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Foreign Direct Investment and Industrial Growth in Algeria: A Nonlinear ARDL Approach

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Abstract:

This paper attempts to find the effect of foreign direct investment on total factor productivity in Algeria's industrial sector. We use the classical paradigm of Solow and a Cobb-Douglas function, to estimate total factor productivity as a proxy for measuring industrial growth. Moreover, trade openness, and human capital which were the main variables are used as determinants of industrial growth, by applying the non-linear autoregressive distributed lag model method over the period 1990-2019. The main findings indicate the presence of asymmetric relations between foreign direct investment and total factor productivity in the long and the short-run time. Furthermore, the estimation results demonstrate an asymmetric interaction between trade openness and total factor productivity in the long-run, both in the short-run time, indicating that positive and negative changes in trade openness induce a decrease in total factor productivity in the industrial sector. Finally, human capital has a positive impact on total factor productivity in the industrial sector.

Keywords: foreign direct investment, Industrial growth, human capital, total factor productivity, trade openness.

Jel classification: C13, E2, F21, O4, O47.

1. Introduction

Foreign direct investment (FDI) is a major key determinant of economic growth (OCDE, 2002). Foreign direct investment as popularly known "FDI" is a strong component of the global economy and integration. As well, the main target of FDI is to establish long-term interest. Therefore, FDI is a steady form of international capital which is preferred over foreign portfolio investment. As a direct result, it is appreciated by both policy maker and government (Kumar, 2018). The FDI environment in the 21st century has largely changed. Both companies and governments are engaged to attract foreign direct investment particularly in emerging markets. Besides, FDI inflows are a significant determinant of total factor productivity (TFP) in the host country (Adan, Chowdhury, & Malik, 2019).

FDI is considered a solution to restricted local capital and the problems of low productivity in major developing countries (Kizilkzya, Ahmet, & Akar, 2016). Then, foreign direct investment is a pivotal factor for economic growth.

Research Problem

The causality that exists between foreign direct investment and economic growth has proved by several types of researches. In this paper, we will focus on the FDI impact on total factor productivity in the industrial sector in Algeria: what is the impact of foreign direct investment on Algeria's industrial economic growth?

Study hypothesis:

In order to answer the research problem, the following hypothesis was formulated:

-the positive changes and the negative changes in foreign direct investment have an asymmetric relationship in long-run on Algeria's industrial economic growth.

-the positive changes and the negative changes in trade openness have a symmetric relationship in long-run on Algeria's industrial economic growth.

-human capital has a positive impact on total factor productivity in the industrial economic growth.

Research Focus

Foreign direct investment plays a major role in the improvement of macroeconomic aggregates. In this context, Algeria is engaged to attract foreign companies by boosting a dimension of attractive measures. In terms of figures, total FDI flows at the end of 2019 were approximately equal to 1.4 USD (Galal, 2023) , with inflation rate close to 5 percent, and a return to economic growth that should be around 1.7 percent. As a result, there are huge opportunities to invest in Algeria this significant opportunity takes a place for transforming Algeria into emerging country. In view, in this research we are focus to analyzing the Impact of Foreign Direct Investment (FDI) on Algerian Industrial Growth through the Application of the Non-Linear Autoregressive Distributed Lag Model (NARDL).

Research Aim and Research Content

The main objective of this paper is to prove the co-integration that exists between industrial growth (TFP) and FDI. Therefore, we use the non-linear ARDL approach (NARDL). Then, our paper structure as follows: the first part is the theoretical part. The second part focuses on the previous empirical studies, and in the last part, we describe the data set, the variable measures and the econometric approach. Finally, we present the results of our estimations.

2. Literature Review

Overall, if we need to determine how an expansion of foreign direct investment flows affects economic growth, we will return to the explanatory theories of economic growth that illustrate the direct link between these two macroeconomic aggregates. At the same time, investment is part of aggregate demand.

Since Adam Smith and his celebrated book "wealth of nations", growth has occupied the minds of many economists. The neoclassical model, as it is perceived today, was developed successively by, (Ramsey, 1928) (Solow r. m., 1956) (Swan, 1956), (Koopman, 1963). Solow's model provides a positive result: "all countries that make an investment effort may achieve economic growth".

The endogenous growth theory clarifies the relationship between foreign direct investment (FDI) and economic growth, indicating that FDI facilitates the transfer of technology, the accumulation of human capital, and the amplification of international trade. So, endogenous growth theories explain growth through the accumulation of four main factors: technology, physical capital, human capital and public capital.

Using Romer's (1993) model a study was done by (Lee, Gregori, & Borensztein, 1998) to verify the impact of foreign direct investment (FDI) on economic growth in 69 developing countries. The results indicate that FDI is a key factor for transferring technology; it has a stronger impact on growth than domestic investment. Even so, the higher productivity of FDI is conditioned by the qualified human capital of the host country. Thus, FDI and economic growth converge if and only if the host country has sufficient absorptive capacity for advanced technologies.

In addition, (Demello, 1999): has demonstrated that FDI stimulates long-term growth through technological upgrading and spillover effects in both the economy of OECD and non-OECD. In the same way, as proposed by (ku & chen, 2000) the suggestion is that FDI is anticipated to enhance the viability and competitiveness of domestic industries rather than diminishing them. However, the relationship between FDI and economic growth is not as definitively established in the case of Morocco.

More importantly (Chowdhury & Mavrotas, 2005): employed Toda-Yamamoto test for causality over the period 1969 to 2000 for countries (Chile, Malaysia & Thailand). The results implied unidirectional causality from GDP to FDI (GDP is an important determinant of FDI) in the case of Chile, while for both Malaysia and Thailand, there is strong evidence of bi-directional causality between GDP and FDI.

(Aklulava, 2011): conducted an analysis of the influence of Foreign of foreign direct investment (FDI) on industrial economic growth and treating the Belarusian industrial aggregated panel data from 2002 to 2009. The estimation results revealed both positive impacts of FDI on (the construction industry, IT, real estate, and machinery, food and fuel industry) and negative on (black metallurgy, construction materials, forestry, communications, and culture). On the other side, (Khan & Agrawal, 2011) proved that 1% rise in FDI would result in a 0.07% rise in GDP of China and 0.02% rise in GDP of India. Thereby, FDI has a higher effect on China's growth than India's. Whereas, in BRICS

countries over the time 1989-2012 (Gaurav, 2015) confirmed the presence of long-run equilibrium relationship between foreign direct investment and economic growth. According to the findings by (Samal & Raju, 2016), FDI emerges as a crucial factor influencing India's industrial growth. Moreover, (Danmola & Olateju, 2017): Applying the VAR approach the main results reveal that FDI has a positive influence on the manufacturing sector.
In the study conducted by (Bobo, Amadu, Idrissa, & Abdou, 2019), findings reveal a negative influence of foreign direct investment (FDI) on the productivity of manufacturing firms, specifically a 1 % increase in the productivity of foreign companies leads to a 4.4% reduction in that of domestic firms. Additionally, a 1% increase in multinational enterprises reduces the sales growth of domestic firms by 0.10%.

In conclusion, (Benyoub, Aouar, & Kharafi, 2019) applied the co-integration technique over the period from 1980 to 2017. Their findings indicate that foreign direct investment flows exert a positive impact on Algeria's industrial growth, both in the short term and the long term.

The conflicting findings across these studies underscore the complexity of the relationship between FDI and economic growth. The impact of FDI is contingent upon various factors such as the institutional environment, technological capabilities, industry characteristics, and policy frameworks of the host country. Consequently, different studies may emphasize different aspects of this relationship, leading to diverse conclusions.

In summary, while some studies suggest a positive impact of FDI on economic growth through technology transfer and spillover effects, others indicate negative effects on domestic firms' productivity due to increased competition from foreign companies. These divergent findings highlight the need for nuanced analysis and consideration of contextual factors when evaluating the impact of FDI on economic growth.

3. Materials and Methods

We employ the non-linear autoregressive distributed lags model (NARDL) to analyze the results, using total factor productivity for the industrial sector (TFP) as a proxy variable for Algeria's industrial growth. Using data collected from the IMF's database, UNACTED's database and Algeria's bank for the period 1990-2019. In this part, we will describe the method that will be used, as well as, we will present the main findings and results.

The examined variables are presented in table1

Table (1)

Variables selected for analysis and respective data source

Variable	Proxy used	Source of Data
Industrial Growth	TFP	Calculate by researchers
Foreign direct investment	Inflow FDI	UNACTED
Trade openness	TO	Calculate by researchers
Human capital	H	Barro and lee

Source: databases mentioned above and computation by the authors.

The inclusion of all these variables is based on previous literature on FDI-growth.

Industrial growth : proxy by total factor productivity.

FDI_t: denotes the foreign direct investment.

H_t: proposed by (Barro & Lee, 1946)and used as a proxy for human capital in the host economy. It reflects the importance of human capital in driving economic growth and development, as evidenced by its significant correlation with growth in empirical studies, similarly, (Paul M, 1990) predicts a strong role for human capital in economic growth.

Total factor productivity (TFP) of Algeria's industrial sector represents the dependent variable. Analyzing is essential to conclude a result that foreign direct investment impacts industrial growth. TPF: is calculated using the cobb-douglas production function (Solow M. R., 1957):

$$Y_t = A * F(K, L) \qquad (1)$$

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http://eelet.org.uk

$$Y_t = AK_t^{\alpha} L_t^{\beta} \quad (2)$$

Where: Y_t: representing the value added by the industrial sector.; L_t: Labor output factor in the industrial sector; K_t: Capital production factor; A: represent the level of productivity; $(\alpha) and (\beta) 1$: are the shares of inputs.

Using the logarithmic function, total factor productivity (TFP) is quantified using a specific formula :

$$log(y_t) = log(TFP) + \alpha log(K_t) + (\beta) log(L_t) \quad (3)$$

$$log(TFP) = log(y_t) - \alpha log(K_t) - (\beta) log(L_t) \quad (4)$$

Therefore, the link between foreign direct investment (FDI) and total factor productivity (TFP) in Algeria's industrial growth is conceptualized as a linear functional form:

$$TFP_t = f(FDI_t; H_t; TO_t) \quad (5)$$

$$TFP_t = C_0 + FDI_t + H_t + TO_t + \mathcal{E}_t \quad (6)$$

FDI: Real value of FDI inflows is calculated using the following formula:

$$Realvalue of FDI = (^{(nominal value of FDI)}/_{GDP deflator}) * 100 \quad (7)$$

Trade openness is calculated using the following equation:

TO: total exports and imports divided by gross domestic product[2].

$$TO = (^{(exports + imorts of goods and services)}/_{GDP}) * 100 \quad (8)$$

H: human capital as a measure to assess skilled labor within Algeria's industrial sector.

But we need to test this relationship in a nonlinear framework, so it's a nonlinear equation format;

$$TFP_t = f(FDI\_Pos_t; FDI\_Neg_t; TO\_Pos_t; TO\_Neg_t; H_t) \quad (9)$$

4. NARDL model presentation:

The most commonly exploited co-integration methods are the two-step process of (Engle & Granger, 1987, pp. 251-276) the approach of (Johansen, 1988, pp. 231-254) and the method of (Soren & Katarina, 1990, pp. 169-210). However, these standard co-integration tests are used in a condition where all series are integrated in the same order $[I(0)\ or I(1)]$. Furthermore, they provide good and significant results with large sample sizes. In an attempt to address these problems, (Saranape, Shin, & Smith, 2001, pp. 289-236) evolved a different mechanism more flexible than preceding methods; it is the autoregressive distributed lag (ARDL). At first, we present the formula of the linear (ARDL) model as in Eq (1), and then we explain the NARDL model.

$$\Delta TFP_t = C_0 + \rho TFP_{t-1} + \theta_1 FDI_{t-1} + \theta_2 H_{t-1} + \theta_3 TO_{t-1} + \sum_{j=1}^{p-1} \alpha_j \Delta TFP_{t-j} + \sum_{j=0}^{q} \mu_j \Delta FDI_{t-j} + \sum_{j=0}^{q} \sigma_j \Delta H_{t-j} + \sum_{j=0}^{q} \delta_j \Delta TO_{t-j} + \varepsilon_t \quad (11)$$

Δ ; represents the first difference operator, TFP_t is the dependent variable in period t, C_0 implies the intercept, $\langle FDI_t; H_t; TO_t \rangle$ vector of regressors, and $\rho and \theta$ indicate the long-run coefficients. As well, α_j ; μ_j ; $\sigma_j; and \delta_j$ are the short-run coefficients, $p and q$ signify the optimal lags for the dependent variable and the independent variables, respectively, to end with, ε_t the error term at time t.

We cannot suppose that all adjustment processes proceed with a linear trend. However, it could be nonlinear. NARDL approach introduced by (Yongcheol, Byungchul, & Greenwood-Ni, 2014, pp. 281-314) suggests a methodology to

[1] Estimated by researchers, by using ARDL model, see appendix A.
[2] https://hbs.unctad.org/calculation-methods. 13/01/2024.

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discern between asymmetric effects of variables in both short-run and long-run time. The approach being described, based on the NARDL (Nonlinear Autoregressive Distributed Lag) model outlined by (Shin, 2014) Shin in 2014, involves a regression model designed to capture asymmetric effects in the long run. This model is formulated to accommodate both positive and negative changes in variables and assess their influence on the outcome of interest over time.

$$TFP_t = \beta_0 + \beta_1 FDI_t^+ + \beta_2 FDI_t^- + \beta_3 TO_t^+ + \beta_4 TO_t^- + \beta_5 H_t + \varepsilon_t (12)$$

Where; the independent variables $\langle FDI; TO \rangle$are decomposed into its positive and negative partial sum:

Increases reaction: appears in equations (13, 14, 15, 16)

$$POS = FDI_t^+ = \sum_{j=1}^{t} \Delta FDI_j^+ = \sum_{j=1}^{t} max\,(\Delta FDI_t; 0) \qquad (13)$$

$$POS = TO_t^+ = \sum_{j=1}^{t} \Delta TO_j^+ = \sum_{j=1}^{t} max\,(\Delta TO_t; 0) \qquad (14)$$

Decreases reaction:

$$NEG = FDI_t^- = \sum_{j=1}^{t} \Delta FDI_j^- = \sum_{j=1}^{t} min\,(\Delta FDI_t; 0) \qquad (15)$$

$$NEG = TO_t^- = \sum_{j=1}^{t} \Delta TO_j^- = \sum_{j=1}^{t} min\,(\Delta TO_t; 0) \qquad (16)$$

(Shin & al, 2014) demonstrate that by relating (2) with the ARDL (p, q) model (1) we get the NARDL (p, q) model as: appears in equation (17)

$$\begin{aligned}\Delta TFP_t = {} & \rho TFP_{t-1} + \theta^+ FDI_{t-1}^+ + \theta^- FDI_{t-1}^- + \gamma^+ TO_{t-1}^+ + \gamma^- TO_{t-1}^- + \varphi H_{t-1} \\ & + \sum_{j=1}^{p-1} \varphi_j \Delta TFP_{t-j} + \sum_{j=0}^{q} (\delta_j^+ \Delta FDI_{t-j}^+) + \sum_{j=0}^{n} (\delta_j^- \Delta FDI_{t-j}^-) + \sum_{j=0}^{m} (\delta_j^+ \Delta TO_{t-j}^+) + \sum_{j=0}^{k} (\delta_j^- \Delta TO_{t-j}^-) \\ & + \sum_{j=0}^{s} (\delta_j \Delta H_{t-j}) + \varepsilon_t (17)\end{aligned}$$

Then, we can observe that the equilibrium relationship among dependent variable $TFP$and explanatory variables $\langle FDI.; TO \rangle$ are separated into positive $(\beta^+ x_t^+)$ and negative $(\beta^- x_t^-)$ changes, ρ_t representing possible deviations from the long-equilibrium. $\langle \theta^+; \gamma^+ \rangle$ and $\langle \theta^-; \gamma^- \rangle$are the asymmetric long-run parameters related to positive and negative changes in $\langle FDI.TO \rangle$, respectively. $\langle \sum_{j=0}^{q} \delta_j^+ ; \sum_{j=0}^{m} \delta_j^+ \rangle$; indicates the short-run effect of foreign direct investment, and trade openness increases on TFP, while $\langle \sum_{j=0}^{n} \delta_j^- ; \sum_{j=0}^{k} \delta_j^- \rangle$ illustrate the short-run effect of foreign direct investment and trade openness decrease on TFP.

5. Bounds test for asymmetric run co-integration:

Similar to ARDL bounds test, NARDL bounds test the non-linear co-integration:

$$H_0 = \rho = \theta^+ = \theta^- = \gamma^+ = \gamma^- = \varphi = 0$$

$$H_1 = \rho \neq \theta^+ \neq \theta^- \neq \gamma^+ \neq \gamma^- \neq \varphi \neq 0$$

Wald test for long-run asymmetry:

We validate the presence of both long run and short run asymmetries relationship between the levels of the series, $TFP_t, FDI_t^+, FDI_t^-; TO_t^+ and TO_t^-$, using standard Wald tests, the relevant joint null hypothesis is $\begin{matrix} H0: L^+ = L^- \\ H_1: L^+ \neq L^- \end{matrix}$.

$L^+ = -\frac{\rho}{\theta^+}; L'^+ = -\frac{\rho}{\gamma^+}$; and $L^- = -\frac{\rho}{\theta^-}; L'^- = -\frac{\rho}{\gamma^-}$; .

European Economic Letters
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http://eelet.org.uk

If we reject H_0 it means we have long run asymmetric relationship. It explains that when FDI and TO increase, the change in TFP is not equal in terms of size to when FDI and TO decrease. In other words, the effect on TFP is not symmetrical; it varies depending on the direction of change in FDI and TO. The long-run coefficients$\langle -\frac{\rho}{\theta^+}; -\frac{\rho}{\theta^-}\rangle$; $\langle -\frac{\rho}{\gamma^+}; -\frac{\rho}{\gamma^-}\rangle$ will represent the long-run effects of foreign direct investment and trade openness increases and decreases, respectively, on the TFP.

6. Asymmetric dynamic multipliers:

Dynamic multipliers show how TFP_t adjusts to its new long-run equilibrium following a NEG and POS shock in $\langle FDI_t; TO_t\rangle$. The cumulative dynamic-multiplier effects of $\langle FDI_t^+; FDI_t^-; TO_t^+; TO_t^-\rangle$ on $TFP_t$are calculated as: appears in equations (18, 19)

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial TFP_{t+j}}{\partial FDI_t^+}\ ;\ m_h^- = \sum_{j=0}^{h} \frac{\partial TFP_{t+j}}{\partial FDI_t^-} for h = 0.1.2 \ldots \quad (18)$$

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial TFP_{t+j}}{\partial TO_t^+}; m_h^- = \sum_{j=0}^{h} \frac{\partial TFP_{t+j}}{\partial TO_t^-} for h = 0.1.2 \ldots \quad (19)$$

$$where h \to \infty\ ; then m_h^+ \to L^+\ ; m_h^- \to L^-$$

7. Results:

7.1. Unit root tests

Stationarity of variables is essential in applying time series data3, when facing the issue of spurious regression, it becomes evident that linear regression using non-stationary variables is not valid. Specifically, the distribution of parameters in the regression model deviates from a Student's t-distribution to that resembling Brownian motion. In situations where variables exhibit non-stationarity, cointegration emerges as a pertinent concept aiding in the selection of appropriate models. Moreover, stationarity significantly influences time series prediction, as the prediction interval varies based on whether the series is stationary or non-stationary.

Stationarity can be ensured by: ADF (Augmented Dickey-Fuller), Phillips-Perron and KPSS tests. Thus, before the estimation, we carried out unit root tests to define the order of integration of the series and to make sure that none are in I(2) conditions for applying NARDL method. The results of the augmented dickey-fuller (ADF) unit root test are presented in appendix A.

The result of ADF test suggests that TFP and LH are stationary at level, while LFDI is stationary at the first level difference, so, none are $I[2]$.

7.2. Co-integration Results

The results of the co-integration are presented in table 2. If the calculated F statistic is greater than the upper bound critical values, then there is evidence of co-integration. That means the null hypothesis of no co-integration is rejected for the model. Thus, the F statistic, as presented in Table 2, provides evidence supporting the existence of co-integration among the variables.

Table (2)

Bounds-test for nonlinear co-integration

F-Bounds Test				
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**

[3] A time series is stationary if it's mean and variance does not change over time.

F-statistic	12.27666	10%	2.08	3
K	5	5%	2.39	3.38
		1%	3.06	4.15

Source: regression output, Eviews 10.

Based on the above results, it is justified that the F-Statistics (12.27666) is greater than the critical upper bound (4.15). It does mean that we can accept the alternative hypothesis of co-integration which indicates the occurrence of a long run relationship between total factor productivity and explanatory variables. Therefore, TFP and FDI are moving together in long-run. The estimation result of asymmetrical short-run and long-run coefficients of our NARDL model is listed in table 3.

Table (3)

Result of asymmetric short-run and long-run coefficients

NARDL Long Run Form and Bounds **Test Dependent Variable: D(TFP)** **Selected Model: ARDL(1, 1, 2, 2, 1, 2)** **Sample: 1990 2019** **Included observations: 30**				
Asymmetric long-run coefficients (Dependent Variable: TFP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LFDI_POS	0.003268	0.001404	2.327467	0.0449
LFDI_NEG	-0.000967	0.000234	-4.131462	0.0026
LTO_POS	-0.733213	0.214132	-3.424112	0.0076
LTO_NEG	-0.033198	0.010020	-3.313141	0.0090
LH	0.115735	0.037464	3.089207	0.0129
C	0.041493	0.012717	3.262817	0.0098
EC = PGF_R - (0.0033*LFDIR_POS -0.0010*LFDIR_NEG -0.7332*LTOR_POS - 0.0332*LTOR_NEG + 0.1157*LH + 0.0415)				
Asymmetric short-run coefficients (Dependent Variable: TFP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LFDI_POS)	0.002506	0.000805	3.114279	0.0071
D(LFDI_NEG)	-0.003253	0.001106	-2.941987	0.0101
D(LFDI_NEG(-1))	0.003545	0.001329	2.668284	0.0175
D(LH)	-0.018701	0.034038	-0.549410	0.5908
D(LH(-1))	-0.055732	0.029351	-1.898786	0.0770

D(LTO_POS)	0.196117	0.049252	3.981904	0.0012
D(LTO_NEG)	-0.013954	0.063804	-0.218699	0.8298
D(LTO_NEG(-1))	-0.378571	0.071227	-5.314996	0.0001
CointEq(-1)*	-0.865625	0.126180	-6.860217	0.0000
R-squared	0.877001	Mean dependent var	-0.000561	
Adjusted R-squared	0.800126	S.D. dependent var	0.006409	
S.E. of regression	0.002865	Akaike info criterion	-8.580622	
Sum squared resid	0.000131	Schwarz criterion	-8.052688	
Log likelihood	126.8384	Hannan-Quinn criter.	-8.423640	
F-statistic	11.40820	Durbin-Watson stat	2.168282	
Prob(F-statistic)	0.000016			

Source: regression output, Eviews 10.

The results in table 3 specify that error correction term EC_{t-1} is negative and statistically significant at 1% level, thus, it confirms the evidence of cointegration among variables in our model and indicates the speed of adjustment of about 0.86 in absolute value which specifies about 86% of the adjustment towards the long-run equilibrium per year.

The results reported in table 4 clearly show the presence of asymmetry impacts of FDI on TFP and asymmetry impacts of TO on TFP (indicator for measuring the growth of the industrial sector). As can be seen, FDI_t^+ , and FDI_t^-appear to be significant meaning that both positive and negative changes in FDI have a divergence impact on TFP. Additionally, the existence of asymmetric impacts of FDI is also affirmed by the standard wald test of asymmetry (see table 4). According to short-term estimations, both an increase in foreign direct investment (FDI) inflows and trade openness have a positive impact on Algeria's industrial growth. However, the decline in foreign direct investment has a negative impact on Algeria's industrial growth. Furthermore, trade openness has a positive impact on industrial growth in the short term, this is due to country's structure as a 96 percent hydrocarbon exporter, because the Algerian economy relies heavily on oil exports which are the main source of foreign exchange and account for about 60 percent of budgetary revenues and which also feed into the Algerian GDP. However, this positive impact does not last in the long term.

Additionally, it shows that the increase in foreign direct investment and trade openness are the most important variables to explain industrial growth in the short run. Thus, the long-run results evinced that the increase in foreign direct investment and human capital increase Algeria's industrial growth.

Similarly, it indicates that a one-unit increase in FDI results in a 0.003 unit increase in industrial growth, indicating a positive correlation between FDI and industrial growth. Conversely, a one-unit decrease in FDI leads to a 0.0009 unit decrease in industrial growth, implying a negative reaction. This suggests that FDI plays a significant role in driving industrial growth in the context being discussed.

Furthermore, the human capital has a positive effect on total factor productivity. This means that investments in education, training, and skill development contribute to improving productivity across various sectors of the economy. The implication is that a well-qualified workforce enhances efficiency, innovation, and overall economic performance, leading to higher total factor productivity.

Overall, the results indicate the importance of both foreign direct investment and human capital in fostering industrial growth and enhancing total factor productivity in the analyzed context.

However, the increase in trade openness will decrease the TFP, so, the negative impact of the trade openness on total factor productivity can be explained by the specificity of Algeria as a developing country. Developing nations often face challenges such as limited infrastructure, institutional constraints, and vulnerability to external shocks, which can impede the realization of productivity gains from increased trade openness. Algeria's heavy dependence on oil exports, comprising 97 percent of its total exports, further complicates the relationship between trade openness and TFP. This concentration in exports suggests a lack of diversification in the economy, which may hinder the effectiveness of trade liberalization in stimulating productivity growth in non-oil sectors.

Table (4)

Wald test

Independent : TFP	**F-Statistics**	**DF**	**P-Value**	**Selected Specification**
Long-run asymmetries				
LFDI				
Long-run	21.10285	(1, 15)	0.0004	Asymmetry
LTO				
Long-run	166.4263	(1, 15)	0.0000	Asymmetry
Short-run asymmetries				
LFDI				
Short-run	39.75476	(5, 5)	0.0005	Asymmetry
Short-run	52.63429	(3, 5)	0.0003	Asymmetry

Source: regression output, Eviews 10.

Using the result of the wald test shown in table 4, therefore, we can reject the null hypothesis of equality because p-value is less than 0.05. As a consequence, the wald test proves that there is an asymmetry relationship in the long-run impact of foreign direct investment on total factor productivity in Algeria's industrial sector. Instead, the p-value for trade openness is less than 5 percent, as a result, the relationship between TFP and TO is asymmetry in long-run, both in short-run.

7.3. Diagnostic tests:

Significant tests were used to obtain the following results:

From appendix (table (4)), all the diagnostic tests (JB, Reset, LM and Arch) associated with asymmetric model indicate that the model is well specified.

- The heteroskedasticity test gives a probability that is equal to 0,9954 > 0,05 (5%). Therefore, the variance is constant. As a consequence, there is homoscedasticity. This means that the coefficients of the model are efficient.
- The LM test indicates there is no autocorrelation of errors because $probability\ (chi2)\ 0.1957 > 0{,}05$;
- Ramsey's specification test shows a probability $F = 0{,}1764 > 0{,}05$. So the model is well specified. Jarque Bera's normality test shows that $JB = 5.55355 > 5{,}991$. Therefore, industrial growth follows a normal law.

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7.4. Stability Tests:

To examine structural stability, recursive estimation has been employed, involving two types of tests. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests are utilized to identify structural stability within the nonlinear autoregressive distributed lag (NARDL) model.

Null hypothesis:

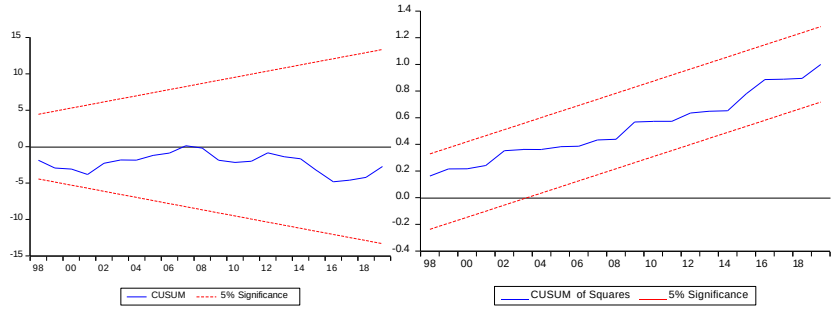
H_0 : *There is no structural change in parameters.*

Alternative hypothesis :

H_A: *There is a structural change in parameters.* The results for the structural stability test have been shown by using the software EViews 10 in figure 1.

Figure (1)

CUSUM and CUSUMSQ tests for parameter stability



Source: regression output, Eviews 10.

The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests are applied to assess the structural stability within the model, as depicted in figure 1.

The decision rule dictates that we fail to reject the null hypothesis when the cumulative sum (CUSUM) line falls within the bounds of two critical lines at a 5% significance level. Conversely, the null hypothesis is accepted in scenarios outside this range. In this instance, since the cumulative sum (CUSUM) line falls within the specified bounds, we cannot reject the null hypothesis. This suggests that the NARDL model maintains structural stability throughout the study period.

8. Results and discussion

Foreign Direct Investment (FDI) plays a significant role in the industrial growth of Algeria, influencing various economic sectors and contributing to overall development.

FDI brings much-needed capital into Algeria, which is crucial for the development of infrastructure and industrial projects. This capital inflow helps in setting up new industries and expanding existing ones, leading to industrial growth. As well, foreign investments often come with advanced technologies and expertise that are transferred to the host country. In Algeria, this technology transfer enhances productivity and efficiency within various industrial sectors, fostering innovation and modernizing production processes. In addition, the establishment and expansion of industries through FDI create employment opportunities for the local population. This not only helps reduce unemployment rates but also improves the skill set of the workforce, contributing to the overall economic growth. Moreover, FDI often leads to the development of critical infrastructure such as roads, ports, and power plants. Improved infrastructure supports industrial activities by reducing operational costs and increasing efficiency, thus attracting more investments and facilitating industrial growth.

Furthermore, foreign investors typically have access to international markets, which can open up new export opportunities for Algerian products. This access helps diversify the economy, reduces dependency on hydrocarbons, and promotes industrial growth by expanding the market reach of Algerian industries.

The presence of foreign firms introduces competition in the domestic market, pushing local companies to improve their standards and efficiency. This competitive environment encourages innovation and the adoption of best practices, contributing to the overall growth and development of the industrial sector. As well, FDI helps diversify Algeria's economy by investing in non-hydrocarbon sectors such as manufacturing, agriculture, and services. This diversification is critical for sustainable industrial growth and reducing the country's reliance on oil and gas revenues.

Asymmetric Effects of FDI on TFP: The study found asymmetric impacts of FDI on TFP, indicating that both positive and negative changes in FDI significantly influence TFP in the industrial sector. Specifically, a positive change in FDI leads to an increase in TFP, demonstrating the beneficial impact of FDI inflows on industrial productivity. Conversely, negative changes in FDI are associated with a decrease in TFP, highlighting the vulnerability of industrial growth to reductions in FDI.

Trade Openness: the impact of trade openness on TFP is also asymmetric. Both positive and negative changes in trade openness negatively impact TFP in the long and short run. So, the results suggest that a rise in trade openness leads to a reduction in TFP in Algeria.This implies that the expected benefits of trade liberalization, such as increased efficiency, innovation, and productivity, are not fully realized in the Algerian context. Besides, the negative impact of trade openness on TFP is attributed to Algeria's status as a developing nation. This suggests that the challenges and dynamics of the Algerian economy differ from those of more advanced economies, influencing the outcomes of trade policies. Further, Algeria's heavy dependence on oil exports, which constitute 97 percent of its total exports. This dependence on a single commodity indicates a lack of export diversification, which can limit the potential benefits of trade openness for stimulating industrial growth and enhancing productivity.

Instead, changes in trade openness seem to hinder TFP growth, suggesting that the relationship between trade openness and productivity is complex and possibly influenced by various factors beyond mere trade policies.

Human Capital: Human capital positively affects TFP in the industrial sector, underscoring the importance of skilled labor and education in enhancing productivity. Furthermore, highly skilled workers are more adept at innovation and technological advancement. They can develop new processes, products, and technologies that enhance productivity and efficiency, thereby increasing TFP. This finding aligns with the broader economic literature, which underscores the critical role of human capital in driving economic development and growth.

The results suggest that FDI plays a crucial role in enhancing industrial productivity in Algeria, but its benefits are contingent on the stability and continuity of investment flows. The negative impact of fluctuations in trade openness on TFP suggests that while economic integration and liberal trade policies are essential, they must be carefully managed to ensure that they contribute positively to industrial growth. The positive role of human capital highlights the need for policies that invest in education and skills development to maximize the benefits of FDI and trade openness.

The asymmetric effects observed suggest that policymakers should focus on creating a stable and conducive environment for FDI, with clear and consistent policies that encourage long-term investment. Additionally, efforts to diversify the economy and reduce dependence on hydrocarbon exports could mitigate the negative impacts associated with trade openness. Investing in human capital development is crucial for enhancing the absorptive capacity of the economy, enabling it to better leverage FDI for industrial and overall economic growth.

Although FDI offers numerous benefits, it also presents certain challenges and considerations. A stable and transparent regulatory framework is essential to attract and retain FDI. Algeria needs to ensure that its policies are conducive to foreign investments. Then, political stability is crucial for maintaining investor confidence. Any political unrest or instability can deter foreign investors. As well, reducing bureaucratic hurdles and corruption can enhance the business environment, making it more attractive for foreign investors.

The relationship between FDI and industrial growth in Algeria is symbiotic. FDI provides the necessary financial resources, technology, and market access that spur industrial development, while industrial growth creates a

more attractive environment for further investments. To maximize the benefits of FDI, Algeria needs to maintain a stable political and economic environment, improve its regulatory framework, and address any structural challenges that may hinder investment.

9. Conclusion:

The NARDL approach is used over the period from 1990-2019 to identify the asymmetric effects of foreign direct investment (FDI) on industrial growth in Algeria. Estimation results indicate the presence of asymmetric relations between foreign direct investment and TFP in both the long and the short-run time. The short-run results revealed that the increase in foreign direct investment inflows increased Algeria's industrial growth. However, the decline in foreign direct investment has a negative effect on industrial growth in Algeria. Moreover, it appears that the increase of foreign direct investment and trade openness are the most important variables to explain industrial growth in the short run. Furthermore, in the long-run, the positive changes of FDI are positively and significantly consistent with the increase in total factor productivity in the industrial sector. Thus, the negative changes of FDI decreased TFP. Furthermore, the estimation results demonstrate an asymmetric interaction between trade openness and TFP in the long-run, both in the short-run time, indicating that positive and negative changes in trade openness induce a decrease in total factor productivity in the industrial sector. Finally, human capital has a positive impact on total factor productivity in the industrial sector.

The long-run results indicate that foreign direct investment and human capital are the most important variables to explain industrial growth. Thus, our study suggests that the continued growth of foreign direct investment is one of the important factors contributing to industrial growth.

In conclusion, with adequate policies in host countries and a minimum level of developed human capital, FDI has technological spillovers. It contributes to human capital formation, facilitates integration into international trade, promotes a more competitive business climate and improves enterprise development.

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