THE IMPACT OF GOVERNMENT SIZE ON ECONOMIC GROWTH IN ALGERIA: A THRESHOLD ANALYSIS

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ABSTRACT

This paper aims to examine the growth-government spending nexus for Algeria. Our empirical investigation follows the endogenous growth literature by using GDP growth rate as dependent variable and government expenditure as a share of GDP as the main explanatory variable. We then perform the Hansen's (2017) regression kink model with an unknown threshold to estimate the optimal government size during the period 1973-2020. The obtained results confirm the validity of the Armey curve hypothesis in the case of Algeria, and suggest an estimated government size that maximizes economic growth around 30.4 percent of GDP. Accordingly, since Algeria has attained its optimal level of government size, it seems to be more important for authorities to improve the efficiency of government expenditure.

KEY WORDS

Government spending, Economic Growth, Armey Curve, Regression Kink Model, Algeria

JEL CLASSIFICATION : E62, C24, F43

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أثر الإنفاق الحكومي على النمو الاقتصادي في الجزائر:
استخدام نموذج انحدار العتبة

ملخص

تهدف هذه الدراسة إلى تحليل العلاقة بين النمو الاقتصادي والإنفاق الحكومي في الجزائر. تعتمد دراستنا التطبيقية على منهج نماذج النمو الداخلي وهذا باستخدام معدل نمو الناتج الداخلي الخام كمتغير تابع والنفقات الحكومية نسبة إلى الناتج الداخلي الخام كمتغير مفسر رئيسي. ولتقدير الحجم الأمثل للإنفاق الحكومي خلال الفترة 1973–2020 فقد استخدمنا نموذج انحدار العتبة الذي اقترحه Hansen سنة2017.أظهرت النتائج صحة فرضية منحنى Armey في حالة الجزائر ،كما توصلت الدراسة إلى أن الحجم الأمثل للإنفاق الحكومي نسبة إلى الناتج الداخلي الخام الذي يساهم في زيادة النمو الاقتصادي إلى الحد الأقصى هو 30.4 في المائة. و بناءا على هذه النتائج يتضح أن الجزائر قد وصلت إلى المستوى الأمثل لحجم الانفاق الحكومي، وبالتالي فإن الأمر الأكثر أهمية بالنسبة للسلطات حاليا هو تحسين كفاءة الإنفاق الحكومي.

كلمات مفتاحية

الانفاق الحكومي، النمو الاقتصادي، منحنى Armey، نموذج انحدار العتبة، الجزائر

تصنيف جال:E62, C24, F43

L'IMPACT DES DÉPENSES PUBLIQUESSUR LA CROISSANCE ÉCONOMIQUE EN ALGÉRIE : APPLICATION DES MODÈLES A SEUILS

RÉSUMÉ

L'objectif de cet article est d'examiner la relation entre les dépenses publiques et la croissance économique en Algérie. Notre étude empirique est basée sur la littérature des modèles de croissance endogène, dans lequel le taux de croissance du PIB est utilisé comme variable dépendante et les dépenses publiques en pourcentage du PIB comme principale variable explicative. En utilisant le modèle à seuil récemment développé par Hansen (2017), les résultats empiriques relèvent que la taille optimale de dépenses publiques (pourcentage du PIB) qui maximise la croissance économique en Algérie est estimée à 30.4 %entre 1973 et 2020.Ils montrent aussi l'existence de la courbe d'Armey dans le cas de l'Algérie. En conséquence, puisque l'Algérie a atteint son niveau optimal de dépenses publiques en pourcentage du PIB, il semble plus important pour les autorités d'améliorer l'efficacité de ces dépenses.

MOTS CLÉS

Dépenses publiques, Croissance économique, Courbe d'Armey, Modelés à seuils, Algérie

JEL CLASSIFICATION: E62, C24, F43

INTRODUCTION

Public spending is widely considered as an important factor in stimulating economic growth. Additionally, public spending is a critical variable that affects a country's public finance sustainability through its effects on the public debt and budget balance. More specifically, in hydrocarbon rich countries the way governments choose to spend their resources rents highly affects the process of economic diversification (Gelb, 2010). According to Gelb and Grasmann (2010), diversification requires an active use of resource

rents to increase the productivity of non-resource exportable sectors and bring down their production costs, whether by funding infrastructure or temporary subsidies, as well as encouraging the entry of investors with new capabilities and knowledge. However, a large increase in domestic spending of resource-related revenues beyond the domestic absorptive capacity of the economy may lead to some problems such as Dutch disease, crowding-out of private investment, wasteful spending and risk of rents seeking, which tend to weaken the non-resource exportable sectors and undermine the process of economic diversification (Gelb, 2010). Although spending tends to support diversification, increased government spending can make diversification more difficult by generating domestic demand pressure, leading to a real exchange rate appreciation and a decline in economic growth. Therefore, to support economic growth and diversification, it is critical for hydrocarbon rich countries to balance the size of government spending against the risks arising from overspending. Accordingly, the analysis of government size (defined as government expenditures as a share of GDP) with respect to economic growth has long been heatedly debated in the economic literature. From the theoretical perspective, the Keynesian view advocates for a long run positive impact of government spending on economic growth, over stimulating aggregate demand and private investment, while the Neoclassical theory postulates a detrimental effect of large government size on growth, mainly through the crowding out effect. However, another stream of theoretical literature led by Barro (1990), Scully (1994) and Armey (1995) has argued for a non-linear inverse U-shaped relation between public spending and economic growth, known as the "Armey curve". According to the Armey curve hypothesis, increased public spending stimulate economic growth until an optimal level, above which large public spending retards economic growth.

Investigating the optimal level of government spending for a natural resource rich country like Algeria seems to be of great of importance, as the country has experienced a massive inflow of revenues from oil exports, a dramatic expansion of government

expenditure, and a low level of economic diversification, thus, it is crucial for Algeria to have an optimal size of public spending that maximize economic growth and ensure an optimal allocation of its resources. The main aim of this study is, therefore, to examine the growth-government size nexus and test whether there is an optimal threshold of government spending in its relation with respect to economic growth in Algeria for the 1973-2020 period. For this purpose, we apply a newly estimation technique, a regression kink model with unknown threshold developed by Hansen (2017).

The rest of the paper is organized as follows. The theoretical background and the literature review on the interaction between government size and economic growth, as well the contribution of the study is discussed in section two. Next, a brief overview on the evolution of the government size and economic growth in Algeria over the period under analysis is reported. The econometric method used, data and empirical model are then provided in section four. The findings and discussion are reported in section five. The conclusion and policy implications drawn from this study are finally provided.

1- THEORETICAL BACKGROUND AND LITERATURE REVIEW

This section reviews the empirical literature and considers the theoretical framework about the effect of public expenditure on economic growth. In fact, the nexus between government size and economic growth has been widely examined at both theoretical and empirical levels, however, there is still no consensus on this issue. At the theoretical point of view, there is two different approaches regarding the role of public policy in long run economic growth. The first approach is the neoclassical growth models proposed by Solow (1956), while the second is the endogenous growth models introduced by Romer (1986) and Barro (1990). The neoclassical growth theory from Solow (1956) assumes that capital accumulation, labor force and technical advances influence economic growth, while government policy has no effect on long run economic growth (Kneller et al, 1999). On the other hand, in endogenous growth models, government policy has an important place in determining long run economic growth

through their play in conducting fiscal policy. Barro (1990) in his famous published article "*Government Spending in a Simple Model of Endogenous Growth*" mentioned the importance of public finances (productive public spending) as an important determinant of long-term growth rate. The author argues that productive expenditures, notably in infrastructures and property rights, create a positive linkage between government spending and economic growth. However, according to Barro, increasing the share of non-productive government expenditures lowers the growth and saving rates. Therefore, the author suggests that economic growth responds non-monotonically to the increase in government expenditures. This certainly indicates the existence of a possible non-linear relationship between government size, defined as government expenditures as a share of GDP, and economic growth. Similarly, an influential and notable contribution of Armey (1995) supports an inverted U-shaped relationship between government expenditures and economic growth, known as the "Armey Curve", also called the "BARS Curve" referring to the studies of Barro (1990), Armey (1995), Rahn and Fox (1996), and Scully (1994). The Armey curve drawn in figure 1, shows a positive influence of government expenditures on economic growth until a certain point, which is the optimal government size, and beyond this point, the relationship between growth and expenditures reverses, implying that an additional increase in spending would turn to be harmful for economic growth. Thus, according to the Armey curve, an optimal size of government expenditures exists (Facchini and Melki, 2011).

According to Facchini and Melki (2011), the initial positive impact of raising government expenditures on economic growth can be explained by the benefits obtained from government intervention to provide public services such as securing property rights and ensuring public safety, and to correct the market's failure, while the negative effect results from the costs inherent to state failure. Certainly, some level of government expenditures is conductive to economic growth, notably in core areas of government such as education, health, infrastructure, rule of law and property rights (Facchini and Melki, 2011). However, beyond certain scope, an

increase in government size can become harmful for economic growth. Accordingly, it is suggested that, as the size of government increases, activities of rent-seeking and the level of bureaucratic inefficiencies become dominant (Facchini and Melki, 2011).

Figure 1. The Armey Curve

Source: Vedder and Gallaway, 1998
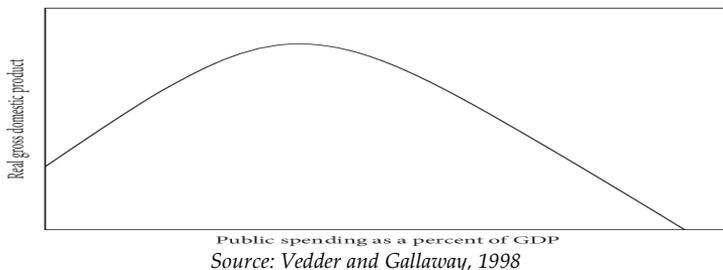
On the empirical front, there is no clear consensus on the optimal size of government and its impact on economic growth. This may be attributed to the fact that several studies used linear models and ignored the possibility of a non-linear nexus between government size and economic growth (Facchini and Melki, 2011). Currently, a large body of empirical literature relies on Army curve that assumes a non-linear relation, when analysing the linkage between government size and economic growth (e.g.,Scully, 1994; Vedder and Gallaway, 1998; Afonso et al., 2003; Chen and Lee, 2005; Facchini and Melki, 2011; Christie, 2012). While the Armey curve non-linear hypothesis between government expenditures and economic growth has been widely supported by the bulk of relevant studies, the optimal government size, which maximizes growth rate, has varied considerably among these studies (El Husseiny, 2018).

Considering developed countries, in a review of 17 studies that investigated the nonlinearrelationship between government expenditures and growth, Facchini and Melki (2011) pointed out that the optimal government size in these countries varied from around 20 percent to 40 percent of GDP. Based on Barro's (1990) endogenous growth model, Karras (1997) estimates an optimal government

expenditure equal to 16 percent of GDP for 20 European countries. Meanwhile, Vedder and Gallaway (1998) estimated the share of government expenditure in GDP that maximises economic growth in the United States as 17.4 percent during the period 1947-1997. The authors also found an optimal government expenditure percentage of 21.37, 26.14, 22.23, 19.43 and 20.97 for Canada (1926-1988), Denmark (1854-1988), Italy (1862-1988), Sweden (1884-1988) and the United Kingdom (1830-1988), respectively. A related work by Afonso and al. (2003) estimated an optimal public expenditure level equal to 35 percent for 23 OECD countries.

Furthermore, the Armey curve hypothesis has also been confirmed for some developing and low-income countries. Based on the methodology proposed in Barro (1990) and Karras (1997), Hassan and Strazicich (1999) estimated government optimal size to be 21, 18, 29, 17 and 22 percent of GDP in Bahrain, Kuwait, Oman, Saudi Arabia and United Arab Emirates, respectively over the time period 1970-1992. Chen and Lee (2005) tested the Armey curve during the period of 1979–2003 in Taiwan and found the optimal government size to be 22.83 percent of GDP. Likewise, Davies (2009) reported that the optimal amount of government consumption expenditures is 33 percent of GDP for low-income countries. In a similar way, Christie (2012) examined the possibility of non-linear relationship between government size and long run economic growth for a panel of 136 countries over the period 1971-2005, and found an optimal public expenditure threshold level equal to 33 percent of GDP. While, when developed and developing countries were analysed separately, the threshold varied from 26 percent for developed countries to 32 percent for developing countries. Altunca and Ayd (2013) determined that optimal government sizes in Turkey, Romania and Bulgaria for the period 1995-2011, were 25, 20 and 22 percent of GDP, respectively. Similarly, El Husseiny (2018) found the optimal government expenditures to be between 30.5 and 31.2 percent of GDP in Egypt over the time period from 1981-2015. Interestingly, Nouira and Kouni (2021) tested the existence of the optimal size of government in selected MENA and developed countries for the period 1988-2016.

Based on this analysis, the optimal government expenditures ranged between 20-30 percent for MENA countries, and between 10-30 percent for the whole sample. Similarly, Al-Abdulrazag (2021) found the optimal government size to be 26.9 percent as a share of GDP in the analysis he conducted in the Kingdom of Saudi Arabia in the 1971-2019 period.

For the case of Algeria, some few studies have been conducted on the optimal government size. Using Dynamic OLS and the Fully Modified OLS, Rennane (2019) found the optimal government size in the Algerian economy in 1973-2019 to be at a 29 percent of GDP. In another empirical study, Belkour (2019) used Johansen cointegration method and fully modified OLS, and found the optimal government expenditure to be between 23.6 and 34.9 percent of GDP for the Algerian economy over the period 1970-2017. Along the same line, in this study we investigate the optimal government size and its effect on economic growth for the Algerian economy. This study, thus contributes to the existing literature by applying a different estimation technique, a regression kink model with unknown threshold proposed by Hansen (2017), as to the best of the authors' knowledge no study has previously been conducted in this field that makes use of Hansen (2017)'s regression kink method to test the Armey curve hypothesis.

2- OVERVIEW OF ALGERIA'S GOVERNMENT SIZE AND ECONOMIC GROWTH

The first part of this section provides a brief outlook of the evolution of Algeria's economic growth and government size, while the second part explores the extent to which increasing public spending in Algeria has not been sufficient to achieve broader diversification. Along the period 1973-2020, the share of government expenditure in GDP for the Algerian economy has averaged around 33.4 percent, as shown in figure 2. During the 1970s and 1980s, government expenditure to GDP ratio averaged around 30 percent. This period was characterized by a centrally planned economy. Moreover, Algeria's development strategy during this period was to create heavy industry, therefore, government expenditure was largely

concentrated in the large-scale public investment projects and was channelled towards industrial and agricultural sectors. Regarding economic growth, figure 2 reports that the growth rate of the Algerian economy was maintained positive until the late of 1980s.

However, in the late 1980s and early 1990s increased government spending synchronized a weak an even negative growth rate. The very miserable performance of the Algerian economy, and the declining trend in economic growth during this period, were due to the political and social instability that hit hard the country, the collapse of oil prices, and the overall decline in the manufacturing sector. Moreover, government expenditure was increasingly reoriented towards current expenditure, while government capital expenditure declined.

During the time period from 1992 to 2000 there has been observed a relatively stable and declining trend in Algeria's government size, while the economy experienced annual growth rate of 1 to 3 percent. This was primarily the results of the economic reforms under the IMF-supported structural adjustment program to help transition Algeria to a market-based economy.

During 2000s and early 2010s, government expenditure as a share of GDP showed an increasing trend, as the government size averaged around 34 percent. This surge in the government size was due partly to the enormous rise of oil revenues and the massive public investment programs initiated in the 2000s, and partly to an expansion of subsidies. Notably, following the January 2011 riots, the Algerian government vastly increased its public spending, by providing subsidies for basic food, such as grains and milk, and providing employment opportunities in order to calm down popular protest, and to avoid a potential spill over-effects of the recent Arab spring from their neighbouring countries. Likewise, the growth rate of GDP has been broadly stable at around 3.6 percent over these decades. After the collapse of oil prices since mid-2014, while government expenditures percent of GDP have surpassed the overall period average and achieved an average of 40 percent from 2014 to 2020, the growth rate of GDP falls over time, and averages around 1.2

percent. This remarkable decline in Algeria's economic growth is due to the intertwined shocks of covid-19 pandemic and the oil price collapse.Certainly, the dramatic fall in oil prices since mid-2014 has adversely impacted Algeria's economic growth, notably through the public spending channel (Figure 2). To adjust to lower oil prices, the government has primarily focused on cutting public investment spending (IMF, 2018). However, spending cuts may eventually be detrimental to economic growth.

Figure 2. Evolution of the government expenditure percent of GDP alongside economic growth rate and oil price in Algeria
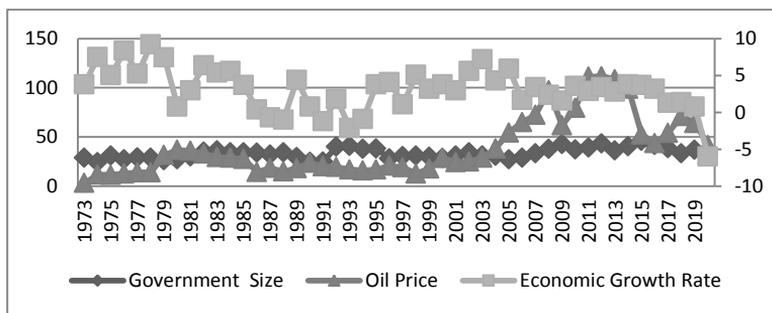
Source: Made by authors based on the data from the World Bank (2021)

It can be seen from figure 2, that most of the time periods where government size is very high, the Algerian economy tends to have a lower economic growth. This has happened particularly during the 1990s, after the 2008 financial crisis, and after the collapse in oil prices in 2014. Therefore, we provide in the subsequent section an empirical investigation based on Hansen's (2017) kink regression modelling approach to unveil the nature of the association between the two variables.

In addition to boosting economic growth, government spending in hydrocarbon rich countries has been used to help promote diversification. In this context it is worth noting that the composite of public expenditure matters for economic diversification. Certainly, well designed and implemented public spending in core infrastructure, human capital and education are crucial for the expansion of non-hydrocarbon private sector activity, which is an

essential element in achieving a broader diversification. As a result of the sharp rise in oil revenues since 2000, Algeria has made massive investments in economic and social infrastructure. During the period 2000-2016, Algeria allocated on average about 70 percent of public investment to infrastructure (such as roads, ports, rails, airports, housing, health, education) (IMF, 2018).

However, despite the sizable amount of public spending allocated to the economy (particularly economic and social infrastructure), Algeria has totally failed to competitively diversify its economy away from the hydrocarbons (Chekouri et al., 2017). The hydrocarbon sector is very strong, accounting for 41 percent of fiscal revenues, 20 percent of GDP, and 94 percent of export earnings in the past decade. However, Algeria's non hydrocarbon exports have barely exceeded the symbol level of 3% over the last decade, and remained too weak, meaning that Algeria is one of the most oil-dependent countries in the world, and among the highest concentration of exports in the MENA region.

Figure 3 illustrates this fact, with the Herfindahl-Hirschmann Index (HHI) of export concentration for Algeria is among the highest in the world (more than 0.50 percent on average during 2000-2020), reflecting the large and growing share of hydrocarbon exports in total exports. For several reasons, diversification has not been successful in Algeria despite its massive investment in infrastructure. Weak public investment efficiency is probably a reason for limited diversification in Algeria. Public investment efficiency in Algeria is lower than in other oil exporting countries in the region and well below the global average (IMF, 2018) (Figure 4). Additionally, poor institutional environment severely hits the process of economic diversification in the country. Therefore, high government spending alone is not enough to diversify the Algerian economy away from oil and gas dependency. Because, ineffective government spending could make the process of export diversification difficult.

Figure 3. Algeria Herfindahl-Hirschmann Index (HHI)

Source: Made by authors based on the data from the World Bank
(2022)https://tcdata360.worldbank.org/indicators/hh.mkt
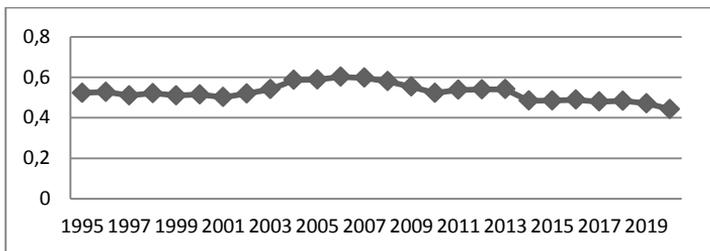
Figure 4. Public spending efficiency (1=minimum, 100=Maximum)
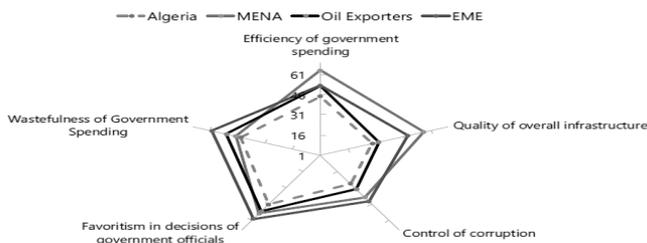
Source: IMF (2018), Article IV consultation press release, staff report, and statement by the
Executive Director for Algeria, IMF Country Report No. 18/168; p.6

3- ECONOMETRIC METHODOLOGY AND DATA

In order to investigate the optimal government size and its effect on GDP growth for the case of Algeria, this paper utilizes the regression kink model recently proposed by Hansen (2017). The regression Kink model is a threshold regression constrained to be continuous with a kink at unknown threshold (Hansen, 2017). In the regression kink model, the regression function is continuous but the slope has a discontinuity at a threshold point. This method is appropriate in the case that the threshold is not set by the policy, which correspond with our objective of examining endogenous thresholds from a relationship between economic growth and government size.

According to Hansen (2017) the functional form of the regression kink model is as follows:

$$Y_t = \beta_1(x_t - \gamma)_- + \beta_2(x_t - \gamma)_+ + \beta_3 z_t + e_t \ldots \ldots \ldots \ldots \ldots . (1)$$

Where: y_t , x_t are the interested time series variables for $t = 1,2,\ldots,n$, and z_t is a k vector of other explanatory variables which includes an intercept. e_t is an error term. The parameters to be estimated are the regression slops β_1, β_2, and β_3 , and the parameter γ called the threshold or the kink point. It is assumed that $\gamma \in \Gamma$ where Γ is compact and strictly interior of the support of the threshold variable x_t.

As in Hansen (2017), we set y_t to be GDP growth rate in year t, and x_t to be the government size measured by government expenditure to GDP ratio, serves as the threshold variable. In addition, the regression contains a lagged dependent variable to account for dynamic effects and minimize autocorrelations. Vector z_t includes two explanatory variables namely, openness to trade (Trade) which is employed as a proxy for trade activity between the country and the rest of the world, and the Gross fixed capital formation (GFCF) is employed as a proxy for private and public investment. It is noteworthy that the chosen explanatory variables were usually used in the endogenous growth literature (Barro, 1990; Karras, 1997).

We use annual data over the period from 1973 to 2020. The data for total government expenditures as a share of GDP are taken from Algeria's National Statistical Office (ONS). The other variables namely, GDP growth rate, gross fixed capital formation (GFCF) and trade openness (TRADE) are collected from the World Development Indicators (WDI) database of the world Bank (2021).

4- RESULTS AND DISCUSSION

In this section we examine the effect of government expenditures on economic growth and investigate whether an optimal level of government size exists for Algeria, by carrying out a new methodology namely a regression kink recently developed by Hansen (2017).

The estimate strategy follows Hansen (2017). We set a closed interval [20%, 50%] for the threshold parameter, with discrete grid increments of one, to guarantee that the majority of observations are inside the bounds of the grid. At each grid point for γ the regression

coefficients are estimated and the least squares criterion Sn∗(γ) are computed and plotted in Figure 5. We see that the function has a global minimum at $\hat{\gamma} = 30.40$, which is the estimated optimal government size threshold for Algeria. This figure reveals that the relationship between government size and economic growth is non-linear.

Figure 5- Concentrated least-square criterion for threshold parameter.
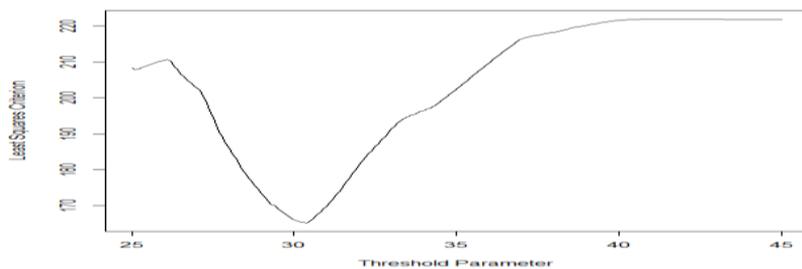
Source: Edited by Authors based on the outputs of R program

Then, the estimated parameters from this regression kink model are as follows:

$$y_t = 0.79(x_{t-1} - 30.4)_- - 0.19(x_{t-1} - 30.4)_+ + 0.14y_{t-1} + 18.67\,Trade + 1.99 GFCF - 38.57 + \hat{e}_t \ldots (2)$$

$$\quad (0.25) \quad\quad (0.90) \quad (0.09) \quad\quad (0.90) \quad (0.13) \quad\quad (3.95) \quad\quad (0.60) \quad\quad (8.16)$$

$$\hat{\delta}^2 = 3.51$$

In this equation, y_t is the GDP growth rate, x_t is government expenditures to GDP ratio (or government size), Trade is trade openness, GFCF is gross fixed capital formation and the parentheticals are the standard errors of estimators. The standard error of our estimated regression kink model is 3.51, which is relatively low. Our estimated equation, also points out to a non-linear relationship (an inverted U shape) between government size and economic growth.

Moreover, the results of the estimates suggest that when government expenditures to GDP ratio is below the 30.4 percent threshold, any increase by 1 percent in the ratio of government spending to GDP increases the growth rate of GDP by 0.79 percent point. However, every 1 percent increase in government expenditures to GDP ratio above the threshold decreases the GDP growth rate by 0.19 percent point. Therefore, the effect of public spending over economic growth in Algeria is positive but is reduced for government

expenditures above 30.4 percent threshold compared to the effect government expenditures to GDP ratios below the estimated threshold. Thus, this outcome confirms that the Armey curve hypothesis is valid for Algeria over the studied period. Our estimates, also show a positive coefficient for the lagged GDP growth rate of 0.14, which is standard for estimating outcome of growth rates time series (Hansen, 2017). Further, the other explanatory variables namely Trade and GFCF have the expected positive effect on economic growth.

After estimating our regression kink model following equation (1), we test whether or not the estimated threshold model (1) is significant relative to a linear model (3).

$$Y_t = \beta_1 x_t + \acute{\beta}_3 + e_t \dots\dots. (3)$$

For this purpose, we test for the null hypothesis of the linear model (3) against the threshold regression kink model (1). We reject the null hypothesis $H_0: \beta_1 = \beta_2$ at significance level α if $p_n < \alpha$, or equivalently if $T_n > c_\alpha$. Where: c_α the critical value of α, and the F statistic $T_n = \frac{n(\tilde{\delta}^2 - \hat{\delta}^2)}{\hat{\delta}^2}$. Following Hansen (2017), to ensure the accuracy of the *p*-value p_n, the number of bootstrap replications is set to be 10000. The obtained results reveal a multiplier bootstrap *p*-value of 0.0065, which is less than α at the 10 percent significance level. Likewise, the bootstrap estimate of the 10 percent critical value (6.65) is less than the F-statistic ($T_n = 16.18$). Therefore, we reject the null hypothesis of linearity in favor of the alternative hypothesis of the regression kink model.

Moreover, to determine the significance of the estimated threshold we use the algorithm proposed by Hansen (2017) to construct the confidence interval by Wild bootstrap Confidence intervals for parameters. For this purpose, the threshold F-statistic is calculated according to the test of hypothesis $H_0: \gamma = \gamma_0$ against $H_1: \gamma \neq \gamma_0$. The criterion test is to reject the null hypothesis if the values of the F-type statistic $F_n(\gamma_0) \left[where, F_n(\gamma) = \frac{n(\hat{\delta}^2(\gamma) - \hat{\delta}^2)}{\hat{\delta}^2}\right]$ are larger than the bootstrap critical value. Figure 6 plots the statistic $F_n(\gamma)$ as a function of the threshold. Because the asymptotic interval (dashed blue line) in Figure 6 is a subset of the bootstrap confidence interval (dashed red line), we

reject the null hypothesis. Therefore, the threshold parameter is statistically significant.

In Table 1 the confidence intervals for the estimated coefficients are also computed by the bootstrap method recommended by Hansen (2017) with 10000 bootstrap replications. The 90 percent confidence intervals for the threshold γ is 28.3 % to 32%, which is relatively small, thus, providing a relatively precise value of government expenditures above which more public spending becomes detrimental for economic growth. The 90 percent confidence intervals for the coefficient β_2 (the slope effect of government expenditures on growth for expenditures ratios above the threshold) is $[-0.395 \, ; 0.018]$, which is relatively wide. Hansen (2017) justifies the wideness of the bootstrap confidence intervals due to the small sample size.

Figure 6. Confidence interval construction for threshold.
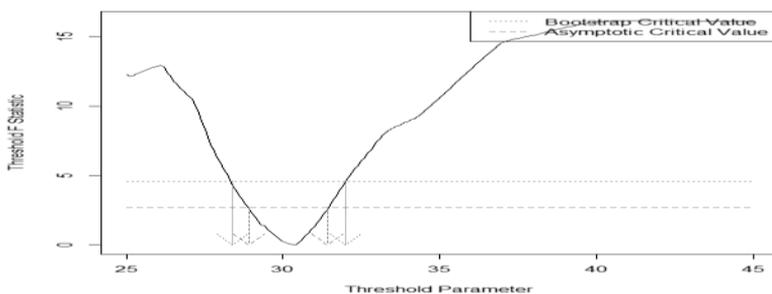
Source: Edited by Authors based on the outputs of R program

Table 1. Coefficient estimates and Bootstrap 90% confidence intervals

	Estimate	Standard Errors (S.E.)	Bootstrap 90% confidence intervals	
			Lower	Upper
β_1	0.79	0.25	0.179	1.398
β_2	-0.19	0.09	-0.395	0.018
Y_{t-1}	0.14	0.13	-0.052	0.339
Trade	18.67	3.95	12.278	25.065
GFCF	1.99	0.60	1.015	2.959
Intercept	-38.57	8.16	-51.297	-25.841
λ	30.40	0.90	28.300	32.000

Source: Edited by Authors based on the outputs of R program

Finally, for a better visualization of the above results, a scatter plot analysis for the relationship between government size and economic

growth is reported in Figure 7. In this figure, the red point corresponds to the kink point (threshold) along with the fitted regression line corresponding to equation (1) and pointwise 90% confidence intervals.

The results obtained from the scatter plot reveal an inverted U-shaped relation between government size and economic growth for Algeria, with a positive slope for low government expenditures ratios, and a negative slope for expenditures ratios above the threshold (the optimal government size) of 30.4 percent (displayed as the red square in figure 5). Figure 5 shows that the confidence intervals remain quietly constant around the optimal threshold of 30.4 percent and then widen slightly as government expenditures ratios increase above its optimal threshold level. This indicates that all our estimators are consistent, statistically significant and robust.

Figure 7. Scatterplot of GDP growth and government size, with estimated regression kink model, and 90% confidence intervals.
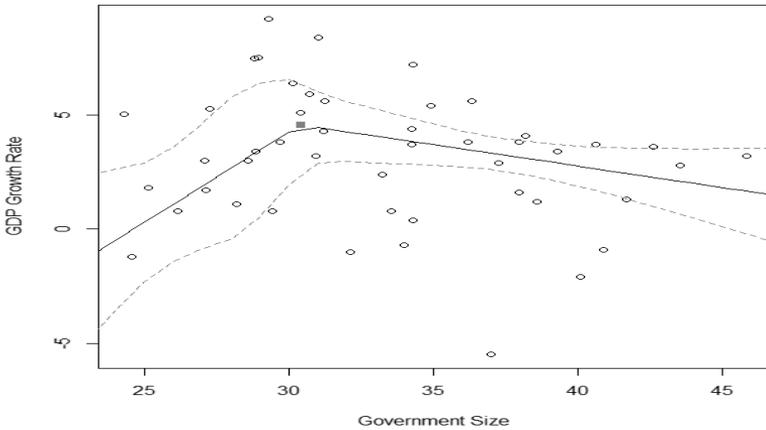
Source: Edited by Authors based on the outputs of R program

The results of the regression kink model analysis suggest that the optimal government size that maximize growth in Algeria is around 30.4 percent. Interestingly, this finding is very close to the optimal government size found by Rennane (2019). As well, our estimated

optimal threshold level is also consistent with the findings of Al-Abdulrazag (2021) for Saudi Arabia, El Husseiny (2018) for Egypt, and close to that of Nouira and Kouni (2021) when determined the optimal government expenditure for selected MENA countries to be between 20 and 30 percent.

CONCLUSION AND POLICY IMPLICATIONS

This study investigated the effect of government expenditure on economic growth, and tested the validity of the Armey curve hypothesis for Algeria during the period from 1973 to 2020. A kink regression with unknown threshold approach recently suggested by Hansen (2017) is conducted for this analysis. It is worth noting that the main advantage of Hansen's (2017) kink regression model over other threshold models, include that Hansen used recently developed inference methods by Fang and Santos (2014) and Hong and Li (2015) instead of the conventional inference methods, which according to Hansen cannot be applied to the regression function, since the latter is a non-differentiable function of the parameter estimates of the regression kink model. Therefore, this new method guarantees the consistency of the regression estimates. Overall, our finding strongly confirms the validity of the Armey curve hypothesis in the case of Algeria, and suggests an estimated optimal government size threshold around 30.4 percent of GDP. Indeed, we find that an increase in the share of government expenditure above the 30.4 percent threshold leads to a significant decline in the economic growth of the Algerian economy. Our finding also reveals that both trade openness and gross fixed capital formation significantly contribute to economic growth.

A quick comparison, showed that the estimated optimal threshold level (30.4) is inferior than the average share of government expenditure of 39 percent that existed during the 2014-2020 period, and the effective share of 35.6 percent in 2020. This, indeed, indicates that the current size of government expenditure in Algeria is slightly above the threshold point of its Armey curve. Regarding the fact that Algeria has attained its optimal level of government size, it seems to be more important for

authorities now to focus more on improving the efficiency of government expenditure. Certainly, strengthening the quality of the state budget institutions helps ensure government accountability, transparency and prevent the waste of public funds.Moreover, policies aimed at diversifying the Algerian economy should first try to improve the quality of public institutions to enable more effective expenditure control, otherwise high public spending could lead to huge opportunities for corruption and waste in public resources.

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