t$	-1.73	2	-1.32	2	0.82	2	I(1)
$\Delta \ln corr_t$	-4.32*	1	-	-	-	-	

The null hypothesis: Presence of the unit root. ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively, ▲ means that the inference is made using the normal distribution

Table 2: Engel-Granger’s cointegration test

Significance test	1%	5%	10%
Critical values	-3.72	-3.01	-3.22
Calculated statistics		-1.27	

On the other hand, the critical values are calculated using the McKinnon (2010) table. While those mentioned here are devoted to a test having a constant since the values for the test having neither a constant nor a trend trend are not available

selection was made on the basis of the lowest Schwartz-Bayesian Criteria (BIC) and Akaike Information Criterion (AIC).

According to Table 3, the ARDL3 model is chosen since it corresponds to the lowest level of the SBS and AIC criteria. Next, the null hypothesis of no cointegration is tested, the results of which are given in Table 4. Besides, the calculated F-statistics is higher than the largest “critical bound,” therefore the null hypothesis of no cointegration can be rejected. It should be noted that the critical values, which were generated by Narayan (2004) with no restrictions of the constant and no trend, are calculated for a sample size equal to 30, which is close to our sample size. In fact, these are the closest possible critical values to use and the calculated F statistic is high enough to choose such a conclusion.

4.4. Results of Long-term and Short-term Dynamics

After showing that the interest variables are cointegrated using the bound approach, we have a model chosen on the basis of the SBS and AIC criteria Table 5. In our case, we chose ARDL5 (the choice of lags) as suggested by Pesaran and Shin, (1999) who showed that this approach does not enable us to get rid of autocorrelation).

Hence, the long-term model is written as follows.

$$\ln y_t = \alpha_0 + \alpha_1 \ln y_{t-1} + \alpha_2 \ln k_{t-2} + \alpha_3 \ln corr_{t-1} + \alpha_4 \ln corr_{t-2} + \varepsilon_t \quad (21)$$

On the other hand, the lags are based on Schwartz Bayesian’s criterion as well as Akaike’s Information criterion, as the model does not suffer from autocorrelation, from ARCH and from non-normality Table 6.

In fact, it can be seen from this table that the investment coefficient is positive, moreover, it has the expected sign but is only significant at 10%, which is acceptable for such a small sample size. Similarly, the two lagged variables are therefore significant at 10%.

Table 3: SBS and AIC criteria for choosing the ARDL model without restrictions

Model	SBC	AIC	No correlation	No arch	Normality
ARDL1	-122.62	-137.13	Yes	Yes	JB=026 (0.77) SW=0.87 (0.68)
ARDL2	-119.46	-135.245	Yes	Yes	JB=0.26 (0.77) SW=0.87 (0.68)
ARDL3	-128.31	-138.39	Yes	Yes	JB=0.12 (0.84) SW=0.86 (0.77)

The P-values in brackets are for the normality test. H_0 : The residue are normal. JB: Jarque-Bera’s test, SW: Shapiro-Wilk test

Table 4: Bound cointegration test

Critical values of Narayan (2004)					
1%		5%		10%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
6.14	7.77	5.24	6.33	4.33	5.01

Calculated F statistics=41.12

Let’s calculate the long-term multipliers:

We know that in the long run:

$$\ln y_t = \ln y_{t-1}$$

$$\ln k_{t-2} = \ln k_t$$

$$\ln corr_{t-1} = \ln corr_{t-2} = \ln corr_t$$

It follows that the long-term model is written:

$$\ln y_t = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 \ln k_t + \alpha_3 \ln corr_t + \alpha_4 \ln corr_t + \varepsilon_t$$

$$\Leftrightarrow (1 - \alpha_1) \ln y_t = \alpha_0 + \alpha_2 \ln k_t + (\alpha_3 + \alpha_4) \ln corr_t + \varepsilon_t \quad (22)$$

$$\Leftrightarrow \ln y_t = \frac{\alpha_0}{(1 - \alpha_1)} + \frac{\alpha_2}{(1 - \alpha_1)} \ln k_t + \frac{(\alpha_3 + \alpha_4)}{(1 - \alpha_1)} \ln corr_t + u_t$$

The long-term multiplier of $\ln k_t$ is $\frac{\alpha_2}{(1 - \alpha_1)} = \frac{0.06}{1 - 0.86} = 3.06$

and that of the $corr_t$ is $\frac{(\alpha_3 + \alpha_4)}{(1 - \alpha_1)} = \frac{0.06 - 0.11}{1 - 0.86} = -0.36$

This means that the increase of the corruption index by a 1% will result in a decrease of the real GDP per capita by 0.36%. On the other hand, increasing the kt investment ratio by 1% will result in

an increase of the real GDP per capita by 3.06%. Therefore, after estimating the long-term model, we then estimated the short-term dynamics using the two-step Engle-Granger 's procedure using the following error correction model (ECM):

$$\begin{aligned} \Delta \ln y_t = & \alpha_1 \Delta \ln y_{t-1} + \alpha_2 \Delta \ln y_{t-2} + \alpha_3 \Delta \ln y_{t-3} + \alpha_4 \Delta \ln y_{t-4} \\ & + \alpha_5 \Delta \ln k_t + \alpha_6 \Delta \ln k_{t-1} + \alpha_7 \ln k_{t-2} + \alpha_8 \ln corr_{t-1} \\ & + \alpha_9 ECM_{t-1} + u_t \end{aligned} \quad (23)$$

The results are presented in Table 7.

Table 5: SBS and AIC criteria for the choice of the long-term model

Model	SBC	AIC	No co-integration	No Arch	Normality
ARDL1	-97.45	-107.45	Yes	Yes	JB=0.90 (0.64) SW=0.97 (0.59)
ARDL2	-100.61	-109.38	No	Yes	JB=0.95 (0.62) SW=0.97 (0.59)
ARDL3	-103.54	-110.11	Yes	Yes	JB=0.61 (0.74) SW=0.96 (0.50)
ARDL4	-104.43	-111.46	Yes	Yes	JB=0.05 (0.98) SW=0.97 (0.63)
ARDL5	-106.32	-115.36	Yes	Yes	JB=0.87 (0.65) SW=0.96 (0.42)

The P-values in brackets are devoted to the test of normality. H_0 : The residuals are normal. JB: Jarque-Bera test, SW: Shapiro-Wilk

Table 6: Long-term estimates

<i>lny_t the independent variable</i>			
Regressors	Coefficients	Standard error	The calculated t student
A constant	0.08	0.26	0.31
Lny _{t-1}	0.86***	0.04	21.50
Lnk _{t-2}	0.06*	0.036	1.67
Lncorr _{t-1}	0.06*	0.04	1.50
Lncorr _{t-2}	-0.11*	0.067	-1.66
F statistics F=498 (P-value: 0.00)			
Jarque-Bera test=0.91 (P-value: 0.71)			
Shaporo-Wilk test=0.93 (P-value: 0.49)			

***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Table 7: Short-term dynamics: ECM

<i>Δln y_t: The independant variable</i>			
Regressors	Coefficients	Newey-West standard errors	The calculated student's t
The constant	0.042***	0.02	2.1
ECM _{t-1}	-0.65*	0.32	-2.34
Δln y _{t-1}	0.37*	0.18	2.05
Δln y _{t-2}	-0.232	0.14	-1.65
Δln y _{t-3}	0.27	0.19	1.42
Δln y _{t-4}	0.08	0.088	0.91
Δln k _t	0.22**	0.08	2.75
Δln k _{t-1}	0.002	0.12	0.016
Δln k _{t-2}	-0.05	0.047	-1.063
Δln corr _{t-1}	0.09***	0.032	2.81
F statistics=24 (P-value: 0.00)			
Jarque-Bera test=0.07 (P-value: 0.96)			
Shaporo-Wilk test=0.97 (P-value: 0.87)			

***, ** and * represent the significance levels of 1%, 5% and 10%, respectively

Since the error correction model suffers from autocorrelation, the inference is made on the basis of the Newey-West correction. On the other hand, the error correction coefficient shows how the equilibrium is quickly restored once the model is out of equilibrium. This coefficient is 0.65 in absolute value and is significant at 10% level, meaning that once the model is out of equilibrium, it adjusts to 65% over the same period. It should be noted that if the coefficient is not significant, the adjustment will not be made during the same period.

The unrestricted ARDL model of the bound test was selected while respecting the criteria of no serial correlation, no ARCH and no normality.

In fact, the autocorrelation was tested not only for a specific lag but also for a number of lags up to 15 and a p-value limit of 30%. Similarly, the null hypothesis of no ARCH, which has been tested for up to 15 lags, will be accepted if there is no ARCH in each of these lags.

Moreover, the, lack of normality is not a problem when the sample size is large however, the major challenge in our study is the small sample size. For this reason, we kept the normality hypothesis while remaining cautious from the time of the selection of lags to that the test performing.

5. CONCLUSION

In this article, we have studied the long-term and also the short-term effects of corruption on Tunisia's economic performance for the period 1992 to 2018. In fact, two different co-integration techniques were used for this purpose.

Furthermore, Engle-Granger's two-step cointegration technique shows that there is no cointegration relationship therefore; nothing can be said about the long-term relationship between corruption and economic growth. In fact, this result is not surprising given the small sample size and the low power of the test.

After that, the ARDL bound testing approach of Pesaran and Shin (1999), which has been applied, shows that there is a cointegrating relationship between the variables, which facilitates the estimation of such a relationship in the long and short term.

As a consequence, estimating the long-term relationship using a reduced structural model shows that corruption has a negative effect on the long-term economic performance. This result can be explained by the fact that corrupt decision-makers prefer large non-productive projects to productive investments. In fact, corrupt public officials divert public funds to unproductive activities, especially mega public infrastructure projects, which enables them to generate greater gains at the expense of productive projects that generate significant social benefits.

In fact, in the short term, the estimation of an ECM model shows that corruption has a positive effect on economic growth. This result is not surprising if we know that corrupt decision-makers

speed up the implementation of investment projects, especially blocked projects, in order to take advantage of the misappropriation of funds as quickly as possible.

Finally, the empirical question that requires further research is that corruption can also have a major impact on income distribution since it mainly affects the poor as it slows down their income growth, reduces public spending on them, causes congestion in social services and induces capital intensity in production, which reduces the impact that investment and economic growth can have on employment (Ndikumana, 2007).

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REFERENCES

- Acemoglu, D., Verdier, T. (2000), The choice between market failure and corruption. *American Economic Review*, 90, 194-211.
- Brown, R.L., Durbin, J., Evans, J.M. (1975), Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society*, 37B, 149-163.
- Dal Bó, E., Rossi, M.A. (2007), Corruption and inefficiency: Theory and evidence from electric utilities. *Journal of Public Economics*, 91, 939-962.
- Enders, W. (2004), *Applied Econometric Time Series*. Manhattan: Wiley.
- Engle, R., Granger, C. (1987), Cointegration and error correction representation: Estimation and testing. *Econometrica*, 55, 251-276.
- Engle, R.F., Yoo, B.S. (1987), Forecasting and testing in co-integrated systems. *Journal of Econometrics*, 35, 143-159.
- Ghatak, S., Siddiki, J. (2001), The use of the ARDL approach in estimating virtual exchange rates in India. *Journal of Applied Statistics*, 28(5), 573-583.
- Heston, A., Summers, R., Aten, B. (2011), *Penn World Table Version 7.0*, Center for International Comparisons at the University of Pennsylvania.
- Johansen, S. (1991), Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica*, 59(6), 1551-1580.
- Johansen, S. (1995), *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford: OUP Catalogue, Oxford University Press.
- MacKinnon, J.G. (2010), *Critical Values for Cointegration Tests*, Queen's Economics Department Working Paper No. 1227.
- Mauro, P. (1995), Corruption and growth. *Quarterly Journal of Economics*, 110(3), 681-712.
- Mauro, P. (1998), Corruption and the composition of government expenditure. *Journal of Public Economics*, 69, 263-279.
- Narayan, P.K. (2004), *Reformulating Critical Values for the Bounds F-Statistics Approach to Cointegration: An Application to the Tourism Demand Model for Fiji*. Department of Economics Discussion Papers No. 02/04. Melbourne, Australia: Monash University.
- Ndikumana, L. (2007), Corruption and pro-poor growth outcomes: Evidence and lessons for African countries. In: *Governance and Pro-Poor Growth*. Nairobi, Kenya: African Economic Research Consortium. p184-216.
- North, D. (1990), *Institutions, Institutional Changes, and Economic Performance*. New York: Cambridge University Press.
- Ouattara, B. (2004), *Foreign Aid and Fiscal Policy in Senegal*. Manchester: Mimeo University of Manchester.
- Pellegrini, L., Gerlagh, R. (2004), Corruption's effect on growth and its transmission channels. *Kyklos*, 57(3), 429-456.
- Pesaran, M.H. (1997), The role of economic theory in modeling the long run. *Economic Journal*, 107, 178-191.
- Pesaran, M.H., Shin, Y. (1999), An autoregressive distributed lag modelling approach to cointegration analysis. In: Strom, S., editor. *Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium*. Ch. 11. Cambridge: Cambridge University Press.
- Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, 289-326.
- Pesaran, M.H., Smith, R.P. (1995), Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68, 79-113.
- Pesaran, M.H., Smith, R.P., Im, K.S. (1996), Dynamic linear models for heterogeneous panels. In: Mityis, L., Sevestre, P., editors. *The Econometrics of Panel Data*. Netherlands: Kluwer Academic Publishers.
- Reinikka, R., Svensson, J. (2005), Fighting corruption to improve schooling: Evidence from a newspaper campaign in Uganda. *Journal of European Economic Association*, 3(2-3), 259-267.
- Svensson, J. (2005), Eight questions about corruption. *Journal of Economic Perspectives*, 19(3), 19-42.
- Tanzi, V. (2002), Corruption around the world: Causes, consequences, scope and cures. In: Abed, G.T., Gupta, S., editors. *Governance, Corruption, and Economic Performance*. Washington, DC: IMF. p19-58.
- Tanzi, V., Davoodi, H.R. (2002a), Corruption, growth, and public finances. In: Abed, G.T., Gupta, S., editors. *Governance, Corruption, and Economic Performance*. Washington, DC: IMF. p197-222.
- Tanzi, V., Davoodi, H.R. (2002b), Corruption, public investment, and growth. In: Abed, G.T., Gupta, S., editors. *Governance, Corruption, and Economic Performance*. Washington, DC: IMF. p280-299.
- Wooldridge, J.M. (2006), *Introductory Econometrics: A Modern Approach*. Cambridge, MA: MIT Press.