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External Indebtedness and Economic Growth in the Maghreb Countries

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Abstract: *The objective of this article is to study the nature of the relationship between external indebtedness and economic activity. This work will make it possible to know the effect of the external debt on the economic performance in the Maghreb countries (Tunisia, Algeria and Morocco), which will allow the authorities to lay new foundations in the orientation of the external debt. This study sets the general objective of expressing the linear relationship between indebtedness and economic growth in the three Maghreb countries: Tunisia, Algeria and Morocco between 1970 and 2018, i.e. a total of T=49 observations per countries (N=3). So, in sum, our model allows us to affirm that the impact of debt on the growth of the 3 Arab Maghreb countries is positive and not significant. This result means that in this segment, debt has no direct impact on growth.*

***Keywords*:** External indebtedness; economic growth; ARDL

***JEL Classification*:** H3, O4, C51

Introduction

After the 1970s marked by very severe economic management, the 1980s began with major shocks (low growth rate, accumulation of large arrears, unbearable budget deficit) which pushed the economies of the Third World into a crisis heavy. In the mid-1980s, cash constraints in the face of increasing financing needs forced States to take on external debt. The external debt burden, despite the various reductions,

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has become a vulgar obstacle to the development of heavily indebted poor countries with the existence of several determining factors such as the deficiency in the level of savings, the fragile situation of the balance of payments as well as defaults observed economic growth rates. It can be said that the link between indebtedness and growth is not clear. Income from growth leads to deleveraging, but can also generate new borrowing. This cautious circle, however, can become reckless when leverage is excessive.

In the Arab Maghreb countries, the reversal of economic conditions in the early 1980s, due to the progression of the balance of payments deficit and the increase in debt growth rates. This causes a difficult situation in terms of debt sustainability. We therefore note that with the initiative in favor of heavily indebted poor countries (IHIPC) that the level of sustainability has been below 50% since 2002. And thereafter, the investment capacities of the State are reduced and this situation increases its dependence on external financing. Our work seeks to contribute to the assessment of this capacity by examining the effects of debt reduction on economic growth in this group of countries. It would indeed be all the easier (difficult) to obtain new debt relief agreements if the effects of past initiatives in terms of growth are positive (negative or insignificant).

The methodology used is based on a standard growth model augmented by variables reflecting debt reduction. The data are panel data and cover the period 1973-2018. Unlike other empirical works, we are interested in a sample composed exclusively of three Arab Maghreb countries and only in the reduction of the outstanding debt. Also, we take into account the idea that different debt relief instruments can lead to different effects on growth. Finally, we test the hypothesis that these effects are conditioned by the weight of the debt. The facts do not entirely support the over-indebtedness theory, but most models of the determinants of growth assume that the level of debt affects growth both directly (by deterring governments from undertaking structural reforms) and indirectly (by discouraging investment). It should be noted that few econometric studies have assessed the direct impact of the stock of debt on investment in low-income countries. This work will make it possible to know the effect of the external debt on the economic performance in the Maghreb countries (Tunisia, Algeria and Morocco), which will allow the authorities to lay new foundations in the orientation of the external debt. This study has the general objective of expressing the linear relationship between indebtedness and growth in the Arab Maghreb Country. Attached to this general objective are the specific objectives:

- Evaluate the link between economic growth and external debt;
- Find the threshold from which the servicing of the external debt will have a significant impact on the economic performance of the Arab Maghreb country.

How does the foreign debt affect the economic growth of the Arab Maghreb Country? This is the fundamental question that this work aims to answer.

Main models on the relationship between indebtedness and economic growth

Over the past thirty years, developing countries (DCs) have benefited from considerable loans to enable their economic development. In view of the different debt ratios, one thing is clear. For many of these economies, debt service is not only a brake on the achievement of economic objectives but also a factor that depends on the management of the country. This situation is in the balance of the debt crisis. This crisis, which began in the 1980s, put many developing countries, including the Maghreb countries, into default and required the intervention of the IFIs, in particular the International Monetary Fund (IMF) and the World Bank. Conceptual evidence conducive to lowering the external debt of developing countries based on the thought that these economies face a debt overhang condition.

Theoretical links between indebtedness and growth

Linear analysis

The doctrine of over-indebtedness assumes that a large debt that proves difficult or unattainable to remunerate has stimulating impacts on the borrowing country to initiate appropriate changes to investment and/or economic growth. Different research certifies the negative impacts of over-indebtedness on growth. Using a cross-sectional regression-based treatment for 99 developing countries linking indebtedness to growth and investment, Elbadawi (1996) showed that the accumulation of old debts (a disposition analogous to over-indebtedness) slows down growth. His results coincide with those of Borensztein (1990) on the experience of the Philippines, where the stock of foreign debt had a strong impact on public investment and hurt private investment. Diwan et Rodrik (1992) and Cohen (1993) came to the same findings. According to Bulow and Rogoff (1990), Easterly (2002) and Asiedu (2003), and because of the impacts of over-indebtedness on economic growth and especially on the payment capacities of low-income countries, some authors support the idea of obligation of debt reductions, the appropriateness of such a maneuver has been dispassionate by some scholars who observe that the accumulation of debt is not the origin but the result of low growth, or that the reduction of debt would not be arrogant to resuscitate investment and growth.

Several studies, including Reinhart et Rogoff (2010a, b), Cecchetti et al. (2011), Checherita-Westphal et Rother (2012), Baum et al. (2012) and Reinhart et al. (2012), have thus shown that there is a negative link between debt and growth, more precisely it is strong when the debt is close to 100% of GDP. Moreover, Checherita et Rother (2010) looked identically at the ratio between debt and economic growth. They reviewed 12 euro area countries between 1970 and 2011 and they found the presence of an inverted U-shaped relationship between economic growth and government

indebtedness, with a threshold value found between 70 and 80%. However, Minea et Parent (2012) proved that the negative link between growth and debt disappears when they use the IMF database (Abbas et al., 2010). Similarly, their PSTR approach concluded that this correlation becomes positive when debt exceeds 115% of GDP.

In this way, on the theoretical level, the rational variation of the debt is advantageous to economic activity but its agglomeration hinders development, because the service of this debt leads to an impact of eviction, caused by means are influenced to its settlement instead of investments or internal charges favorable to growth. The research reviewed on the effect of foreign debt on economic growth prohibits a theory concerning the non-linearity of the relationship between growth and debt. From there, if the treaties looking at the impact of the external debt on the growth stir, few are those which specifically interest the countries of the Arab Maghreb. The above analysis proves on a theoretical scale that the two-way relationships between external debt and economic growth are ambiguous. This vagueness has been exonerated by the fact that all of the previous research on this relationship has focused on the negative impacts of excessive indebtedness. For this, the theory assumes that credit, understood within rational bounds, can participate in the development of developing countries in order to support their growth.

Jamel Jouini (2015) seeks to study the causal links between economic growth and remittances for Tunisia over the period 1970-2010 through two specific transmission channels, namely financial development and investment. The analysis is based on the Autoregressive Distributed Delay (ARDL) approach to co integration proposed by Pesaran et al. (2001). The results give co integrated relationships between the variables and show evidence of limited support in the long run as most causal links are one-way. While in the short run there are two-way causal links significant between variables, specifically between remittances and economic growth, their results are then of great interest and support the idea that causal links are relevant for economic policy makers.

Empirical studies on the relationship between growth and indebtedness

Devarajan et al. (1996) demonstrated a positive link between public consumption charges and economic growth, and an opposite link between the latter and domestic investment. According to the researchers, this result would develop through an appalling allocation of budgetary means in favor of capital expenditure and to the detriment of infrastructure maintenance expenditure. Thus, Devarajan et al. (1996) highlighted the differentiation between productive and unproductive public offices. Hansen (2001) arrived at the same result: the negative impact of external debt on the growth of these economies is not statistically significant. Using a sample of 13 Latin American countries between 1965 and 1990, Rockerbie showed in 1994 that the impact of indebtedness on investment stems, on the one hand, from the economy

examined and, on the other hand, the study period. The impact is negative for Mexico but positive for all other countries. After 1981, the debt parameter drops but is not regularly non-positive. The elasticity of investment with respect to other indicators is distinct depending on the country and the period examined. Swapan et al. (2007) showed that excessive indebtedness severely slows growth in Latin American countries, while the effect was moderately non-positive in the Asian region.

A series of studies carried out following the article by Reinhart and Rogoff (2010) failed to establish causality between the level of public debt and growth (Panizza et Presbitero, 2013). Yet the theoretical arguments in favor of such a link remain relevant: higher debt leads to higher taxation, which discourages work and innovation, to a reduction in public investment and to a diversion of private savings, which also reduces private investment. Moreover, if the level of public debt increases the perceived risk of government default, this can cause a liquidity crisis on the financial markets accompanied by a massive increase in interest rates that is harmful to growth. The discussion of the link between public debt and growth has perhaps overshadowed the more systematic study of the link between debt in general and growth. If too much public debt can be a drag on growth, too much household or non-financial corporate debt can also limit economic growth. When household debt reaches a level that they themselves or their creditors consider excessive, these households will increase their savings rate by reducing their consumption and residential investment. In any case, domestic demand will be substantially reduced.

For the adjustment of savings rates to weigh as little as possible on growth, an adjustment between countries is also desirable: it involves an increase in domestic demand in countries with current account surpluses. The decline in global interest rates and the appreciation of the real exchange rate of surplus countries are the two most effective channels to achieve this result. If these adjustments are hampered, the cost to growth is greater and more durable. These obstacles appear in particular when the real exchange rate cannot adjust quickly (as within the euro zone) or when household savings behavior is very rigid. In this case, a very sharp fall in the real interest rate is needed to compensate for the re-saving of indebted households, and this fall may come up against the constraint of zero interest rates. As these two disadvantages are compounded in the euro zone, it is foreseeable that household debt will be very harmful to growth there. The primordial limit of these researches remains in the fact that they are simplified to a linear approach.

For their part, **Ehikioya et al. (2020)** used the Johansen Cointegration test and the Generalised system Method of Moments to investigate the dynamic relationships between external debt and economic growth in 43 African countries from 2001 to 2018. They supported a long-run equilibrium relationship between external debt and African economic growth. They also showed that, beyond a specific capacity, the short-run converges to long-run equilibrium, and external debt begins to have a negative impact on African economic growth. For his part, **Olaoye (2022)** examined the

sustainability and inclusiveness of economic growth in a panel of 44 SSA countries, over a period of 38 years, while taking into account the diversity of the continent's institutional quality, income growth and resource endowment. He adopted the innovative nonlinear fiscal reaction function and the dynamic panel threshold model to account for potential asymmetric phenomena in public debt series. He showed that the recent increase in the economic growth rate in Sub-Sahara African (SSA) is not sustainable and inclusive. This is tenable since if economic growth is debt induced, more money will be spent on servicing public debt, thus depriving governments of funds for critical intervention programs. He also found a public debt/ gross domestic product ratio threshold of 34% beyond which public debt impairs growth inclusiveness across SSA.

As for Aguayo (2022), he examined the impact of international organizations on the institutional development of investment activity through the prism of the asymmetry of FDI (direct investment flows). It uses a linear regression model, a scenario-based forecast of FDI flows for 32 countries and revealed that the majority of countries are experiencing moderate financial imbalance. In this case, the investment policies of the states of the world focus on promoting the efficiency of the use of investment. The long forecast suggests that countries will focus on improving and developing their investment potential. The solution proposed in the study will contribute to reducing the financial asymmetries available in relation to the investment needs.

More recently, **Shah et al. (2024)** investigated public debt sustainability across 29 SSA economies, using various econometric specifications, for the sampled years 1996-2020. They indicated that although majority of the SSA economies have sustainable public debt ratios, four countries namely Uganda, Sudan, Togo and Cote d'Ivoire have unsustainable public debt ratios. They argued that these countries need to achieve primary surplus with broadening of the tax base in order to collect the much-needed tax revenue in order to remain sustainable as well as rationalize their expenditure and achieve sustained economic growth. In addition, they also suggested to the SSA economies to strengthen the fiscal framework through reforms which might also increase the debt carrying capacity of these economies. Strengthening of the fiscal balance also means that the SSA economies would be able to have more fiscal space and, thus, lesser need for further borrowing, eventually allowing the countries to have sustained economic growth due to more funding availability for the developmental projects.

Estimation methods and economic contribution

Unit root tests on Panel data

The study of non-stationary time series has now become essential in current econometric practice. Although the analysis of no stationary is a very frequent theme in

time series econometrics, the analysis of no stationary panel data has developed only very recently, since the pioneering work of Levin et Lin (1992). This article aims to take stock of these developments by providing a synthesis of the literature on unit root tests on panel data.

Co integration tests on panel data

The fact of showing that most of the variables are not stationary in level (integrated of order 1), it is judicious to study the presence of a long-term relationship between the series of the different parametric models to be estimated in the sections that follow. Indeed, co integration is an econometric technique to test the correlation between non-stationary variables of the time series. If two or more series are themselves no stationary, but a linear combination of them is stationary, then the series are said to be co integrated. To test the hypothesis of the existence of a considerable statistically significant relationship between two non-stationary variables could be done by finding a co integrating vector. (If such a vector has a low order of integration it can signify an equilibrium relation between the original series, which are said to be co integrated by an order below 1).

Serial correlation test

It is imperative that we test for the presence of a serial correlation of the estimation results. Ignoring the serial correlation when it exists will cause inefficient estimation and biased errors.

Empirical validation of the relationship between indebtedness and economic growth in the three Maghreb countries

Empirical tests of the effect of external debt on economic growth have been widely developed since the late 1980s. Their objective was often to analyze the conformity of the theory of excessive indebtedness, and they looked from even on whole rather to specific country cases. The purpose of this section is to study the relationship or relationships between indebtedness and economic growth in the three Maghreb countries: Tunisia, Algeria and Morocco between 1970 and 2018, i.e. a total of T=49 observations by country (N=3). Indeed, we will begin, as a first step, by presenting the model and all the variables that build it while specifying their graphical, descriptive and integration analyses. In the second step, we will study the linear relationship, through the ARDL approach, the direction of causality between the two indicators.

Presentation of the model and analyzes of the variables in the sample

Our purpose here is to see if indebtedness could have had a significant effect on the economic growth of three countries in the Maghreb region (Tunisia, Algeria and Morocco) during the period 1970-2018, characterized by a rate of significant indebtedness in the region. Since we are interested in macroeconomic relationships, the debt and growth rate should be treated as interactive variables. In addition, given the forward-looking nature of debt decisions, it is important to use a framework that allows for more detailed dynamic analysis.

To take into account both feedback effects and dynamic effects, we have chosen for our analysis an augmented Cobb-Douglas type growth model expressing the direct and indirect effects of the different variables on economic growth and one thereafter on the debt ratio. An autoregressive representation makes it possible to apply causality tests. At the outset, it is a question of pointing out that several limits have characterized the various empirical works that have been carried out on this relationship. In fact, the relationships observed between indebtedness and economic growth may suffer from causality problems due to the fact that indebtedness could be achieved by countries where the growth rate is quite low, hence the need to introduce control variables in order to solve these endogeneity problems.

To overcome these problems and to take into account the channels through which indebtedness acts on economic growth, we decided to build a structural model composed of several macroeconomic variables.

Model Specification

In our study, assuming that the debt ratio alone influences economic growth is inefficient and does not allow us to identify the real impact. Other variables can influence growth, which is why we extend our model to several variables in order to get closer to theory and reality. After the brief overview of the empirical literature and the theoretical foundations and adaptation of a structural linear dynamic model, we will now address the appropriate empirical form of this modeling in order to respond to the problem. First, we will test the stationary of our variables using the panel structural unit root test (Levin, Lin et Chu, 2002; Im, Peseran et Shin, 2003; Hadri, 2000), and if we reject the null hypothesis of no-stationary that all the variables are integrated in the same order of integration, in this case, we pass to the two types of co integration test of Pedroni (1999, 2004) et Kao (1999). In this case, and to examine the existence of the long-term relationship, we will study the effects of the variables on economic growth for each country through the econometric estimation technique ARDL by Pesaran et al. (2001) and Narayan (2005).

We then retain, to explain economic growth, real GDP growth (RGDP growth) as an endogenous variable explained by a series of explanatory variables (X). We add a constant (c) which will capture the unobservable factors. For the present study,

the model used is inspired by that of Patillo et al. (2002). The year 2002 served as a frame of reference for the combination of debt ratios and the main determinants of economic growth. In fact, these authors have arrived at satisfactory results. Our objective is, therefore, to study the direction of causality between external debt and economic growth and to verify, in what follows, whether there is an optimal threshold beyond which external indebtedness slows down economic growth (c i.e. the existence of a possible debt Laffer curve) as a second step.

The equation of the growth model, taking into account the availability of data and the characteristics of the economies of the three Maghreb countries, is as follows:

$$RGDP_{it} = \beta_0 + \beta_1 PGR_{it} + \beta_2 IR_{it} + \beta_3 DO_{it} + \beta_4 DR_{it} + \beta_5 IR_{it} + \beta_6 CTT_{it} + u_{it} \quad (1)$$

Thus, economic growth (endogenous variable) will be approximated by the real GDP growth rate (RGDP). As explanatory factors, we retained the population growth rate (PGR), the investment rate (IR), the degree of openness of a country (DO), the debt ratio (DR), the inflation rate (IR), the change in the terms of trade (CTT), and u is an assumed error term satisfying the Gauss-Markov hypotheses.

Présentation et définition des variables dans l'échantillon

This section describes the data used in the empirical analysis, specifically the measures of economic growth and a number of controlling variables used in growth regressions. Our sample consists of four countries from Maghreb countries, namely, Tunisia, Algeria, and Morocco with annual data for the 1970-2018 period. The choice of the selected countries for this study is primarily dictated by the availability of reliable data over the sample period. Data is missing for Libya and Mauritania.

In the chosen growth model, economic growth (endogenous variable) will be approximated by the real GDP growth rate (RGDP). The annual growth of gross domestic product (GDP) in % represents the relative variation in the volume of GDP in constant dollars between two years. It reflects the increase (or decrease in the case of negative growth) in the level of economic activity in a country. This is an indicator often used when one wants to make short and medium-term forecasts on the economic situation of a country. The typical determinants of this growth on which this study is based are as follows:

Population growth rate (PGR): An increase in population could negatively influence the rate of economic growth. The population growth rate is a demographic indicator that allows you to know the increase in the population at a given time, unlike other more forward-looking indicators such as the birth rate or the fertility rate. In other words, high population growth tends to impoverish a country since it is difficult to preserve a large volume of capital per worker in the presence of rapid growth in the number of workers (Mankiw, 2003).

Investment rate (IR): This variable indicates the share of total investment in GDP and reflects the impact of the physical capital factor in the production process. Considered as a source of growth, this variable makes it possible to increase physical capital, increase production, and consequently, income. The investment rate is homogeneously positive with life expectancy, increases with the degree of the quality of life of human capital, but likewise, it is negatively linked to public consumption and inflation. These effects can be proportional for a preferable consideration of law, a weak public consumption and for price equilibrium. All of these ways incentivize growth by encouraging investment.

The degree of openness of a country (DO): This is an indicator of trade openness. It is an indicator of the measurement of a country's foreign trade. It indicates the dependence of the country vis-à-vis the outside world. The calculation formula is as follows: [(Exports + Imports) / GDP] x 100. Most studies (theoretical and empirical) claim that the more a country was open to the outside, the more it would allow it to boost its productivity and redirect its scarce resources towards more efficient sectors and thus improve its well-being. The openness of an economy measures the place that the rest of the world holds in a country's economy. It assesses the degree of foreign constraint and is measured by several significant and informative components of the level of a country's trade with the rest of the world. To do this, flows such as net imports and/or exports can be used. Significant ratios can also be used. An economy with a very low rate of openness lives in near autarky. A country with a high rate of openness has an extroverted economy.

The debt ratio (DR): This is the nominal value of the outstanding external public debt, expressed as a percentage of GDP. The external debt is intended to make up for the lack of internal resources needed to finance growth. Indeed, the entry of foreign capital helps to strengthen the investment capacity and thus cause an increase in national wealth. However, its growth means that the total debt is growing faster than the basic sources of income.

The rate of inflation (IR): The term inflation refers to a lasting, general, and self-sustaining increase in the prices of goods and services. Inflation is also characterized by the increase in the circulation of money (money supply). The inflation rate is generally measured using the Consumer Price Index (CPI). The majority of empirical work considers that this variable negatively influences real growth. Indeed, inflation increases the cost of capital, which reduces investment and therefore economic growth. Moreover, the introduction of this variable into the growth equation reveals the eviction effect of debt service (Agénor et Montiel, 1999). High debt service can encourage governments to adopt inflationary policies, which negatively affects investment and therefore economic growth.

Change in terms of trade (CTT): This variable makes it possible to capture the effects of external shocks in these economies, especially since most of the countries considered are dependent on and export raw materials. In international economics,

the terms of trade refer to the purchasing power of imported goods and services that a country has thanks to its exports. The most common terms of trade index measure the ratio of export prices to import prices. An increase in this index corresponds to an improvement in the terms of trade: for example, a country sells its exports at a higher price for a constant import price. Conversely, a decrease in the index corresponds to deterioration in the terms of trade. The evolution of the terms of trade does not alone determine the evolution of the trade balance, which reflects both prices and volumes.

Graphical and descriptive analysis of the variables in the sample

Table 1 above presents the descriptive analysis of the different variables of the model. To enrich our analysis, we add the trend evolution as well as the histogram of each of these variables for all the countries. Indeed, and based on the statistics presented in Table 3.1, we will describe the main characteristics of the different variables used in this study. In addition, we add the Jarque & Berra statistic and its probability to test the normality of the series and the Q (p=2) autocorrelation test and its probability with reference to the Bias-corrected test of Born et Breitung (2016). It is clear from this last test that all the variables have a serial autocorrelation problem.

Table 1: Overall descriptive analysis of variables

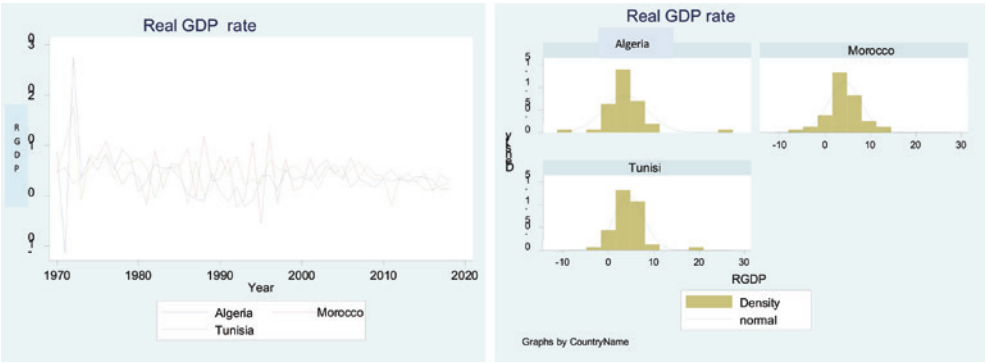
Statistics	RGDP	PGR	IR	DO	DR	INFLATION	CTT
N	147	147	147	147	147	147	147
Mean	4.177	1.892	22.895	56.958	45.828	6.393	0.900
Standdard deviation	3.968	0.653	11.154	16.062	21.785	5.512	5.905
Minimum	-11.332	0.747	-11.244	27.613	2.501	0.339	-21.338
p25	2.233	1.287	18.182	44.923	29.600	2.917	-2.726
p50	3.813	1.951	24.922	57.785	47.877	4.940	0.467
p75	6.008	2.350	30.280	67.542	59.677	8.116	4.393
Maximum	27.424	3.124	69.226	97.997	107.103	31.670	18.719
Skewness	1.177	0.102	-0.161	0.190	-0.037	2.276	-0.180
Kurtosis	11.818	1.853	5.401	2.473	2.939	9.467	4.401
Coefficient of Variation	0.950	0.345	0.487	0.282	0.475	0.862	6.563
Jarque-Bera (JB)	510.100	8.315	35.960	2.586	0.056	383.000	12.810
p-value JB	0.000	0.016	0.000	0.274	0.972	0.000	0.002
Auto corrélation Test Q(2)	12.130	31.200	429.930	31.570	767.090	17.88	6970.400
p-value Q(2)	0.002	0.000	0.000	0.000	0.000	0.000	0.000

Source: Authors' calculations.

Concerning the descriptive analysis, we start with GDP growth (RGDP) where the latter, according to Figure 1, is characterized by an oscillation of each value for each country around its relative average. Overall, this series displays an overall mean of

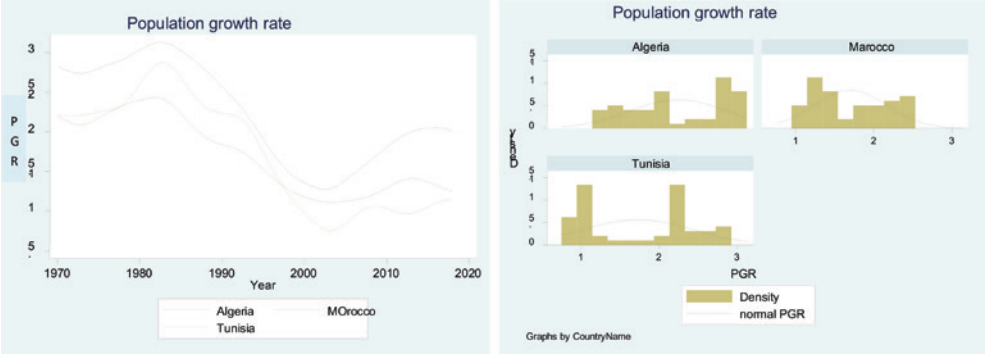
4.17 accompanied by a significant standard deviation of 3.97 making it highly heterogeneous (CV=0.95). These values are between -11.33 (Algeria) and 27.42 (Algeria) with a high concentration around 3.6. The sample distribution of the RGDP is asymmetrical right-spread (Skewness=1.17) and strongly leptokurtic (Kurtosis=11.81). According to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Figure 1: Trend evolution and Histogram of the RGDP by country



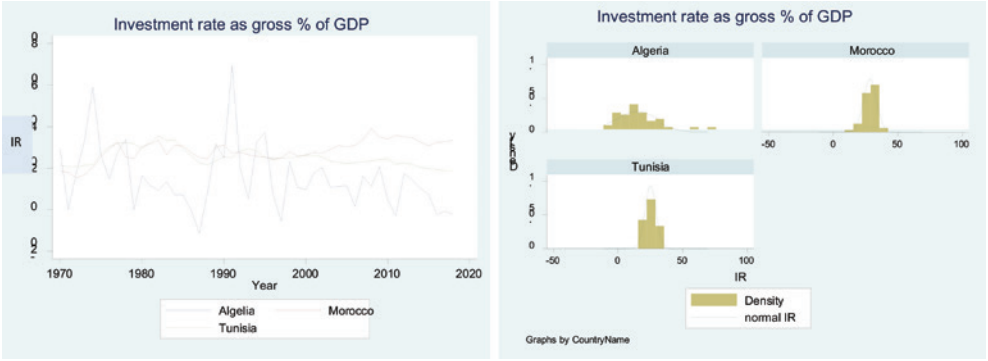
The PGR variable, according to Figure 2, is characterized by the same upward and downward trends along the study period for the three countries with different proportions. In total, this series displays an overall average of 1.89 with a standard deviation of 0.65 making it more homogeneous (CV=0.35). Their values are between 0.75 (Algeria) and 3.12 (Tunisia) with a high concentration around 1.95. The CPOP sample distribution is weakly asymmetric right-spread (Skewness=0.102) and leptokurtic (Kurtosis=1.85). According to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Figure 2: Trend evolution and Histogram of the PGR by country



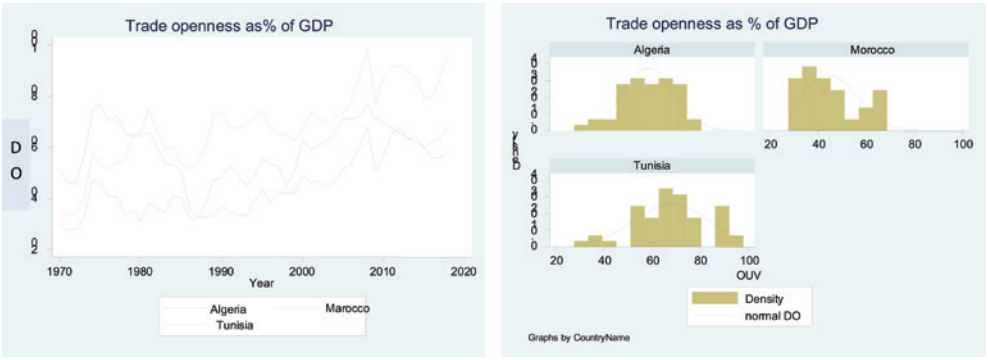
With regard to the investment rate (IR), according to Figure 3, this series is determined by the same oscillatory trends along the study period for the three countries with different proportions and especially for the case of Algeria. Overall, this series shows an overall mean of 22.89 with a standard deviation of 11.15 making it less heterogeneous (CV=0.48). Their values are between -11.24 (Algeria) and 69.22 (Algeria) with a strong concentration around 24.92. The sample distribution of the IR is weakly asymmetric spread to the left (Skewness=-0.161) and strongly leptokurtic (Kurtosis=5.401). According to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Figure 3: Trend evolution and Histogram of the IR by country



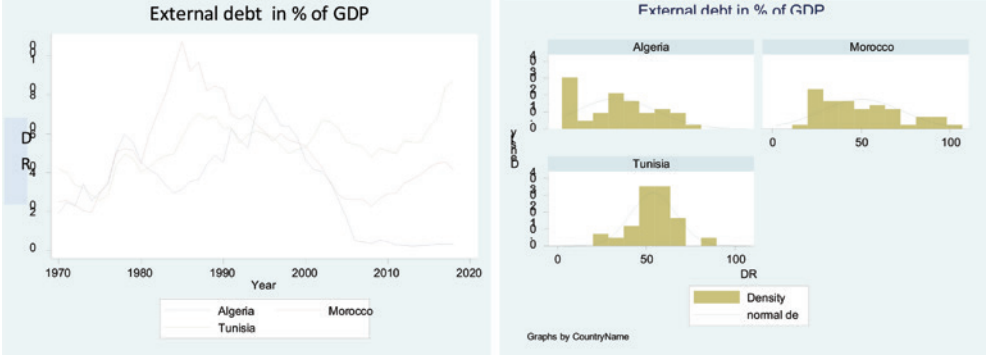
For the trade opening variable (DO), with reference to figure 4, this series is determined by the same upward trends along the study period for the three countries with the presence of several breaks relating to the different crises of the study period and especially for the case of Algeria and Tunisia. All the values are between 27.61 (Morocco) and 97.99 (Tunisia) with a high concentration around 57.78. These results make this variable have an overall mean of 56.95 with a standard deviation of 16.02 making it less heterogeneous (CV=0.28). The sample distribution of (DO) is weakly asymmetric right-spread (Skewness=0.189) and leptokurtic (Kurtosis=2.473). Similarly, according to the probability of the Jarque-Bera test of normality we accept the null hypothesis of normality.

Figure 4: Trend evolution and histogram of the DO by country



With reference to figure 5 of the debt ratio variable (DR), the latter is characterized by upward and downward trends along the study period for the three countries with different proportions and especially for the case of Morocco. Tunisia is characterized by a clear upward trend. Overall, this variable has an overall mean of 45.82 with a standard deviation of 21.79 making it homogeneous (CV=0.47). These values are between 2.50 (Algeria) and 107.10 (Morocco) with a high concentration around 47.88. The sample distribution of (DR) is weakly asymmetric left-spread (Skewness=-0.036) and leptokurtic (Kurtosis=2.939). According to the probability of the Jarque-Bera test of normality we accept the null hypothesis of normality.

Figure 5: Trend evolution and Histogram of DR by country



Concerning the inflation rate variable (IR), with reference to figure 6, this series is determined by the same upward and downward trends along the study period for the three countries with the presence of several breaks relating to the different crises of the study period with a strong increase during the 90s for the case of Algeria. All the values are between 0.34 (Morocco) and 31.67 (Algeria) with a high concentration around 4.94. These results make this variable have an overall mean of 6.39

with a significant standard deviation of 5.51 making it too heterogeneous (CV=0.86). The sample distribution of INF is asymmetric right-spread (Skewness=2.275) and strongly leptokurtic (Kurtosis=9.467). However, according to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Figure 6: Trend evolution and histogram of inflation by country

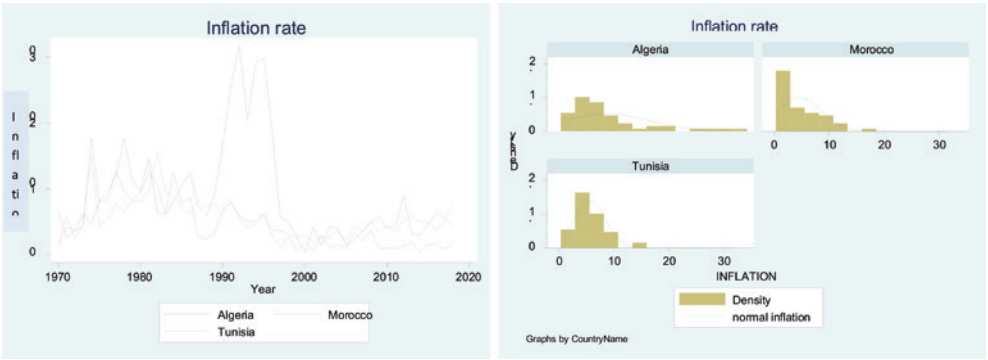
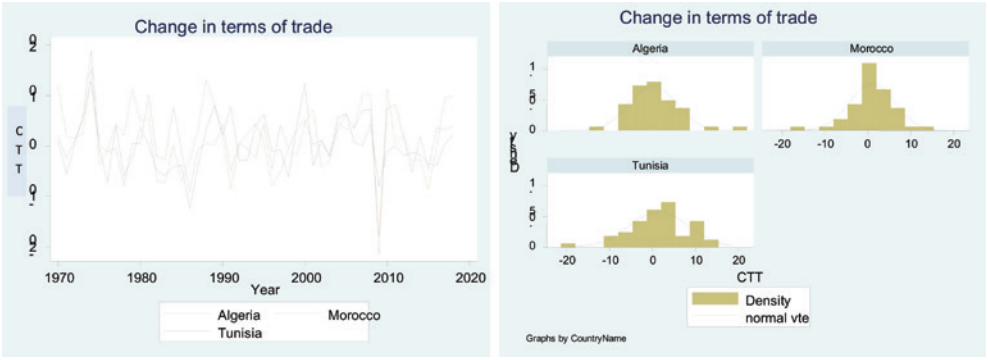


Figure 7: Trend evolution and CTT histogram by country



At the end and with reference to figure 7 of the variable Terms of trade variation (CTT), the latter is characterized by oscillations around the average for each country to give an overall average of 0.89 with a standard deviation too important compared to the average of 5.90 make it highly heterogeneous (CV=6.56). Their values are between -21.35 (Tunisia) and 18.72 (Algeria) with a high concentration around 0.47. The sample distribution of VTE is weakly asymmetrical left-spread (Skewness=-1.179) and strongly leptokurtic (Kurtosis=4.401). According to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Integration analysis and cointegration test

Unit root tests on Panel data

The main problems of panel unit root tests are, on the one hand, the form of the heterogeneity of the model used to test the unit root, it is the simplest form which consists in postulating the existence of specific constants to each individual and, on the other hand, any correlations that may exist between individuals. The taking into account or not of these possible inter-individual dependencies opposes two types of generations. Those who take the assumption of no autocorrelation of residuals (Levin, Lin et Chu, 2002, LLC; Im, Pesaran et Shin, 2003, IPS; Hadri, 2000; etc.), because they consider them as factors nuisance, and those who try to take up this alternative because, for them, these co-movements can be used to conduct new tests (Bai et al, 2004; Moon et Perron, 2004; etc.). The results of the LLC, IPS et Hadri unit root tests on our panel data are presented in Table 2.

Table 2: Unit root tests of variables

Variables	In level				In first difference			
	LLC	IPS	Hadri	Décision	LLC	IPS	Hadri	Decision
RGDP	-4.843***	-8.350***	2.293**	NS	-14.905***	-10.221***	-1.838	S
PGR	-3.135***	1.977	42.531***	NS	-4.404***	-2.232**	0.602	S
IR	-2.059**	-2.224**	7.302***	NS	-7.293***	-6.942***	-1.724	S
DO	-1.528*	-0.214	31.893***	NS	-7.165***	-6.946***	-1.275	S
DR	0.663	1.406	15.750***	NS	-3.767***	-5.779***	1.001	S
INFLATION	-1.144	-2.847***	11.194***	NS	-9.024***	-8.416***	-1.287	S
CTT	-6.715***	-7.034***	-0.931	NS	-10.904***	-9.017***	-1.697	S

Notes: *, **, *** significant at 10%, 5%, 1%. NS denotes no stationary; S denotes stationary.

Source : Authors' calculations.

From Table 3, all runs failed to pass all three units root tests (LLC, IPS et Hadri). It is clear that the test of Hadri (2000) is the most relevant because all the series show the presence of a unit root in level (reject H0). On the contrary, the same series accept the hypothesis of stationary in first differences. Thus, we can consider that all the series are integrated of order 1 [I (1)].

Co integration tests on Panel data

Since most of the variables are stationary in first difference, it is important to study the existence of a co integrating relationship between them. For this, we apply in this part the three tests of Kao, Pedroni et Westerland. Table 3.3 presents the main results of the main statistics of the co integration tests where all are in favor of the presence of a co integration relationship between the six variables constituting our basic model for the three Maghreb countries. Thus, the various statistics reject the null hypothesis of absence of co integration for a risk of 1%.

Table 3: Kao's cointegration test (1999)

Test	t-Statisti	Probability
Kao ADF	-7.261	0.000
Pedroni ADF	-17.163	0.000
Westerlund	-1.718	0.000

Source: Authors' calculations.

From this descriptive diagnostic and integration of the different variables of our model, we have reached the important results of the non-stability of the variables and the existence of a strong heterogeneity and dependence between the three Maghreb countries. For this, the objective of the following part is to seek the nature of the relationship between economic growth expressed by the RGDP and the other variables using the ARDL technique of Pesaran et al. (2001).

Linear multivariate processing of variables

Test of bivariate links between the different series

In this first step of the Multivariate study between the six variables of our model, we will proceed to a description of the relationship between the variables used. We start by calculating the different simple linear correlation coefficients between the different variables of the model and the variable representing GDP growth, as well as their confidence intervals to affirm the robustness and reliability of the parameters obtained.

Table 4: Evaluation of the different linear correlations between the series in Log

Correlation/Probability	RGDP	PGR	IR	DO	DR	Inflation	CTT
RGDP	1.000						

PGR	0.081	1.000					
	0.330	-----					
IR	0.152	-0.092	1.000				
	0.066	0.268	-----				
DO	-0.065	-0.355	-0.005	1.000			
	0.436	0.000	0.951	-----			
DR	-0.061	-0.090	0.332	-0.094	1.000		
	0.467	0.278	0.000	0.255	-----		
Inflation	-0.102	0.492	0.098	-0.111	0.224	1.000	
	0.221	0.000	0.240	0.179	0.006	-----	
CTT	-0.013	-0.100	0.233	0.149	0.018	0.010	1.000
	0.881	0.226	0.005	0.073	0.834	0.907	-----

Note: Correlation/Probability represents the linear Pearson correlation accompanied by the p-value.

Source: Authors' calculations.

The significance test of the Pearson correlation coefficients cannot be regarded as effective in the study of the economic growth-external debt (ED) relationship, but it gives us a good idea of the distinct possible links that we can detail them in the following. . The Pearson correlation parameters presented in Table 4 prove that the economic growth rate is exclusively positively and significantly correlated with the investment rate (IR). Nevertheless, there is no significant correlation with the external debt ratio.

Empirical evaluation of short and long-term relationships by ARDL

The ARDL model allows to estimate (p + 1) k coefficients, where p represents the number of optimal lags and k represents the number of variables in the model. For the optimal number of delays, we will choose a maximum duration of two periods. Indeed, the optimal number of lags selected is the one that respects the criteria of absence of serial correlation. This ARDL method makes it possible to introduce shifted values of exogenous variables into the co integration relationship, in order to rule out the seriousness attached to endogeneity and the serial correlation of residuals. In this part, we will develop two models dealing initially with the impact of the external debt ratio on the growth rate and then the effect of the growth rate on the external debt ratio for the three main countries of the Maghreb region. : Tunisia, Algeria and Morocco. Before starting with the evaluation of the model, it should be announced that we will carry out by a whole of tests of which we quote the serial correlation test of Breusch-Godfrey (LM) of order 1, the ARCH test of heteroscedasticity of order 1, the Jarque-Bera (JB) test for normality of residuals, and the Ramsey functional form test (RESET) of order 1.

Short and long-term estimation using the ARDL approach

Impact of the external debt ratio on the growth rate

Table 5 displays the short-term results, the recall strength of the ECM model as well as the majority of the diagnostic tests to validate our growth model. The effective growth model is verified by a 1-lag ARDL with trend where the bounds test F statistic which displays a high value of 18.754 with a significance equal to 0.000 greater than the critical value at 5% of Pesaran et al. (2001) which equals 3.62. This leads us to accept the alternative hypothesis of co integration.

Table 5: Short-term estimation of the growth model by ARDL

ARDL Model	**Maximum number of delay**	**Fisher**	**VC à 5% (*k*=6)**	**Akaike**
ARDL (1,0,0,1,0,0,0)	1	18.754	3.62	2.289
endogenous $\Delta RGDP_{it}$	**Coefficient**	**Standard deviation**	**t-Statistic**	**Probability**
Constant	14.944	2.729	5.476	0.000
$RGDP_{it-1}$	-1.500	0.130	-11.566	0.000
PGR_{it-1}	-1.493	0.733	-2.036	0.044
IR_{it-1}	0.042	0.018	2.325	0.022
DO_{it-1}	-0.029	0.016	-1.874	0.063
DR_{it-1}	0.037	0.020	1.805	0.074
INF_{it-1}	-0.234	0.066	-3.536	0.001
CTT_{it-1}	-0.251	0.153	-2.637	0.009
$\Delta RGDP_{it-1}$	0.108	0.076	1.418	0.159
ΔPGR_{it}	4.825	4.357	1.107	0.270
ΔIR_{it}	0.073	0.033	2.190	0.030
ΔDO_{it}	-0.178	0.046	-3.854	0.000
ΔDR_{it-1}	0.174	0.045	3.845	0.000
ΔIR_{it}	0.177	0.147	1.202	0.231
ΔINF_{it}	-0.188	0.082	-2.298	0.023
ΔCTT_{it}	-0.242	0.144	-1.674	0.097
TREND	-0.226	0.038	-6.023	0.000
θ (ECT_{t-1})	**-0.845**	**0.094**	**-8.977**	**0.000**
R^2	0.800			
Adjusted R^2	0.774			
F statistiC (*bounds test*)	20.427			0.000
Akaike	2.245			
Schwarz	2.601			
LM (5)	7.453			0.189
McLeod-Li ARCH (1)	3.778			0.151
Jarque-Bera	2.909			0.233
Ljung-Box (p=5)	7.854			0.165
McLeod	2.776			0.734
RESET	0.871			0.553

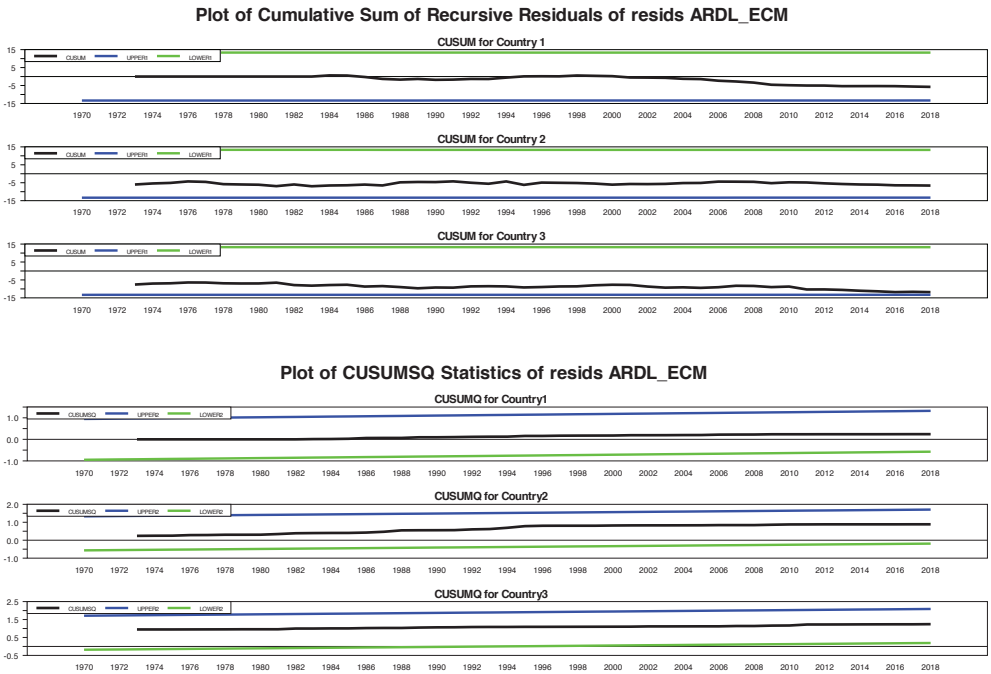
Note: LM Test = the Lagrange Multiplier test (Breusch–Godfrey serial correlation). ARCH = the autoregressive conditional heteroscedasticity test. RESET = Ramsey Regression Equation Specification Error Test. θ (ECT) is the error correction term that shows the speed of adjustment towards long-term equilibrium (this term must be significantly negative in order to guarantee the existence of the long-term relationship). k number of explanatory variables of the bound test of Pesaran et al. (2001).

Source: Authors' calculations.

The short-term evaluation of the growth model above, presented by a final model of the ARDL type (1,0,0,1,0,0,0), shows us that it is globally significant given that the probability associated with the Fisher statistic which is equal to 20.426 with a

probability well below 5%. Moreover, it is of good quality since the value of the adjusted R2 statistic tends towards the value 1 (0.8). The consequences of model validation tests; namely Breusch-Godfrey (LM) serial autocorrelation test of order 5, ARCH test for heteroscedasticity of order 1, Jarque-Bera (JB) test for normality of residuals, McLeod test d squared serial autocorrelation and the Ramsey functional form test (RESET); certify the non-existence of serial correlation, the non-existence of heteroscedasticity, and the normality of the residuals. Alternatively, the functional form of our specification is exact. Similarly, the CUSUM and CUSUM square tests for each country prove that the estimated coefficients are stable in mean and in variance during the study period (see Figure 8).

Figure 8: Representation of CUSUM and CUSUMQ statistics



Indeed, in the short term, we observe the significant effect of all the lagged series of a lag on the rate of economic growth. From there, we record the negative and significant effect, at least 10%, of the population growth rate (PGR), the debt ratio (DR), the inflation rate (INFR) and the variations in the term of exchange (CTT). On the other hand, the domestic investment rate (IR) and trade openness (DO) variables show positive and significant effects. Thus, it can be said that the growth rate reacts to short-term variations in the trade policy indicators of North African countries. It is clear that the trend component is largely significant but has a negative effect on the

rate of economic growth. Our growth model proves the presence of a long-term error correction mechanism. Thus, the estimated parameter of the error correction term is negative and significant at the 1% level. There thus persists a mechanism of convergence towards the long-term target. For this, short-term changes in growth correct themselves at a rate of 84.5%.

Table 6: Long-term estimation of the growth model by ARDL

Variables	Coefficient	Standard deviation	t-Statistic	P-values
Constante	9.963	1.766	5.639	0.000
PGR	-0.995	0.493	-2.019	0.045
IR	0.028	0.011	2.356	0.020
DO	-0.196	0.104	-1.872	0.063
DR	0.025	0.013	1.829	0.069
INFLATION	-0.159	0.042	-3.692	0.000
CTT	-0.167	0.064	-2.623	0.009

Source: Authors' calculations.

The long-term relationship evaluated by means of the ARDL approach, displayed in Table 6, proves to us that the variable of interest, debt ratio, impacts significantly (at 10%) and negatively on economic growth. In addition, we observe the positive and significant effect of the investment rate (at 5%) and trade openness (at 10%). Furthermore, the results show a significant and negative effect of the population growth rate (at 5%), the inflation rate (at 1%) and the variation in the terms of trade (at 1%).

Impact of growth rate on external debt ratio

Table 7 displays the short-term evaluations; the recall strength of the ECM model as well as all of the diagnostic tests validated the growth model. The optimal indebtedness model is verified by an ARDL model with 1 lag and with trend where the statistic F of bounds test presents a value of 3.679 with a significance equal to 0.001 higher than the critical value at 5% of Pesaran et al. (2001) which is equal to 3.62. Thus, these results lead us to accept the alternative hypothesis of the presence of co integration.

Table 7: Short-term estimation of the debt model by ARDL

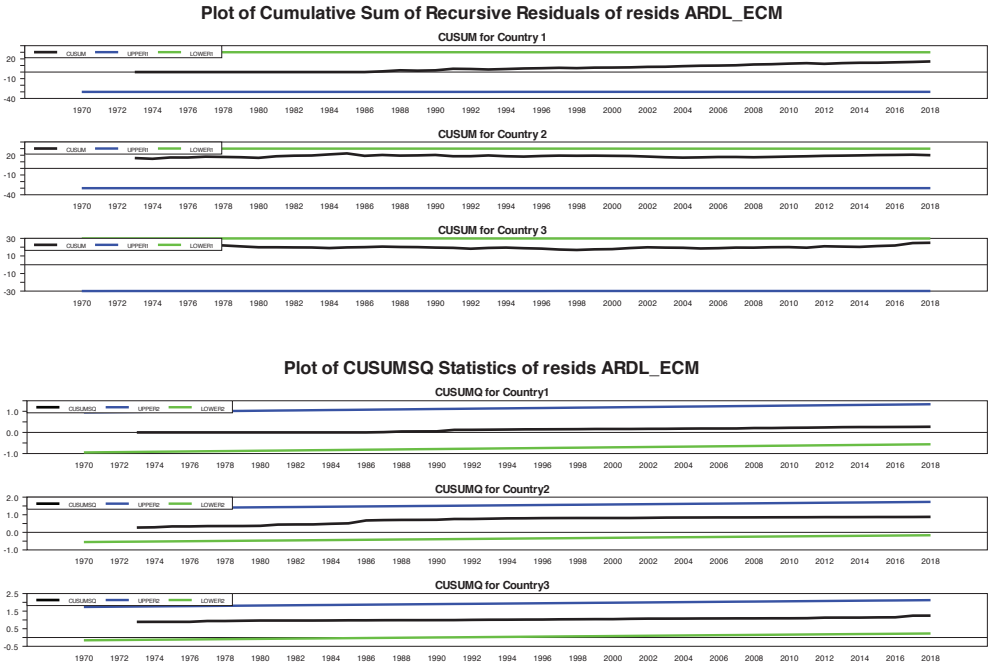
ARDL model	**Maximum Delay Number**	**Fisher**	**VC at 5% (*k*=6)**	**Akaike**
ARDL (1,0,1,1,1,0,1)	1	3.679	3.62	3.421
Endogenous Variable ΔDE_{it}	**Coefficient**	**Standard deviation**	**t-Statistic**	**Probability**
Constant	5.645	5.424	1.041	0.300
ED_{it-1}	-0.878	0.280	-3.140	0.002
$RGDP_{it-1}$	-0.956	1.358	-0.704	0.483
IR_{it-1}	0.198	0.061	3.257	0.001
$RGDP_{it-1}$	-1.048	0.320	-3.276	0.001
DO_{it-1}	0.081	0.037	2.172	0.032
INF_{it-1}	0.055	0.126	0.438	0.662
CTT_{it-1}	0.218	0.395	0.550	0.583
ΔED_{it-1}	0.314	0.084	3.737	0.000
ΔPGR_{it}	-5.158	7.975	-0.647	0.519
ΔIR_{it}	0.305	0.055	5.565	0.000
ΔIR_{it-1}	-0.056	0.054	-1.042	0.299
$\Delta RGDP_{it}$	-0.599	0.153	-3.920	0.000
$\Delta RGDP_{it-1}$	0.342	0.135	2.529	0.013
ΔDO_{it}	0.186	0.267	0.696	0.488
ΔDO_{it-1}	-0.758	0.258	-2.936	0.004
ΔINF_{it}	0.152	0.152	0.997	0.321
ΔCTT_{it}	-0.310	0.262	-1.185	0.238
ΔCTT_{it-1}	0.067	0.084	0.804	0.423
TREND	-0.178	0.076	-2.331	0.021
θ (ECT_{t-1})	**-0.484**	**0.164**	**-2.951**	**0.004**
R^2	0.448			
Adjusted R^2	0.362			
F statistic (*bounds test*)	4.474			0.000
Akaike	3.420			
Schwarz	3.839			
LM (5)	6.189			0.288
McLeod-Li ARCH (1)	0.033			0.851
Jarque-Bera	1.27			0.531
Ljung-Box (p=5)	6.580			0.254
McLeod	7.053			0.214
RESET	0.874			0.550

Note: LM Test = the Lagrange Multiplier test (Breusch–Godfrey serial correlation). ARCH = the autoregressive conditional heteroscedasticity test. RESET = Ramsey Regression Equation Specification Error Test. θ (ECT) is the error correction term that shows the speed of adjustment towards long-term equilibrium (this term must be significantly negative in order to guarantee the existence of the long-term relationship). K number of explanatory variables of the bound test of Pesaran et al. (2001).

Source: Author's calculations.

The short-term estimate of the growth model above, presented by a final model of the ARDL type is (1, 0, 1, 1, 1, 0, 1). This proves to us that this model is largely significant knowing that the p-value added to the Fisher statistic, which is equal to 4.474, is well below 5%. In addition, it is of average quality of adjustment because the value of the adjusted R2 statistic tends towards the value 0.5 (0.45). The results of all the model validation tests (Breusch-Godfrey (LM) serial autocorrelation test of order 5, ARCH heteroscedasticity test of order 1, Jarque-Bera (JB) test for normality of the residuals, McLeod's test of squared serial autocorrelation and test of the functional form of Ramsey) affirm the non-existence of serial correlation, the non-existence of heteroscedasticity, and the normality of the residuals. Moreover, the functional form of our specification is correct. Similarly, the stability tests of the CUSUM and CUSUM parameters squared for each country prove that these coefficients are stable in mean and in variance during the study period (see figure 9).

Figure 9: Evolution of CUSUM and CUSUMQ of the growth model



Source: Authors' calculations.

Indeed, in the short term, we observe the significant impact of a reduced set of lagged variables of a lag on the debt ratio. From there, we record the negative and significant effect, at least at 1%, of the economic growth rate (RGDP). On the other hand, the domestic investment rate (IR) and trade openness (DO) variables show

positive and significant effects. However, the population growth rate (PGR), inflation rate (INF) and terms of trade (CTT) variables have no significant effects on the external debt ratio (DE). Thus, we can observe that the external debt ratio reacts to variations in the cyclical growth rate in the countries of North Africa. Similarly, it is clear that the trend component is significant but has a negative effect on growth in the order of 0.178. In the long term, our model proves the persistence of an error correction mechanism. Thus, the estimated parameter of the error correction term is negative and significant at the 5% level. There therefore persists a system of convergence towards the long-term target. For this, the short-term changes in economic growth are fighting at a rate of 48.4%.

Table 8: Long-term estimation of the debt model by ARDL

Variables	Coefficient	Standard Deviation	t-Statistic	p-value
Constant	6.430	5.698	1.128	0.261
PGR	-1.089	1.473	-0.739	0.461
IR	0.226	0.085	2.654	0.009
RGDP	-1.194	0.499	-2.394	0.018
DO	0.092	0.049	1.885	0.062
INF	0.063	0.143	0.439	0.662
CTT	2.479	4.589	0.540	0.590

Source: Authors' calculations.

The long-term relationship estimated by the ARDL approach, shown in Table 8, shows us that our variable of interest, the debt ratio, acts significantly (at 10%) and negatively on the rate of economic growth. In addition, we observe the positive and significant effect of the investment rate (at 5%) and trade openness (at 10%). Furthermore, the results show a significant and negative effect of the population growth rate (at 5%), the inflation rate (at 1%) and the variation in the terms of trade (at 1%).

Interpretations of empirical results

The variables that can influence growth are many; this is why we build our model with several variables in order to get closer to theory and reality. And subsequently, we will now focus on the appropriate empirical specification of this model in order to answer our problem. The stationary of our variables from the panel structural unit root test (Levin, Lin et Chu, 2002; Im, Peseran et Shin, 2003; Hadri, 2000), and if we reject the null hypothesis of no stationary that all the variables are integrated in the same order of integration, in this case we pass to the two types of co integration test of Pedroni (1999, 2004) and Kao (1999). In this case, and to examine the existence of the long-term relationship, we will study the effects of the variables on economic

growth for each country through the econometric estimation technique ARDL by Pesaran et al. (2001) and Narayan (2005). So economic growth, real GDP growth (RGDP) as an endogenous variable explained by a series of explanatory variable (X). We add a constant (c) which will capture the unobservable factors. The model used is inspired by that of Patillo et al. (2002). The year 2002 served as a frame of reference for the combination of debt ratios and the main determinants of economic growth. The ARDL model is to study the direction of causality between external debt and economic growth and to verify, in what follows, whether there is an optimal threshold beyond which external indebtedness slows down economic growth (i.e. i.e. the existence of a possible Laffer curve of the debt). The definition of variables by country is in the sample. In fact, our Panel includes N=3 Maghreb countries, namely Algeria, Morocco, and Tunisia between 1970 and 2018, see 49 observations per country.

The typical determinants of this growth on which this study is based are as follows:

The population growth rate (PGR): An increase in the population could negatively influence the economic growth rate, this series displays an overall average of 1.89 accompanied by a standard deviation of 0.65 to make it more homogeneous (CV=0.35). Their values are between 0.75 (Algeria) and 3.12 (Tunisia) with a high concentration around 1.95. High population growth tends to impoverish a country since it is difficult to preserve a large volume of capital per worker in the presence of rapid growth in the number of workers (Mankiw, 2003).

The investment rate (IR): This variable indicates the share of total investment in GDP and According to Figure 3.3; this series is determined by the same oscillatory trends along the study period for the three countries with different proportions and especially for the case of Algeria. Overall, this variable has an overall mean of 22.89 with a standard deviation of 11.15 making it less heterogeneous (CV=0.48). This variable reflects the impact of the physical capital factor in the production process.

The degree of openness of a country (DO): This is an indicator of trade openness. It is an indicator of the measurement of a country's foreign trade. It indicates the dependence of the country vis-à-vis the outside world. Figure 3.4, this series is determined by the same upward trends along the study period for the three countries with the presence of several breaks relating to the different crises of the study period and especially for the case of Algeria and Tunisia. All the values are between 27.61 (Morocco) and 97.99 (Tunisia) with a high concentration around 57.78. These results make this variable have an overall mean of 56.95 with a standard deviation of 16.02 making it less heterogeneous (CV=0.28).

The debt ratio (DR): This is the nominal value of the outstanding external public debt, expressed as a percentage of GDP. The external debt is intended to make up for the lack of internal resources needed to finance growth graph 3.5 of the variable DE indebtedness ratio, the latter is characterized by upward and downward trends along the study period for the three countries with different proportions and especially

for the case of Morocco. Tunisia is characterized by a clear upward trend. Overall, this variable has an overall mean of 45.82 with a standard deviation of 21.79 making it homogeneous (CV=0.47). These values are between 2.50 (Algeria) and 107.10 (Morocco) with a high concentration around 47.88. The sample distribution of the DE is weakly asymmetric spread out on the left (Skewness=-0.036) and leptokurtic (Kurtosis=2.939). This ratio is characterized by upward and downward trends along the study period for the three countries with proportions different and especially for the case of Morocco. The entry of foreign capital makes it possible to strengthen the investment capacity and thus cause an increase in national wealth.

The rate of inflation (INFR): The term inflation refers to a lasting, general, and self-sustaining increase in the prices of goods and services. This inflation rate variable INF, with reference to chart 3.6, this series is determined by the same upward and downward trends along the study period for the three countries with the presence of several breaks relating to the different crises of the period of study with a strong increase during the 90s for the case of Algeria. All the values are between 0.34 (Morocco) and 31.67 (Algeria) with a high concentration around 4.94. These results make this variable have an overall mean of 6.39 with a significant standard deviation of 5.51 making it too heterogeneous (CV=0.86). The sample distribution of INF is asymmetric right-spread (Skewness=2.275) and strongly leptokurtic (Kurtosis=9.467). The inflation rate is generally measured using the Consumer Price Index (CPI). The majority of empirical work considers that this variable negatively influences real growth. Indeed, inflation increases the cost of capital, which reduces investment and therefore economic growth.

Variation in the terms of trade (CTT): Figure 3.7 of the variable (VTE), the latter is characterized by oscillations around the average for each country to give an overall average of 0.89 with a standard deviation that is too large by compared to the average of 5.90 make it highly heterogeneous (CV=6.56). Their values are between -21.35 (Tunisia) and 18.72 (Algeria) with a high concentration around 0.47.

The sample distribution of CTT is weakly asymmetrical left-spread (Skewness=-1.179) and strongly leptokurtic (Kurtosis=4.401). This variable makes it possible to capture the effects of external shocks in these economies, especially since most of the countries considered are dependent on and export raw materials.

Descriptive analysis of the different variables of the model: To enrich our analysis, we add the trend evolution as well as the histogram of each of these variables for all the countries. Hadri's test (2000) is the most relevant because all the series show the presence of a unit root in level (reject H0). We consider that all the series are integrated of order 1 [I (1)].

The Jarque & Berra statistic and its probability to test the normality of the series and the Q (p=2) autocorrelation test and its probability with reference to the Bias-corrected test of Born et Breitung (2016). It is clear from this last test that all the variables have a serial autocorrelation problem. Economic growth (endogenous variable)

will be approximated by the real GDP growth rate (RGDP). The annual growth of gross domestic product (GDP) in % represents the relative variation in the volume of GDP in constant dollars between two years. It reflects the increase (or decrease in the case of negative growth) in the level of economic activity in a country. This is an indicator often used when one wants to make short and medium-term forecasts on the economic situation of a country.

According to Figure 1, GDP growth (RGDP) is characterized by an oscillation of each value and each country around its relative average. Overall, this variable has an overall mean of 4.17 with a large standard deviation of 3.97 making it highly heterogeneous (CV=0.95). These values are between -11.33 (Algeria) and 27.42 (Algeria) with a high concentration around 3.6. The sample distribution of the RGDP is asymmetrical right-spread (Skewness=1.17) and strongly leptokurtic (Kurtosis=11.81). According to the probability of the Jarque-Bera test of normality we reject the null hypothesis of normality.

Table 3 presents the main results of the main statistics of the co integration tests where all are in favor of the existence of at least one co integration relationship between the six variables constituting our basic model for the three Maghreb countries. Then, we find the no stability of the variables, the existence of a strong heterogeneity and dependence between the three Maghreb countries. For this, we will go on to look for the nature of the relationship between economic growth expressed by the RGDP and the other variables using the ARDL technique of Pesaran et al. (2001) between the six variables of our model.

The Multivariate study advances a description of the relationship between the variables used. We start by calculating the different simple linear correlation coefficients between the different variables of the model and the variable representing GDP growth, as well as their confidence intervals ensuring the robustness and reliability of the parameters obtained. By the empirical results, the correlation coefficient is therefore significantly different from 0. The simple correlation coefficients detailed in Table 4 which demonstrates that the economic growth rate is only positively and significantly correlated with the investment rate (IR). However, we find no significant correlation with the external debt ratio. Being part of the family of dynamic approaches, the ARDL approach accepts to evaluate the short-term dynamics and the long-term impacts for variables that are co integrated or even integrated at different orders as we will see with the test approach at bounds of Pesaran et al. (1996), Pesaran et Shin (1995), and Pesaran et al. (2001).

This ARDL approach consists in including lagged values of the explanatory variables in the co integration relation, in order to eliminate the nuisances linked to the endogeneity and the serial correlation of the residuals. The optimal growth model is verified by an ARDL with 1 lag and with trend where the F statistic of bounds test which displays a high value of 18.754 with a significance equal to 0.000 higher than the critical value at 5% of Pesaran et al. (2001) equal to 3.62.

The results of model validation tests; namely Breusch-Godfrey (LM) serial autocorrelation test of order 5, ARCH test for heteroscedasticity of order 1, Jarque-Bera (JB) test for normality of residuals, McLeod test d squared serial autocorrelation and the Ramsey functional form test (RESET); express the absence of serial correlation, the absence of heteroscedasticity, and the normality of the residuals. Alternatively, our functional form of our specification is correct.

In the short term, we observe the significant impact of the majority of lagged variables on the economic growth rate. From there, we record the negative and significant effect, at least 10%, of the population growth rate (PGR), the debt ratio (DR), the inflation rate (INF) and variations in the exchange term (CTT). The variables domestic investment rate (IR) and trade openness (DO) display positive and significant effects. Thus, we can say that the growth rate reacts to cyclical variations in commercial policy indicators in North African countries. It is clear that the trend component is largely significant but acts negatively on the economic growth rate.

In the long term, this equation shows the existence of an error correction mechanism. Indeed, the estimated coefficient of the error correction term is negative and significant at the 5% threshold. There is therefore a mechanism for convergence towards the long-term target. Thus, short-term deviations in economic growth correct at a rate of 84.5%.

The model estimated in the long term by ARDL, displayed in table 6, proves to us that the variable of interest, the debt ratio, has a significant (at 10%) and negative impact on the economic growth rate. In contrast, we observe the positive and significant effect of the investment rate (at 5%) and trade openness (at 10%). Furthermore, the results show a significant and negative effect of the population growth rate (at 5%), the inflation rate (at 1%) and the variation in the terms of trade (at 1%). The optimal growth model is verified by an ARDL with 1 lag and with trend where the F statistic of bounds test which displays a value of 3.679 with a significance equal to 0.001 higher than the critical value at 5% of Pesaran et al. (2001) equal to 3.62. Therefore, the results of the model validation tests show the non-presence of serial correlation, the non-presence of heteroscedasticity, and the normality of the residuals. Likewise, the functional form of our specifications is correct. In addition, the CUSUM and CUSUM squared tests for each country prove that the estimated coefficients are stable in mean and in variance over the study period.

Conclusion

This research work met the objectives set out in the introduction. It was essentially a question of verifying the link between indebtedness and economic growth by means of the study and/or the evaluation of the maximum sustainable level of indebtedness, which could be favorable to economic growth. The results obtained by the ARDL

econometric estimation technique appear to be intuitive for certain series. Indeed, the signs of the parameters of the rate of openness of the economy and of the credit granted to the private sector allow us to conclude that these series therefore have a positive impact on GDP growth. Moreover, trade openness has no direct effect on growth. This is all the more intelligible as the condition of these economies in terms of the economy.

However, the econometric evaluation by the ARDL approach allowed us to affirm the presence of a non-linear relationship between growth and public debt. Below this limit, the impact of debt on the growth of the three Arab Maghreb countries is positive and not significant. This result means that in this segment, debt has no direct impact on growth. Thus, this result brings to the fore the use of debt resources in these countries. The poor management of public funding, unproductive investments and poor governance are thus at the origin of a (more or less significant) absence of the real impacts of public debt on economic growth. Beyond this limit, the debt has a negative and significant impact on the growth of Arab Maghreb countries. This being mainly due to the presence of a real problem in the use of resources arising from indebtedness, the question then arises of productive public investment within these economies.

Our findings suggest that too much reliance on public debt must be discouraged since it has adverse effect on economic growth in the long run. However, the negative impact of public debt can be minimised if it is used to finance government investment. In this context, governments of the Maghreb countries should adopt investment-supportive policies to boost private investment in order to achieve faster economic growth in the long-run.

Declarations

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Conflicts of interest/Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and material

Data will be made available on request.

Code Availability

The computer program results are shared through the tables in the manuscript.

Authors' Contributions

Adnan Ahmed Esharif: Conceptualization, data curation, analysis, methodology, writing – review and editing.
Imen Saleh: Writing – Original Draft, Review and Editing.

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