

# **The interactive impact of FDI, economic openness and the institutional environment on economic growth in North African countries: A panel data analysis**

## **L'impact interactif des IDE, de l'ouverture économique et de l'environnement institutionnel sur la croissance économique dans les pays d'Afrique du Nord : une analyse des données de panel**

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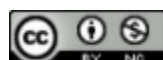
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## Abstract

This paper analyzes the interactive impact of foreign direct investment, economic openness, and institutional quality on economic growth in five North African countries: Morocco, Algeria, Tunisia, Libya, and Egypt. Using panel data covering the period 2000–2019, a Ridge regression was employed to study the interactions among these three dimensions, while incorporating control variables such as human capital, inflation, and population growth. The results show that FDI has a significant and positive direct effect on economic growth, confirming its role as a development driver. However, economic openness exhibits a marginally negative direct effect, reflecting vulnerabilities related to external shocks and trade imbalances. Institutional quality, on the other hand, does not have a significant direct effect but acts as a catalyst, enhancing the impact of both FDI and economic openness. The study reveals that the interactions among FDI, economic openness, and institutional quality generate positive synergies. The tripartite interaction between these three dimensions has a significant impact, demonstrating that coordinated institutional reforms, combined with controlled openness and increased FDI attractiveness, can maximize economic growth.

**Keywords:** Foreign direct investment, economic openness, institutional quality, economic growth, North Africa.

**JEL classification :** F21, O11, O43, C23.

## Résumé

Cet article analyse l'impact interactif des investissements directs étrangers (IDE), de l'ouverture économique et de la qualité institutionnelle sur la croissance économique dans cinq pays d'Afrique du Nord : le Maroc, l'Algérie, la Tunisie, la Libye et l'Égypte. En utilisant des données de panel couvrant la période de 2000 à 2019, une régression Ridge a été utilisée pour étudier les interactions entre ces trois dimensions, tout en incorporant des variables de contrôle telles que le capital humain, l'inflation et la croissance démographique. Les résultats montrent que les IDE ont un effet direct significatif et positif sur la croissance économique, confirmant leur rôle de moteur du développement. Cependant, l'ouverture économique présente un effet direct marginalement négatif, reflétant des vulnérabilités liées aux chocs externes et aux déséquilibres commerciaux. En revanche, la qualité institutionnelle n'a pas d'effet direct significatif, mais agit comme un catalyseur, renforçant l'impact des IDE et de l'ouverture économique. L'étude révèle que les interactions entre les IDE, l'ouverture économique et la qualité institutionnelle génèrent des synergies positives. L'interaction tripartite entre ces trois dimensions a un impact significatif, démontrant que des réformes institutionnelles coordonnées, combinées à une ouverture contrôlée et à une attractivité accrue des IDE, peuvent maximiser la croissance économique.

**Mots-clés :** Investissements directs étrangers, ouverture économique, qualité institutionnelle, croissance économique, Afrique du Nord.

**Classification JEL :** F21, O11, O43, C23.

## Introduction

Foreign direct investment, economic openness, and institutional quality play a central role in the dynamics of economic growth in developing countries. While these three dimensions have been studied separately in numerous works, their interactions reveal potential to either amplify or limit their respective impacts on economic development. In the context of North African countries, these factors are particularly significant due to the structural challenges and unique opportunities characterizing the region. Over the past two decades, North African nations have undertaken major reforms to attract FDI, diversify their economies, and improve their institutional frameworks. However, these efforts face persistent constraints, including governance often deemed inadequate, heightened vulnerability to external shocks due to economic openness, and reliance on investments in low-value-added sectors.

In this context, it becomes imperative to analyze not only the direct effect of each dimension but also their interactions, to better understand how these factors can be combined to maximize their contribution to economic growth. This paper examines the interactive impact of FDI, economic openness, and institutional quality on economic growth in five North African countries: Morocco, Algeria, Tunisia, Libya, and Egypt. Using panel data covering the period 2000–2019 and employing econometric methods, the study seeks to address several key questions: To what extent do these dimensions individually influence economic growth? What roles do the interactions among these factors play in amplifying their effects? And what strategies can policymakers adopt to optimize these interactions? The objective of this research is to provide both theoretical and empirical contributions to understanding the synergies between FDI, economic openness, and institutions in the context of emerging economies.

### 1. Literature review

Canh et al. (2018) highlight that institutional quality plays a key role in the interaction between FDI and economic openness, fostering innovation, a critical driver of economic growth. By reducing information asymmetries and transaction costs, high-quality institutions create an environment more conducive to innovation, thereby promoting long-term growth. Chortareas et al. (2015) reinforce this perspective by emphasizing that effective institutions, coupled with financial development and increased economic openness, are essential to

maximizing the positive outcomes of FDI, particularly by aligning public policies with sustainable growth objectives. Bengoa and Sanchez-Robles (2003) stress the decisive role of economic freedom in the relationship between FDI and growth. Robust institutions optimize the productivity of foreign investments, enhancing their contribution to economic growth. This interaction is also addressed by Falvey, Foster, and Greenaway (2012), who point out that strong institutions reduce transactional barriers and improve the conversion of FDI flows and trade into growth. These dynamics demonstrate that targeted institutional reforms can amplify the economic benefits of these interactions.

Hayat (2019) focuses on the importance of institutional quality in low- and middle-income countries, where FDI generates a more pronounced impact on growth in the presence of factors such as political stability and corruption control. However, he notes that an FDI substitution effect on domestic investments may limit their contribution in high-income countries. Shahbaz et al. (2019) echo this analysis, demonstrating that the interaction between FDI, economic openness, and strong institutional governance fosters sustainable economic growth. They also show that channeling FDI into strategic sectors, supported by effective institutions, facilitates technology and innovation transfer, thereby enhancing productivity and competitiveness. Durham (2004) underscores the role of institutions as a central element for maximizing the effects of FDI on economic growth. He asserts that a country's absorptive capacity, closely tied to institutional quality, is critical. This perspective aligns with the work of Ansari et al. (2019), who emphasize the importance of interactions among FDI, economic openness, and institutions in reducing economic inefficiencies and promoting sustainable growth. Together, these authors illustrate how strong institutions facilitate resource allocation and stabilize economies over the long term.

Buchanan et al. (2012) expand on this idea, demonstrating that improving institutional quality attracts more FDI, thereby amplifying its impact on economic growth. Agbloyor et al. (2016) complement this reflection by positioning institutions as an essential mediator in the FDI-growth relationship. However, they observe that even with institutional progress, the outcomes of FDI may remain limited in certain regions, such as Sub-Saharan Africa, highlighting specific contexts requiring institutional optimization. Mengistu and Adhikary (2011) provide a regional perspective by focusing on Asian economies, where indicators such as government efficiency and corruption control amplify the positive effects of FDI on growth. This complementarity is shared by Bhasin and Garg (2019), who emphasize that

balanced institutional environments, combined with economic openness and effective regulation, promote the attraction and accumulation of FDI. Collectively, these authors demonstrate that the convergence of governance, trade openness, and the attractiveness of emerging markets forms an essential foundation for sustained and durable growth.

Tran et al. (2019) highlight the catalytic effect of the interaction between FDI, economic openness, and institutional quality on economic growth. They explain that institutional quality optimizes the positive impacts of FDI, particularly by enhancing national innovation and productivity. Furthermore, economic openness fosters increased competition and encourages economic specialization, thereby driving sustainable economic gains. North (1993) supports this view by emphasizing the central role of institutions, which reduce uncertainty and guarantee property rights, creating an environment conducive to the adoption of innovations and technologies introduced by FDI, thereby amplifying their contribution to economic growth. Bissoon (2011) points out that indicators such as political stability and regulatory quality positively influence FDI inflows. Additionally, trade openness acts as a strategic lever, reinforcing the impact of a high-quality institutional framework on FDI flows. Mukherjee and Chakraborty (2013) expand on this idea by showing that the integration of FDI into open economies heavily depends on institutional strength, which drives economic mechanisms supporting both growth and environmental objectives. Jude and Leveuge (2013) emphasize that the effectiveness of FDI on economic growth is achieved only when institutional quality exceeds a critical threshold. They explain that robust institutions facilitate technology transfers and improve economic efficiency, enabling a broader distribution of benefits.

Similarly, Azman-Saini, Baharumshah, and Law (2010) stress the importance of strong institutional frameworks, while noting that attracting FDI and trade must be complemented by initiatives aimed at developing financial markets to maximize positive impacts on economic growth. Tebaldi and Elmslie (2013) underscore the importance of institutions in promoting innovation, a key factor in leveraging FDI and economic openness. They show that corruption control and high-quality regulation foster knowledge accumulation, thus stimulating economic growth. Alguacil, Cuadros, and Orts (2011) reinforce this argument by highlighting that local conditions, including macroeconomic stability and quality governance, maximize the effects of FDI on economic growth, particularly through better absorption of technological and managerial transfers. These interactions create a virtuous cycle between FDI, economic openness, and institutions. Procházka and Čermáková (2015) shed light on the role of

economic openness, through indicators such as investment and trade freedom, in supporting economic growth. Their study demonstrates that favorable environments, including R&D expenditures and economic freedom, foster high levels of economic development. However, they nuance their findings by noting that the relationship between trade openness, FDI, and growth is not systematically direct in the medium term, underscoring the importance of institutional frameworks for sustaining this dynamic over time.

Based on these elements, the following research hypotheses can be constructed:

- *H1: FDI has a positive and significant impact on economic growth.*
- *H2: Greater economic openness has a positive and significant impact on economic growth.*
- *H3: Improved institutional quality has a positive and significant impact on economic growth.*
- *H4: FDI, combined with greater economic openness, has a positive and significant impact on economic growth.*
- *H5: FDI, combined with better institutional quality, has a positive and significant impact on economic growth.*
- *H6: Economic openness, combined with better institutional quality, has a positive and significant impact on economic growth.*
- *H7: FDI, combined with greater economic openness and better institutional quality, has a positive and significant impact on economic growth.*

## 2. Methodology

### 2.1. Model and Data

The aim of this study is to analyze the relationships between foreign direct investment, economic openness, and institutional quality, with a focus on their interactive impact on economic growth. The objective is to examine how these three dimensions, often treated independently in the literature, can generate synergies when combined, particularly in the specific context of North African countries. These countries, characterized by developing economies and ongoing institutional reforms, provide an ideal framework for analyzing economic and institutional dynamics over two decades. The adopted approach also allows for testing the hypothesis that the tripartite interactions among FDI, economic openness, and

institutions play a key role in maximizing economic benefits. Based on these considerations, the model is specified as follows:

$$\begin{aligned} GDP_{it} = & \beta_0 + \beta_1.FDI_{it} + \beta_2.OPEN_{it} + \beta_3.INST_{it} + \beta_4.FDI_{it}.OPEN_{it} \\ & + \beta_5.FDI_{it}.INST_{it} + \beta_6.OPEN_{it}.INST_{it} + \beta_7.FDI_{it}.OPEN_{it}.INST_{it} \\ & + \beta_8.HC_{it} + \beta_9.INF_{it} + \beta_{10}.POP_{it} + \varepsilon_{it} \end{aligned}$$

Where GDP represents economic growth measured by the real per capita GDP growth rate. The main variables include FDI, representing inflows of foreign direct investment as a percentage of GDP, and OPEN, the degree of economic openness calculated as the trade ratio (exports + imports) to GDP. INST corresponds to a composite institutional quality index incorporating dimensions such as governance, political stability, and corruption. The interactions FDI.OPEN, FDI.INST, and OPEN.INST assess, respectively, whether economic openness moderates or amplifies the effect of FDI, whether FDI and institutional quality have a combined effect, and whether strong institutions enhance the benefits of economic openness. The tripartite interaction FDI.OPEN.INST measures the joint effect of FDI, economic openness, and institutional quality on growth. Control variables are also included, such as HC (public spending on education), INF (inflation rate), and POP (population growth rate).

The study sample covers a 20-year period, from 2000 to 2019, and focuses on five North African countries: Morocco, Algeria, Tunisia, Libya, and Egypt. These countries were selected due to their economic similarities, particularly their status as developing economies, and their shared challenges regarding foreign direct investment flows, economic openness, and institutional governance. The study incorporates longitudinal data to examine the evolution of economic and institutional dynamics over two decades, accounting for reforms and changes in public policies.

The main variables include FDI, measured as a percentage of GDP, economic openness, evaluated by the trade ratio to GDP, and a composite institutional quality index encompassing governance, political stability, and corruption. To complement the analysis, socio-economic variables such as human capital (public spending on education), inflation rate, and population growth were included. The data sources comprise the World Bank, the IMF, and Transparency International, along with national databases for country-specific information.



## 2.2. Choice of empirical methodology

Table 1 presents the results of the Levin, Lin & Chu stationarity test, applied to the study variables after transforming the annual data into quarterly data. This test is used here to verify that the time series used are stationary, a necessary condition to avoid biases in econometric estimates. The variables FDI, OPEN.INST, FDI.OPEN.INST, and HC require second-order differencing to achieve stationarity (I(2)), while OPEN, INST, FDI.OPEN, and INF become stationary after first-order differencing (I(1)). The variable FDI.INST, on the other hand, is stationary at level (I(0)), meaning it did not require any further transformation. Transforming the data into quarterly series increases the granularity and accuracy of the analyses while enhancing their statistical robustness.

**Table 1: Levin, Lin & Chu test**

| Variables     | Statistique du Test Levin, Lin & Chu t | Prob.  | Order of integration |
|---------------|----------------------------------------|--------|----------------------|
| FDI           | -15,871152                             | 0.0000 | 2                    |
| OPEN          | -18,939314                             | 0.0000 | 1                    |
| INST          | -21,247491                             | 0.0000 | 1                    |
| FDI.OPEN      | -19,802651                             | 0.0000 | 1                    |
| FDI.INST      | -24,857848                             | 0.0000 | 0                    |
| OPEN.INST     | -18,135256                             | 0.0000 | 2                    |
| FDI.OPEN.INST | -17,766437                             | 0.0000 | 2                    |
| HC            | -16,180658                             | 0.0000 | 2                    |
| INF           | -11,764958                             | 0.0000 | 1                    |
| POP           | -10,732201                             | 0.0000 | 1                    |

Source : authors;

The centered VIFs (Table 2) for the variables FDI, OPEN, and INST are 17.19, 15.92, and 15.56, respectively, which exceed the generally accepted threshold of 10, indicating notable multicollinearity among these variables. The interaction terms, such as FDI.OPEN (32.05), FDI.INST (31.61), and OPEN.INST (30.30), show even higher centered VIFs, suggesting strong multicollinearity, as expected for interaction variables. The tripartite interaction FDI.OPEN.INST has the highest centered VIF at 45.35, indicating extremely high multicollinearity. In contrast, the control variables (HC, INF, POP) have low centered VIFs (between 1.02 and 1.03), indicating that they do not introduce significant multicollinearity.



**Table 2: Variance Inflation Factors / OLS**

| Variable      | Coefficient Variance | Uncentered VIF | Centered VIF |
|---------------|----------------------|----------------|--------------|
| C             | 0.014763             | 64.94213       | NA           |
| FDI           | 0.044259             | 65.73330       | 17.18682     |
| OPEN          | 0.040985             | 59.12467       | 15.91652     |
| INST          | 0.043154             | 61.94093       | 15.55526     |
| FDI.OPEN      | 0.138636             | 68.77283       | 32.05242     |
| FDI.INST      | 0.138722             | 71.31877       | 31.60776     |
| OPEN.INST     | 0.126851             | 64.71874       | 30.30419     |
| FDI.OPEN.INST | 0.401506             | 74.46798       | 45.35268     |
| HC            | 0.002665             | 4.059508       | 1.019325     |
| INF           | 0.002768             | 4.374163       | 1.025315     |
| POP           | 0.003032             | 4.144642       | 1.029724     |

Source : authors;

The use of Ridge regression in this context is justified to address the high multicollinearity issues observed in the model. Indeed, the model structure includes interactions between the various economic and institutional dimensions, which significantly increases the variance inflation factors. These levels of collinearity can lead to instability in the estimated coefficients and reduce the reliability of the results. Ridge regression, by introducing a penalty on the sum of the squared coefficients, reduces the variance of the estimates without significantly biasing the results. This helps stabilize the coefficients of highly correlated terms, particularly for the interactions, while keeping all the variables in the model.

### 3. Regression robustness analysis

Table 3 presents the results of the Ramsey RESET test applied to the Ridge regression. The t-statistic is 0.423, associated with a probability of 0.6725, while the F-statistic reaches a value of 0.179, with a similar probability. The likelihood ratio test gives a value of 0.184, also non-significant, with a probability of 0.6675. These probabilities, well beyond the 5% threshold, indicate that the squared adjusted values do not have a significant effect on the model. These values confirm that the model specification is adequate and does not suffer from significant omissions or incorrect functional forms. The Ridge regression appears to effectively handle the complexity of the relationships being studied, particularly those related to interactions between the variables, while ensuring a stable and reliable structure for the estimates.

**Table 3: Ramsey RESET Ridge regression test**

| Ramsey RESET Test                                                                       |          |          |             |  |
|-----------------------------------------------------------------------------------------|----------|----------|-------------|--|
| Specification: GDP C FDI OPEN INST FDI.OPEN FDI.INST OPEN.INST FDI.OPEN.INST HC INF POP |          |          |             |  |
| Omitted Variables: Squares of fitted values                                             |          |          |             |  |
|                                                                                         | Value    | df       | Probability |  |
| t-statistic                                                                             | 0.423073 | 388      | 0.6725      |  |
| F-statistic                                                                             | 0.178991 | (1, 388) | 0.6725      |  |
| Likelihood ratio                                                                        | 0.184484 | 1        | 0.6675      |  |

Source : authors;

Table 4 presents the variance inflation factors (VIFs) obtained after applying Ridge regression, compared to those calculated under ordinary least squares (OLS). The centered VIFs for the Ridge regression are significantly reduced compared to those from the OLS analysis. The interaction terms now have values close to 1, compared to the high values exceeding 30 in the OLS analysis. Similarly, the main variables, which had VIFs exceeding 15 under OLS, now have values close to 1. This significant reduction in VIFs confirms that Ridge regression effectively mitigates the effects of multicollinearity, stabilizing the coefficient estimates. The centered values close to 1 reflect increased independence between the explanatory variables, allowing for a better interpretation of the coefficients in the model with multiple interactions.

**Table 4: Variance Inflation Factors for Ridge regression**

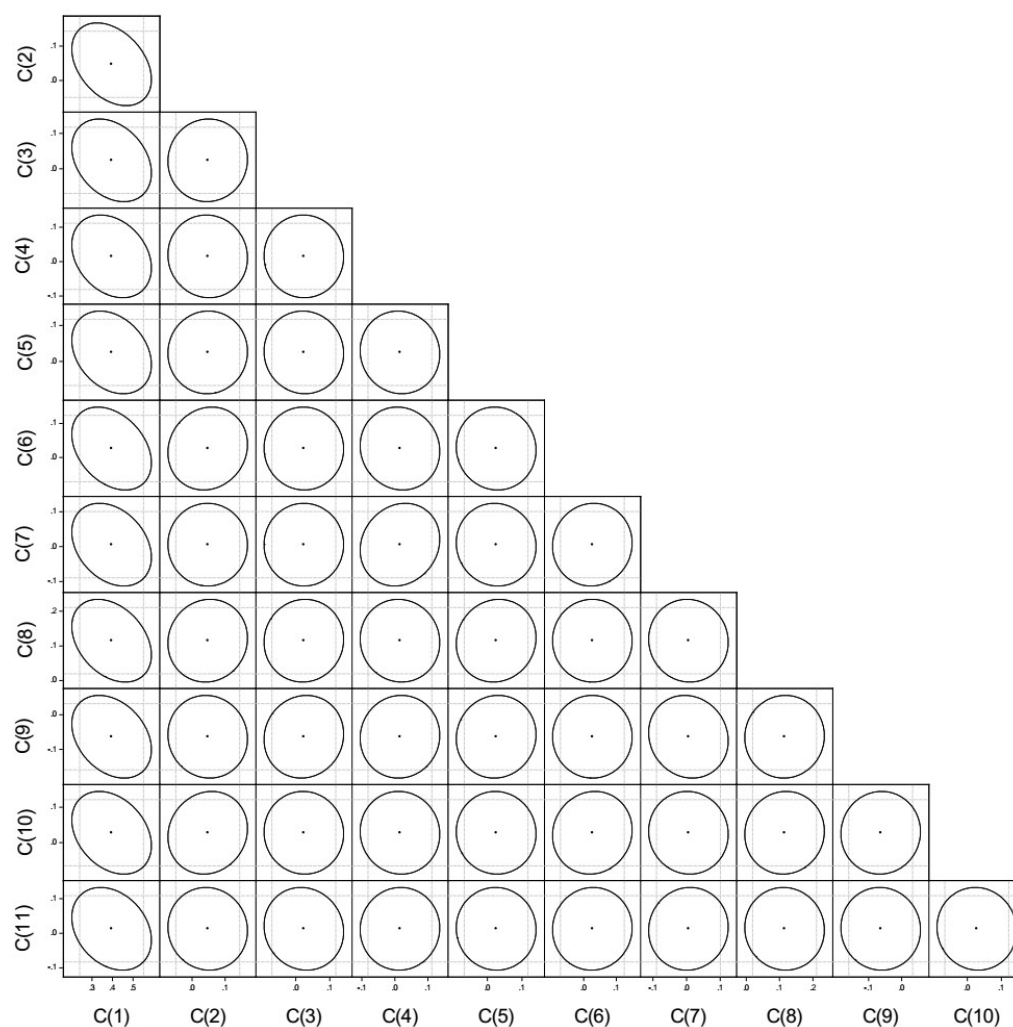
| Variable      | Coefficient Variance | Uncentered VIF | Centered VIF |
|---------------|----------------------|----------------|--------------|
| C             | 0.006248             | 32.34626       | NA           |
| FDI           | 0.002398             | 4.222654       | 1.030189     |
| OPEN          | 0.002281             | 4.231972       | 1.013774     |
| INST          | 0.002399             | 3.877527       | 1.032073     |
| FDI.OPEN      | 0.002196             | 4.126976       | 1.015434     |
| FDI.INST      | 0.002473             | 4.224475       | 1.023432     |
| OPEN.INST     | 0.002328             | 4.066961       | 1.035609     |
| FDI.OPEN.INST | 0.002356             | 4.123080       | 1.014251     |
| HC            | 0.002383             | 4.084295       | 1.023703     |
| INF           | 0.002259             | 3.644244       | 1.020569     |
| POP           | 0.002366             | 4.325825       | 1.012165     |

Source : authors;

Figure 1 displays the confidence ellipses associated with the Ridge regression coefficients. These ellipses help assess the correlation between the estimates of the different coefficients

and their precision in a multivariate space. In the context of Ridge regression, the goal is to reduce the impact of multicollinearity, which is reflected in narrower and more well-defined ellipses. The nearly circular ellipses visible in the figure indicate limited correlation between the coefficients, highlighting that the Ridge penalty has successfully reduced the initially high interdependencies among certain explanatory variables. Compared to a traditional ordinary least squares (OLS) regression, where strong correlations would manifest as flattened or highly stretched ellipses, this figure demonstrates a noticeable improvement in the stability of the estimates. Moreover, the symmetry of the ellipses in this figure reflects homogeneity in the effects of the coefficients after regularization, which is essential for ensuring reliable econometric results in a model that includes interaction terms. This confirms the effectiveness of Ridge regression in addressing multicollinearity issues.

**Figure 1 : Confidence ellipses for Ridge regression**



Source : authors;

Table 5 presents the results of the autocorrelation and partial autocorrelation tests applied to the residuals of the Ridge regression. The autocorrelation (AC) and partial autocorrelation (PAC) coefficients for each lag are low and oscillate around zero, indicating a notable absence of structural correlation in the residuals. The associated Ljung-Box (Q-Stat) statistics, along with their probabilities, confirm these observations: for all lags, the probabilities exceed the 5% threshold, suggesting that the autocorrelation of the residuals is not significant. These results demonstrate that the Ridge model is well specified in terms of residual dependence. This ensures the independence of errors and, consequently, the validity of the inferences and predictions derived from the model.

**Table 5: Test of autocorrelation and partial correlation of residuals for Ridge regression**

| Lag | AC     | PAC    | Q-Stat | Prob  |
|-----|--------|--------|--------|-------|
| 1   | -0.006 | -0.006 | 0.0150 | 0.903 |
| 2   | 0.035  | 0.035  | 0.5112 | 0.774 |
| 3   | 0.001  | 0.002  | 0.5120 | 0.916 |
| 4   | -0.090 | -0.091 | 3.8024 | 0.433 |
| 5   | 0.073  | 0.072  | 5.9654 | 0.310 |
| 6   | 0.015  | 0.022  | 6.0567 | 0.417 |
| 7   | 0.008  | 0.002  | 6.0805 | 0.530 |
| 8   | -0.082 | -0.093 | 8.8316 | 0.357 |
| 9   | 0.048  | 0.062  | 9.7626 | 0.370 |
| 10  | -0.060 | -0.057 | 11.267 | 0.337 |
| 11  | -0.010 | -0.016 | 11.309 | 0.418 |
| 12  | 0.090  | 0.079  | 14.654 | 0.261 |
| 13  | -0.058 | -0.036 | 16.052 | 0.246 |
| 14  | 0.031  | 0.009  | 16.462 | 0.286 |
| 15  | 0.014  | 0.024  | 16.544 | 0.347 |
| 16  | -0.015 | -0.004 | 16.634 | 0.410 |

Source : authors;

The Harvey test (Table 6) is used in this study to check for the presence of heteroskedasticity in the model estimated by Ridge regression. Heteroskedasticity, which manifests as non-constant variance of the residuals, can bias statistical inferences and compromise the reliability of confidence intervals. While Ridge regression addresses multicollinearity issues, it does not directly address problems related to heteroskedasticity. In the context of this model, which includes interactions (FDI.OPEN, FDI.INST, OPEN.INST, FDI.OPEN.INST), the risk of heteroskedasticity is higher, justifying the use of a specific diagnostic test. The results of the test, as shown in Table 7, indicate that the F-statistic is 0.5857, with an

associated probability of 0.8258. This value, well above the usual 5% significance threshold, shows that the null hypothesis of homoskedasticity cannot be rejected. This implies that the variance of the residuals remains constant, ensuring that the coefficients estimated by Ridge regression are not affected by potential biases related to heteroskedasticity.

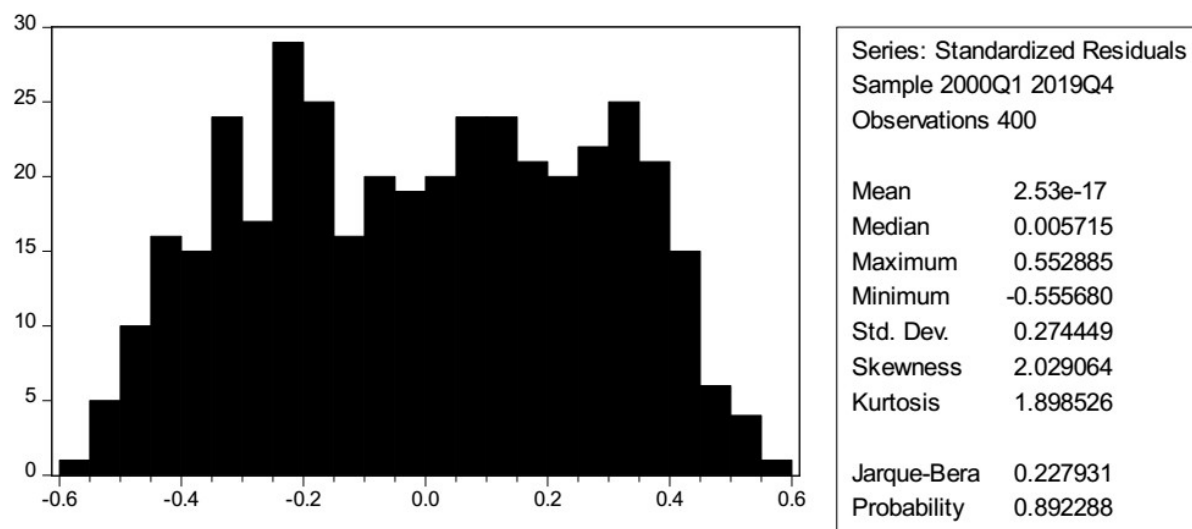
**Table 6: Diagnosis of heteroscedasticity (Test: Harvey) for Ridge regression**

| Heteroskedasticity Test: Harvey |          |                      |        |
|---------------------------------|----------|----------------------|--------|
| F-statistic                     | 0.585730 | Prob. F(10,389)      | 0.8258 |
| Obs*R-squared                   | 5.933582 | Prob. Chi-Square(10) | 0.8208 |
| Scaled explained SS             | 4.168378 | Prob. Chi-Square(10) | 0.9394 |

Source : authors;

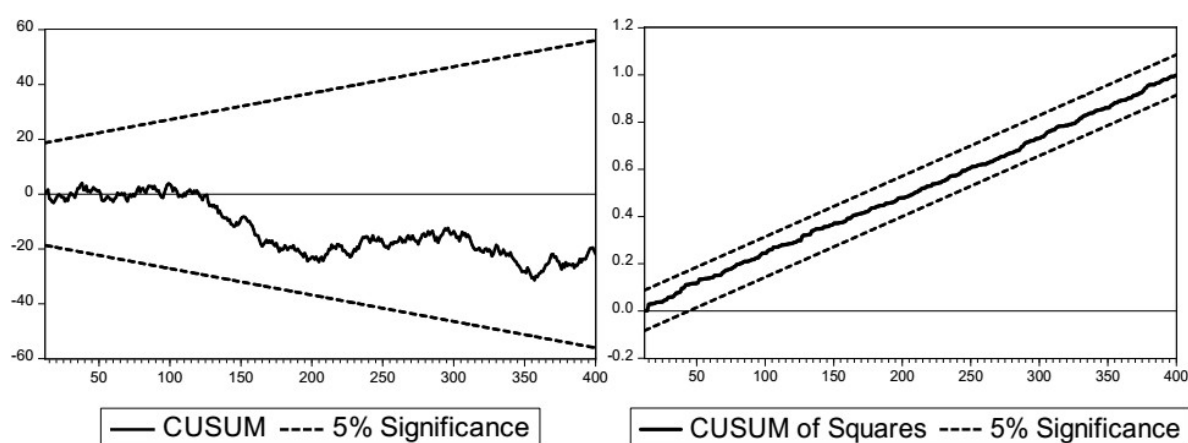
Similarly, the Obs\*R-squared statistic is 5.9336, with an associated probability of 0.8208. These results corroborate the previous analysis by reinforcing the idea that the variance of the residuals does not vary systematically with the explanatory variables in the model. Finally, the Scaled Explained SS statistic, with a value of 4.1684 and a probability of 0.9394, provides additional confirmation. The high probability indicates that the residual errors are not significantly influenced by the explanatory variables, even in a weighted specification.

Figure 2 presents the normality test for the standardized residuals of the Ridge regression. The histogram of the residuals shows a symmetric distribution centered around zero, with the majority of observations falling between -0.2 and 0.2. Although normality of residuals is not required for Ridge regression to be effective, these results are interesting for evaluating the model's quality. Descriptive statistics reinforce this observation: the skewness is 2.029 and the kurtosis is 1.898, which are close to the values expected for a normal distribution. The Jarque-Bera test, with a statistic of 0.228 and an associated probability of 0.8925, confirms that there is no reason to reject the null hypothesis of normality of the residuals.

**Figure 2: Residual normality test for Ridge regression**

Source : authors;

Figure 3 presents the results of the CUSUM and CUSUM of squares (CUSMSQ) tests applied to the Ridge regression to assess the structural stability of the model. The CUSUM test shows that the cumulative curve of the standardized residuals remains well within the 5% confidence bands throughout the entire sample period. This suggests overall stability of the model's coefficients over time, indicating that there is no significant structural change in the modeled relationship.

**Figure 3: CUSUM and CUSMSQ tests for Ridge regression**

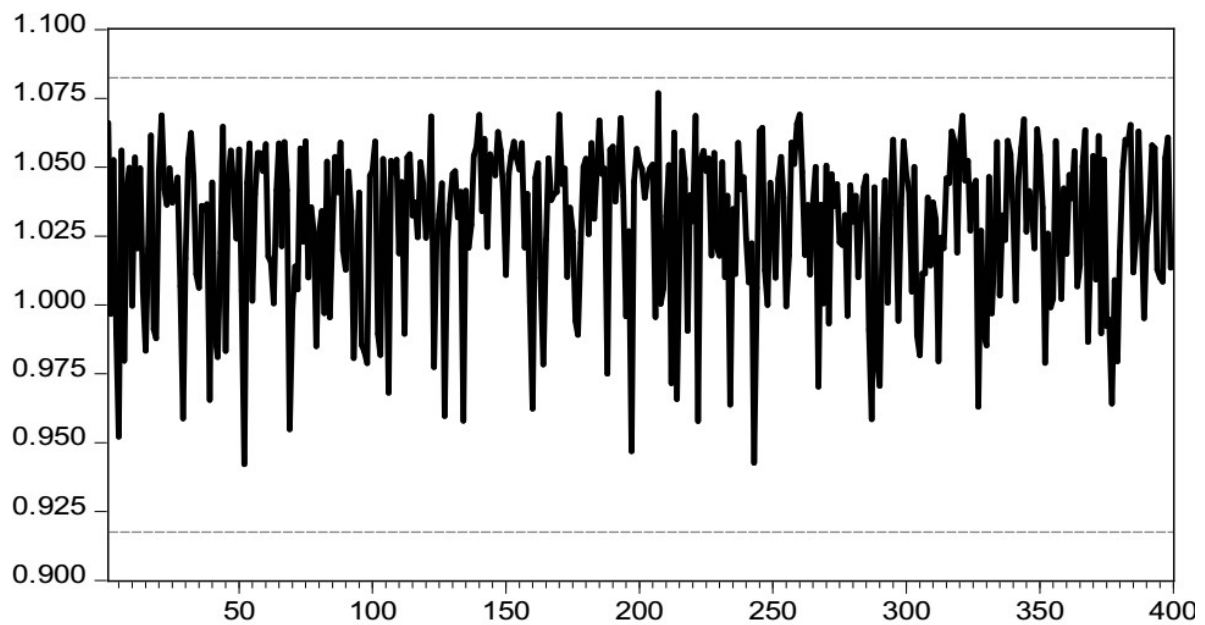
Source : authors;

Similarly, the CUSUM of squares test, which examines the variance of the residuals to detect potential instability, shows that the curve also remains within the critical 5% bands. This



result indicates that there is no abnormal variation in the residual errors, thereby reinforcing the robustness of the model specification. These tests confirm that Ridge regression produces a stable and consistent model despite the presence of interaction terms and initial multicollinearity. The model's ability to maintain structural stability enhances its relevance for analyzing the complex effects between the economic and institutional dimensions studied.

**Figure 4: Influence statistics for Ridge regression: COVRATIO**



Source: authors;

The link between the COVRATIO statistic and collinearity lies in the impact of multicollinearity on the stability of the covariance matrix of the estimated coefficients. When multicollinearity is high, the coefficients become sensitive to variations in the data, and certain observations may have a disproportionate influence on the estimates. This leads to instability in the covariance matrix, which can be detected by outlier or fluctuating values in the COVRATIO measure. This stability is particularly important in the context of Ridge regression, which is used to reduce the impact of multicollinearity. The results (Figure 4) show that this approach effectively minimized the effect of individual observations on the coefficients while maintaining the reliability and consistency of the estimates in the model framework incorporating multiple interaction variables.



#### 4. Results

This study examines the impact of foreign direct investment, economic openness, and institutional quality on economic growth in five North African countries between 2000 and 2019. An econometric model integrates these key dimensions, their interactions, and control variables such as human capital, inflation, and population growth. The data, adjusted for stationarity and transformed into quarterly series, allow for an analysis of the dynamic relationships. To correct for high multicollinearity, particularly among the interaction terms, Ridge regression is employed, ensuring stable coefficients and reliable estimates. The validity and stability of the model are verified using specification tests (Ramsey RESET), autocorrelation, heteroskedasticity, and residual normality, further reinforced by CUSUM and CUSUMSQ analyses.

**Table 7 : Ridge regression results**

| Variable      | Coefficient | Std. Error | t-Statistic | Prob.     |
|---------------|-------------|------------|-------------|-----------|
| C             | 0.236051    | 0.066445   | 3.552558    | ***0.0004 |
| FDI           | 9.944412    | 3.369215   | 2.951552    | ***0.0033 |
| OPEN          | -2.131279   | 1.138740   | -1.871612   | *0.0620   |
| INST          | 2.319493    | 7.449895   | 0.311346    | 0.7557    |
| FDI.OPEN      | 28.707172   | 10.376929  | 2.766442    | ***0.0059 |
| FDI.INST      | 7.792243    | 4.126769   | 1.888219    | *0.0597   |
| OPEN.INST     | 24.551201   | 9.269136   | 2.648704    | ***0.0084 |
| FDI.OPEN.INST | 9.339643    | 3.942085   | 2.369214    | **0.0183  |
| HC            | -1.767799   | 1.358472   | -1.301314   | 0.1939    |
| INF           | -19.271958  | 10.277539  | -1.875153   | *0.0615   |
| POP           | 19.791607   | 7.410268   | 2.670835    | ***0.0079 |

Source: authors; \*\*\*Significant at 1%; \*\*Significant at 5%; \*Significant at 10%.

The results of the Ridge regression (Table 7) show that foreign direct investment has a positive and significant impact on economic growth, thus validating hypothesis H1. This result, significant at the 1% threshold, confirms that FDI inflows directly contribute to the economic development of the studied countries, supporting the idea that these investments bring resources and technologies that foster productivity. Regarding economic openness (OPEN), the direct effect is negative and marginally significant at the 10% threshold, which nuances hypothesis H2. Although economic openness is often associated with increased trade opportunities, this effect may reflect the vulnerabilities of open economies to external shocks or imbalances in trade. The direct impact of institutional quality (INST) is not significant, thus

rejecting hypothesis H3. However, this result does not diminish the importance of institutions, as their interactions with other variables show significant effects. This suggests that institutional quality alone may not be sufficient to stimulate growth, but it acts as a catalyst in specific frameworks.

The interactions between foreign direct investment and economic openness (FDI.OPEN) have a positive and significant effect at the 1% threshold, validating hypothesis H4. This highlights that economic openness amplifies the benefits of FDI by creating a more conducive environment for integrating local businesses into global value chains. The interaction between FDI and institutional quality (FDI.INST) is marginally significant at the 10% threshold, partially confirming hypothesis H5. This indicates that higher-quality institutions strengthen the impact of FDI, likely by ensuring better management and allocation of resources. The interaction between economic openness and institutional quality (OPEN.INST) has a positive and significant effect at the 1% threshold, validating hypothesis H6. This result emphasizes that strong institutions are necessary to maximize the benefits of greater economic openness, particularly by enhancing stability and transparency. Furthermore, the tripartite interaction between FDI, economic openness, and institutional quality (FDI.OPEN.INST) is significant at the 5% threshold, confirming hypothesis H7. This interaction shows that these three dimensions work together to stimulate economic growth, reinforcing the idea that institutional reforms, combined with policies promoting FDI and economic openness, can generate significant synergies.

Regarding the control variables, human capital (HC), measured by public spending on education, shows a negative and non-significant effect on economic growth. Although not significant, this result may reflect inefficiencies in the use of educational spending or a delay in its impact on productivity and growth. Inflation (INF) has a negative and marginally significant effect at the 10% threshold. This result aligns with expectations, as high inflation tends to erode purchasing power, increase production costs, and introduce economic instability, thus limiting its impact on growth. This confirms that inflation control policies are essential to maintaining an economic environment conducive to growth. The population growth rate (POP) shows a positive and significant effect at the 1% threshold. This result suggests that, in the context of the studied countries, well-managed population growth can

offer favorable economic dynamics by increasing domestic demand and expanding the labor force.

## 5. Discussion

Foreign direct investment is distinguished as a key source of development, bringing financial flows, managerial skills, and innovative technologies that can transform local economies. However, its effectiveness is not uniform and appears to be strongly influenced by the environment in which it operates. In particular, when FDI interacts with open economies and strong institutional frameworks, its positive effects are significantly amplified. This observation underscores the importance of an integrated strategic approach to maximize the benefits of these investments. Economic openness, while associated with challenges such as increased vulnerability to fluctuations in international markets, can also be a powerful lever for stimulating growth. However, its effectiveness depends on the ability of economies to exploit the opportunities offered while minimizing the risks. A robust institutional environment seems to play a central role in this dynamic, ensuring stability and providing a transparent framework that facilitates trade and investment flows. Institutions, although they do not have a direct significant effect on growth, act as catalysts by strengthening the impact of other economic factors such as openness and FDI.

The tripartite interactions between FDI, economic openness, and institutional quality highlight the existence of synergies that can only be fully exploited through coordinated structural reforms. The results suggest that strong institutions favor better absorption of FDI and more efficient management of the resources they bring. Furthermore, economic openness, well framed by adapted institutional policies, seems to strengthen the integration of local economies into global value chains, contributing to sustainable growth. These synergies emphasize that isolated efforts in one area, whether attracting FDI, promoting international trade, or strengthening institutions, are likely to produce limited effects in the absence of a comprehensive and coherent vision. Beyond these main dimensions, the results encourage a deeper reflection on priorities regarding economic management and public policies. The ability of economies such as Tunisia or Algeria to absorb investment flows, manage vulnerabilities linked to openness, and strengthen their institutions appears as a determining factor for success. Special attention should be given to coordinating structural reforms to ensure that these three dimensions act in harmony. This implies not only creating incentives

to attract FDI but also developing mechanisms to channel their benefits to the most strategic sectors and promoting trade policies that reduce risks related to external dependence.

## Conclusion

This study highlights that the interactions between foreign direct investment, economic openness, and institutional quality play a key role in stimulating the economic growth of North African countries. While each of these factors has an individual effect on economic development, their combination reveals synergies that significantly amplify their impact. These results emphasize the importance of a coordinated and strategic approach to maximize the benefits of these dimensions. FDI stands out as an essential source of capital, technology, and managerial expertise, which foster the modernization of local economies and their integration into global value chains. However, their impact largely depends on the context in which they are deployed. When FDI interacts with strong institutional frameworks and well-managed trade openness, its positive effects are significantly strengthened, demonstrating its reliance on favorable economic and institutional environments.

Economic openness, although associated with increased trade opportunities, presents vulnerabilities in the context of North African countries. A negative direct effect has been observed, revealing the challenges associated with increased exposure to external shocks and trade imbalances. However, when this openness is accompanied by strong institutional frameworks, it acts as a lever to maximize the benefits of FDI and enhance economic resilience. This finding shows that economic openness must be framed by targeted policies to avoid the risks of excessive dependence and ensure sustainable benefits. Institutional quality plays a crucial catalytic role. While its direct effect on economic growth is not significant, its interactions with FDI and economic openness demonstrate a determining influence. Robust institutions promote transparency, stability, and better resource allocation, while creating an attractive environment for foreign investors. They also help channel the benefits of economic openness into strategic sectors, thereby reducing risks related to instability.

The tripartite interaction between FDI, economic openness, and institutional quality highlights particularly powerful synergies. This interaction confirms that these three dimensions work complementarily to generate significant and sustainable economic growth. The results show that well-designed institutional reforms, combined with policies that promote foreign

investment and trade openness, can create ideal conditions for inclusive growth. Thus, strengthening institutional quality, promoting targeted economic openness, and maximizing the impact of FDI through appropriate incentives are essential priorities. These efforts must be accompanied by coordination of public policies to ensure that the synergies between these dimensions are fully exploited. Through this integrated approach, countries in the region can transform the challenges of globalization into opportunities, thereby strengthening their long-term development trajectory.

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