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| RESEARCH ARTICLE

Time Series Analysis to Evaluate the Impact of Foreign Direct Investment on Economic Growth in Sudan

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| ABSTRACT

The study aimed to evaluate how foreign direct investment (FDI) impacts economic growth in Sudan. A standard model was designed to analyze the relationship between the study variables from 2000 to 2022. The primary problem of the study is whether Sudan can offer the required standards, incentives, and privileges to attract foreign investors. In the theoretical aspect, the study utilized a descriptive analytical approach, but in the practical aspect, it employed a statistical method grounded on econometric tools in the analysis, applying the Autoregressive Distributed Lag (ARDL) model. The relevant data were acquired from the Sudan Central Bureau of Statistics for the study period. The study hypothesized that there is a statistically significant correlation between FDI and economic growth in Sudan. The findings determined a statistically significant long-term association between FDI and economic growth. The study recommended enhancement of an environment favorable to both foreign and domestic investment

| KEYWORDS

Economic growth, foreign direct investment, capital formation, GDP, trade openness.

| ARTICLE INFORMATION

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1. Methodological framework of the study

1.1. Introduction

Studies on economic growth and FDI have received significant attention in recent decades. They have investigated the reciprocal relationship between FDI and economic growth, as it is considered the most significant factor for understanding how the former affects the latter.

Developing countries need to employ economic growth strategies to address their critical economic conditions. FDI, as a significant catalyst for global development, has emerged as a crucial financing mechanism for investments in these countries. This trend has become increasingly popular over the last thirty years because of the significant advantages and economic benefits it offers to both investing and host countries.

Sudan is a developing country that has faced significant economic challenges due to stringent sanctions imposed by the United States, resulting in a downturn across various sectors of its economy. Introducing foreign investment is essential for Sudan, as it plays a key role in addressing economic imbalances. Foreign investment fosters economic growth, enhances development through improved infrastructure, generates job opportunities, facilitates the localization of modern technology, offers appropriate financing resources, and broadens the country's investment infrastructure.

Given its abundance of economic and natural resources, Sudan needs to foster foreign investment by establishing a favorable investment environment. This study endeavors to elucidate the influence of FDI on economic growth through a meticulous analysis of quantitative data sourced from secondary materials. The objective is to draw informed conclusions and subsequently suggest viable solutions to address the identified problems.

1.2. Study problem

FDI is regarded as a significant economic factor impacting multiple sectors of economy. It plays a crucial role in enhancing the overall supply of goods and services while generating job opportunities for numerous unemployed individuals. This study aims to investigate the degree to which FDI influences economic growth in Sudan, particularly considering the current decline in economic growth rates and high unemployment rates in the community. Furthermore, considering that Sudan presents, compared to other countries, investment opportunities to numerous African and Arab nations, the study evaluates Sudan's capacity to deliver the essential requirements, incentives, and privileges aimed at attracting foreign investors. It is important to recognize that establishing a conducive economic environment, coupled with providing tax and customs benefits and trade liberalization, alone may not suffice to persuade foreign investors to engage in investments in Sudan.

1.3. Study questions

The study problem focuses on one main question: To what extent can aspects related to FDI contribute to economic growth in Sudan? Two sub-questions are also addressed:

a. Does FDI affect economic growth?
b. What is the extent of the impact of FDI on economic growth?

1.4. Study hypotheses

The study hypothesizes that FDI has a positive effect on long-term economic growth in the Sudanese economy.

1.5. Study model

The impact of FDI on economic growth will be measured through the following model:

$$\log(GDP) = B_0 + B_1 log(FDI) + B_2 \log(OP) + B_3 \log(FC) + \varepsilon_t$$

Where:

The gross domestic product (GDP) is a dependent variable; (foreign direct investment) FDI, trade openness (TO), fixed capital accumulation (FCA) are the independent variables. (Bs) are the coefficients, and ε_t is a random variable.

According to the economic theory related to economic growth, the correlation between FDI and economic growth must be positive. Therefore, the coefficient of FDI is positive.

1.6. Study objectives

The study aims to achieve the following objectives:

a. Understanding the concept of economic growth and FDI.
b. Investigating the relationship between FDI and economic growth.
c. Measuring the impact of FDI on economic growth in Sudan.
d. Using quantitative econometric analysis to reach the study results and qualify them.

1.7. Significant of the study

The significance of the study arises from the recognition that FDIs are a contemporary financing modality, serving as a distinguished alternative to traditional financing methods like external loans and international aid, owing to their low cost and associated risks. Furthermore, considerable literature has emerged regarding the efficacy of FDI in enhancing economic growth in developing nations, where leading countries like China, India, and Malaysia may engage to leverage FDI for stimulating economic expansion and fostering integration between foreign and domestic investments to initiate holistic economic development. Sudan is one of the countries seeking to capitalize on FDI; thus, evaluating the influence of FDI on its economic growth would help in analyzing the process and prompt the government to rectify deficiencies.

1.8. Methodology of the study

The study used the statistical, case study, and descriptive analytical approaches; Sudan was selected to ascertain the quantitative influence of these factors on its economic growth.

1.9. Scope of the study

This study is confined to the Republic of Sudan and covers the period from 2000 to 2022.

1.10. Sources of data collection

The study primarily utilizes secondary sources for data collection.

1.11. Structure of the study

The study is organized into three parts:

- methodological framework,
- theoretical framework and previous studies, and
- methodological analysis for findings of model estimation.

2. Theoretical framework of the study

2.1. The concept of economic growth

Economic development is a quantitative concept that denotes an increase in production over the long term. It is defined as an increase in income that occurs without any modifications to the national economy or the structure of production (Abdullah, 2021) [1]. It is also defined as the expansion of a country's productive capacities because of the enhancement or expansion of the utilization of economic resources or the advancement of production technology (Misawi, 2018) [2]. (Bin Qana, 2012) [3] also defines economic growth as a continuous increase in real average per capita income over time. This definition implies that economic growth is not limited to an increase in total income or total output but also encompasses an enhancement in the standard of living of individuals, as evidenced by an increase in their share of total income.

Based on the above and through the previous definitions, the study defined economic growth as a quantitative increase or change in production. This increase should not only be at steady and continuous rates over a long period of time, but it should be at real rates, excluding the effect of inflation as well, and that the rate of increase in production should exceed the rate of population growth. Furthermore, this increase does not necessarily involve any structural changes at the level of the country's economy.

As for the operational definition of the study, it is defined as the positive change in the level of production of goods and services, which leads to an increase in the country's income, and is measured using the percentage of GDP growth.

2.2. Types of economic growth

According to (Misawi, 2018) [2], two types of economic growth can be identified:

a. Inclusive growth: It is an increase in the rates of real national output growth (GDP at constant prices to remove the effects of inflation) even if this does not reflect an increase in per capita share. In other words, this type is characterized by income growth occurring at the same rate as population growth, meaning that per capita income remains stagnant.
b. Intensive growth: It is achieved through an increase in the goods and services available per person. Therefore, the per capita share of real production (real income) is a measure of intensive economic growth. If the growth rate of a country's production of goods and services exceeds the population growth rate, it means an increase in the per capita share of real income, which in turn leads to an improvement in individuals' living standards. This indicates that intensive economic growth has occurred. Conversely, if the population growth rate in a country exceeds its production growth rate, it will lead to a decrease in the per capita share of real income, indicating a deterioration in the economic grow of the country.

2.3. The basic factors of economic growth

Misawi (2018) [2], mentioned that three essential factors are needed to achieve economic growth:

a. Capital accumulation: It constitutes all new investments, whether material or human. It occurs when a portion of the current income, such as savings, is allocated for investment to increase future income and output growth. For example, establishment

of factories, increase in equipment and machinery, and construction of buildings are all investments that would enhance the country's material capital. Consequently, this allows for an expansion in the levels of achievable production.

b. The workforce: This is the economically active population sector whose ages range between the minimum and maximum age allowed for work. In other words, the workforce includes all those who are currently employed and those who are unemployed but are willing and able to work.
c. Technological advancement: Technological advancement is considered a fundamental and indispensable factor for economic growth. It often does not come without a cost; rather, it requires a planned effort, which is often driven by the pursuit of material profit. Technology consists of a set of scientific knowledge that may be included in capital goods such as machinery and equipment or in human investment in the form of competencies and skills inherent to and inseparable from individuals.

2.4. Concept of FDI

The concept of FDI has a multifaceted definition and is considered one of the concepts that researchers have extensively studied due to its significance for countries and individuals alike, especially over the past decades that have globally witnessed substantial growth and expansion in the movement of these investments.

FDI is defined as the process by which a resident entity acquires ownership of assets for the purpose of control, production, distribution, and various other activities (Musa, 2002) [4]. Meanwhile, the International Monetary Fund views FDI as a long-term relationship that arises from a foreign investor holding 10% or more of the ordinary shares or voting power within a specific institution outside their country, with the aim of obtaining lasting benefits in that institution and having the actual ability to make decisions and manage it (Al-Muhtasib, 2009) [5]. The World Trade Organization (WTO) also defines FDI as the ownership of a productive asset in one country by an investor residing in another country, with the intention of managing it and obtaining an investment return from it (Mohammed, 2012) [6].

2.5 . Objectives of FDI

(Ilham (2015) [7] states that FDI aims to achieve the following objectives:

a. Preserving the original capital of the project (the value of assets) by choosing projects with the least risk and diversifying investment areas to prevent the devaluation of its assets over time due to rising prices and market fluctuations.
b. Searching for a location and establishing itself in proximity to sources of raw materials or primary materials, thereby maximizing profits and reducing production costs. The global competition among foreign investors has made it imperative for them to control sources and raw or primary materials, allowing them to dominate global markets.
c. Benefiting from cheap labor, as the cost of labor in the investors' home countries tends to be high, encouraging investing companies prefer to settle in the host countries of these investments.

2.6 . Relationship between FDI and economic growth

Recent theories that have attempted to explore the relationship between FDI and economic growth. These theories have concluded that there exists a positive relationship between FDI and economic growth on the one hand and the presence of indirect positive effects accompanying FDI on the other hand, which contribute to increasing economic growth within the country. Such theories assume the existence of a mutual interest relationship between the two parties involved in an investment, where both parties – the investing companies and the host country – mutually benefit from this relationship, and these benefits depend on the policies of each party. Proponents of such a theory also believe that FDI contributes to the utilization of human and financial resources available in the host country and works on transferring various technologies in the fields of production, marketing, management, and the likes in the host country (Sayed et al., 2022) [8].

3. Previous studies

Mustafa and (Mustafa, 2022) [9] studied the impact of FDI on economic growth in Sudan during the period 1991-2019. The significant of the study lies in enriching the research in the field of Sudanese economics regarding the impact of FDI on economic growth. The study employed descriptive, inductive, historical, and standard quantitative methods, utilizing Statistical Package for Social Sciences (SPSS) with the two-stage least squares method for simultaneous equations. The study hypothesized the existence of a statistically significant correlation between economic growth and the flow of FDI. It concluded that FDI in Sudan has a significant and positive relationship with economic growth. Additionally, FDI contributes to job creation, which reduces unemployment and increases exports, thereby contributing to economic growth.

Nilofer and Abdul Qayyum (2018) [10] conducted a study on the impact of FDI on economic growth in Pakistan during the period 1970-2015 using the Auto-Regressive Lag (ARDL) model. The study found existence of positive effects of both public and private investment on economic growth. It also found a negative impact of both FDI and public consumption on economic growth in

Pakistan. This effect is attributed to, firstly, the relatively low FDI flows for several decades compared to similar developing countries and, secondly, these flows were in the form of loans, which cost more than the returns from FDI.

Hamdan (2016) [11] conducted a study, using Panel Data Approach, to investigate the role of FDI in economic development in some Arab countries, namely Jordan, Qatar, Oman, Yemen, Saudi Arabia, Morocco, Algeria, Lebanon, Palestine, Djibouti, Mauritania, and Egypt during the period 1995-2013. The researcher applied three models: the pooled regression model, the fixed effects model, and the random effects model. For preference of the previous models, three approaches were used: the pooled regression model, fixed effects model, and the Haussman Test to compare the fixed effects model and the random effects model. The study reached several key findings, including: the presence of a negative impact of FDI on economic growth in the studied Arab countries during the study period, as well as the positive effect of exports, imports, and gross capital formation on economic development in the same countries. The study recommended reducing fully foreign-owned projects and encouraging the establishment of joint ventures that help the local investor exert control over the foreign investor.

Shawqi (2015) [12] conducted a study on the influence of FDI on economic growth, focusing on Algeria, as a case study, by investigating the relationship between the variables within an economic theoretical framework, followed by a quantitative econometric analysis from 1990 to 2013, prompted by the surge in FDI flows and the initiatives undertaken to attract such investments to Algeria during this period. The study determined that FDI adversely impacts the economic growth rate in Algeria as evidenced by the two analyzed models. This is mostly attributable to the adverse growth rates observed in the hydrocarbons sector. Simultaneously, its influence on local investment was favorable and statistically significant; nonetheless, it was unable to convert the adverse effect on economic growth into a beneficial one. The research revealed that FDI positively and significantly influences exports, attributable to the strong correlation between the export structure and the concentration of such investment in the hydrocarbons industry. The study proposed several recommendations to enhance the environment for FDI, notably emphasizing the imperative of infrastructure enhancement, prioritizing human capital development through training and skill acquisition to assimilate modern technology, the necessity of reforming the banking and financial sector, and the pursuit of broadening bilateral and international agreements.

Saeed (2015) [13] studied the impact of FDI on the economic growth in Sudan, focusing on Chinese Investments from 2005 to 2014 as a case study. Saeed examined the barriers to investments and contributions of these investments to the Sudanese economic development. The significance of the study stems from the fact that it addresses significance of foreign investments and their contribution to economic development. The research employed descriptive, analytical, and applied methodology. The study hypothesized that the improper implementation of investment regulations adversely impacts foreign investments and that a direct correlation exists between FDI and economic development. The study concluded that the economic climate in Sudan is notably flexible in attracting foreign investors. The study advocated for the reform of the tax system to align with price structures and encourage investment production, while emphasizing promotion in global markets and decision-making centers aimed at investment.

4. A comparative review between the current and previous study

This study is consistent with the findings of Mustafa and Mustafa (2022) concerning the dependent and independent variables, the significance of the study, objectives, hypotheses and spatial domain; but it differs in the style and methodology of data analysis. It also aligns with Nilofer's and Abdul Qayyum (2018) research regarding the objectives, methodology, and model used, but it differs in the scope of the investigation. In addition, the study aligns with Hamdan's (2016) [11] study concerning the independent variables, significance, objectives, and data collection method. However, it diverges regarding the study's scope and data analysis method. The current study also aligns with Shawqi's study (2015) in terms of variables, objectives, methodology, and data collection and analysis methods; however, it differs in its temporal and geographical scope. Finally, this study parallels Saeed's (2015) in terms of independent and dependent variables, objectives, significance, and methodology; however, it diverges in the time frame and data analysis method employed by Saeed.

This study is distinguished from prior research by its prediction of expected economic growth values and the descriptive and quantitative mapping of these trajectories through realistic potential scenarios. Furthermore, it entails the development of a mathematical model and the evaluation of its significance. This study includes an extended time frame, enhancing the accuracy and objectivity of the results.

5. Methodology for analysis and findings

5.1. Model development and estimation findings

It is crucial to assess the influence of FDI on economic growth, including the identification of model variables, data sources and unit root tests to ascertain the integration level of the variables. The analysis subsequently examines cointegration to ascertain the presence of a long-term cointegrated relationship among the study variables and estimates both the long-term and short-term relationships using ARDL model, accompanied by an evaluation of the diagnostic tests employed for the estimated model and an assessment of the model's predictive capability.

5.2. Model Description

The study relied on economic theories and previous studies in determining the relevant variables, where GDP was used to represent the dependent variable, which reflects economic growth, while the FDI, trade openness (OP), and fixed capital formation (FC) as independent variables. The data were obtained from the Central Bureau of Statistics as a realized government official body. Accordingly, the standard model was formulated as follows:

$$\log(GDP) = B_0 + B_1\log(FDI) + B_2\log(OP) + B_3\log(FC) + \varepsilon_t$$

Where:

Log (GDP) is the logarithm of the gross domestic product representing the economic growth rate, Log (FDI) is the logarithm of the FDI, Log (OP) is the logarithm of the trade openness and Log (FC) is the logarithm of the capital formation. B_{es} are the model coefficients and ε_t represent the random error term (residuals).

5.3. Estimation Methodology

The study, within its methodological framework, relied on time series analysis covering the period (2000-2022), where a series of standard statistical procedures were followed to verify the data characteristics and ensure their suitability for standard estimation:

5.3.1. Testing the properties of time series (Unit Root Tests)

Due to the time-bound nature of the data, the stationarity properties of the variables were initially verified to ensure their suitability for use in time series regression models and to avoid the problem of spurious regression. To achieve this, an Augmented Dickey-Fuller Test (ADF) was used to measure the presence of a unit root in time series. All variables were subjected to the level stationarity test, considering the presence of three forms of test models:

- Model without constant and without time trend (None).
- Model with intercept only (Intercept).
- Model with intercept and trend (Intercept and Trend).

In the case of not rejecting the null hypothesis (H_0) of the unit root, the test was moved to the first difference to determine whether the variables become stationary after taking the difference. The integration order of each variable was determined based on the test results, when the variable becomes stationary at the first difference, it is considered integrated of order one I (1).

5.3.2. Johansen Co-integration Test

Upon confirming the stationarity characteristics and establishing the integration order of the variables, it is imperative proceeded to the subsequent phase, which entails conducting a cointegration test to assess the long-term equilibrium relationship between FDI and economic growth, alongside the other independent variables incorporated in the model.

The Johansen methodology (1988, 1991) [14] was employed, recognized as one of the most thorough and appropriate tests for analyzing several integrated variables of the same order. This test is predicated on constructing a Vector Error Correction Model (VECM) utilizing the Vector Autoregression (VAR) methodology.

$$\Delta x_t = \Pi_{x_{t-1}} + \Sigma\Gamma_l\Delta_{x_{t-1}} + Cd_t + \varepsilon_t$$

The assessment depended on two primary criteria to ascertain the quantity of cointegration vectors (Cointegration Equations):

The linear hypotheses about the cointegration vectors have to be tested to figure out the asymptotic distribution (et al, Søren Johansen 1988) [15]

If Y_t = $y_{1t} + \cdots + y_{nt}$ denote an (n × 1) vector of I(1) time series. Y_t is

Co-integrated if there exists an (n × 1) vector $\beta_1, \beta_2 \ldots \ldots \beta_n$ such that $\beta Y_t = \beta_1 y_{1t} + \cdots +, \beta y_t = \beta_n y_{nt}$

- Trace Statistic: Evaluates the null hypothesis of possessing no more than r cointegration vectors.
- Max-Eigenvalue Statistic: Evaluates the null hypothesis of at most r cointegrating vectors in contrast to the alternative hypothesis of $r + 1$ cointegrating vectors.

The computed statistics were juxtaposed with the critical tabular values at various significant levels (1%, 5%, 10%). If the computed value surpasses the tabular value, the null hypothesis is rejected in support of a long-term link between the variables.

This step ascertains whether the economic variables under examination, including FDI, GDP, trade openness, and capital formation, exhibit long-term spontaneously move to maintain a stable equilibrium relationship, which is essential for progressing to the construction of a VECM and analyzing the dynamic interrelationships among the variables in both the short and long term.

5.3.3. Fully Modified Ordinary Least Squares (FMOLS)

The FMOLS method, was first developed by Phillips and Hansen (1988) [16] , it is an appropriate technique for estimating time series models defined by cointegration, entails implementing statistical modifications to tackle two primary challenges frequently encountered by models utilizing integrated time series data:

- Serial Correlation: the existence of correlation among mistakes over time results in bias in the Ordinary Least Squares (OLS) estimations.
- Endogeneity: Arising from the dynamic interplay of variables, resulting in bias and inconsistency in estimations.

The FMOLS method corrects for deviations caused by these issues through the Long-run Covariance Matrix, enabling the derivation of coefficients that accurately represent the relationship between FDI and economic growth, along with other control variables, unaffected by statistical anomalies that could skew the results. The method is characterized by its capacity to yield reliable and efficient estimates, even with relatively small sample sizes.

5.3.4. Diagnostic Tests

To ensure the efficiency of the estimated model and the validity of the obtained results, the model was subjected to a series of statistical diagnostic tests aimed at verifying the viability of the underlying hypotheses of the estimation methodology, including:

a. Multicollinearity Test: The Variance Inflation Factor (VIF) was used to measure the degree of correlation between the independent variables. High VIF values indicate the presence of multicollinearity, which may negatively affect the accuracy of coefficient estimation.
b. Homoscedasticity Test: To verify the constancy of error variance across time observations, the Breusch-Pagan Test (BPT) was applied. Homoscedasticity is a fundamental condition for obtaining efficient and unbiased estimates.
c. Autocorrelation Test: The Ljung–Box Q test was relied upon to detect the presence of serial correlation among the residuals of the model. The absence of autocorrelation enhances the reliability of the results derived from the model.
d. Residual Normality Test: The Jarque–Bera Test was used to ensure that the residuals follow a normal distribution, which is one of the essential prerequisites for proper statistical inference.

6. Results of the study model estimation

The results of estimating the practical application of the FMOLS involve a) determining the order of integration of the variables using unit root tests; b) testing for the existence of a cointegrating relationship using the Johansen Co-integration Test; and c) estimating FMOLS to obtain the estimation coefficients, then the FMOLS estimation is conducted to obtain the estimation coefficients.

6.1. Variables descriptive statistical analysis

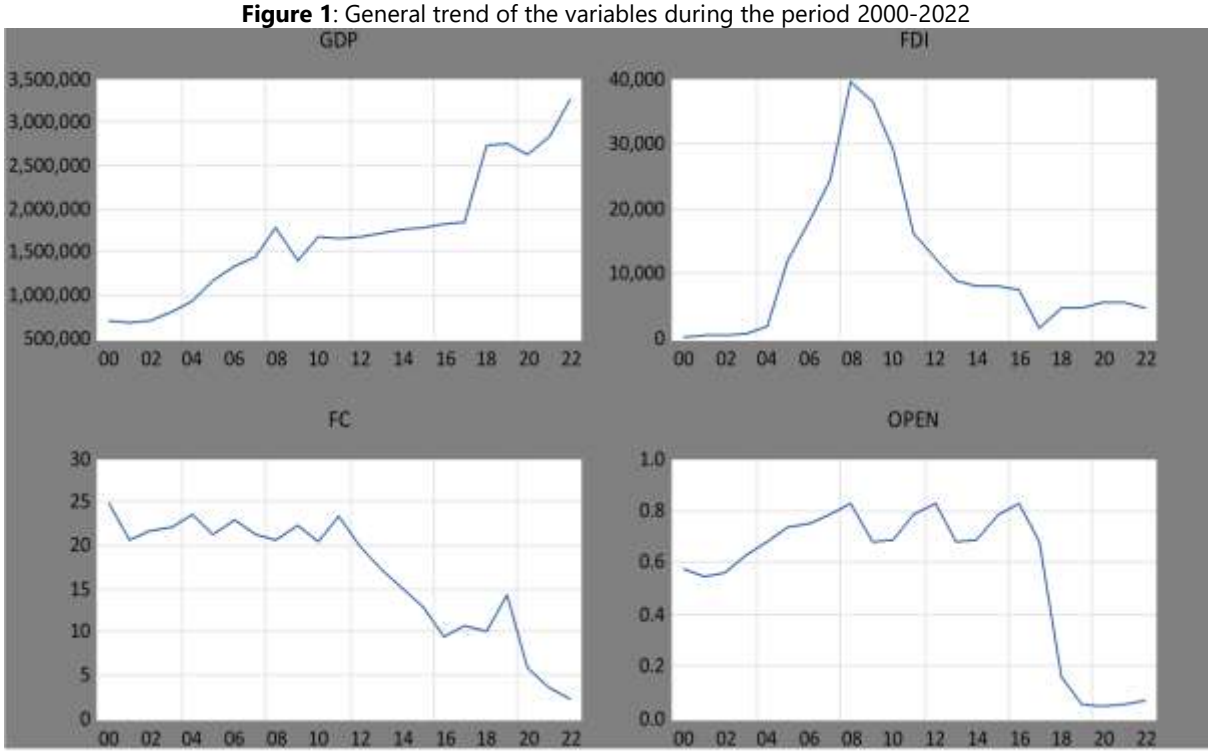
To understand the characteristics of the data, some descriptive indices obtained, to allow for examining the trends of time series, the degree of their dispersion and the shape of their distribution. A variety of statistical measures were employed, including the arithmetic mean, standard deviation (SD), minimum and maximum values, skewness, kurtosis, and the Jarque-Bera Test to evaluate the characteristics of the statistical distribution.

Table 1: Results of the descriptive analysis of the study variables

Descriptive analysis indicators	GDP	FDI	Capital formation	Trade openness
Mean	1696120.	10906.29	16.75209	0.568996
Median	1681855.	7452.500	20.39854	0.676200
Maximum	3254123.	39455.90	24.88803	0.830900
Minimum	679163.0	183.0000	2.178264	0.043100
Std. Dev.	733924.0	11455.06	6.872275	0.279435
Skewness	0.463524	1.292827	-0.802041	-1.102086
Kurtosis	2.446043	3.611210	2.366975	2.623055
Jarque-Bera	1.117690	6.765053	2.849891	4.792110
Probability	0.571869	0.033962	0.240522	0.091077

Source: Researchers of the study data based on program findings, E. Views 12, 2025

Figure 1: General trend of the variables during the period 2000-2022



Source: Researchers of the study data based on program findings, E. Views 12, 2025

It is evident from results of the descriptive analysis that the examined variables—GDP, FDI, trade openness, and capital formation—demonstrate considerable heterogeneity in their statistical characteristics. Nevertheless, they typically exhibit behavior approximating a normal distribution, as indicated by the results of the Jarque-Bera Test (except for the FDI variable). All variables exhibited acceptable averages that accurately represent their typical levels during the study period. There is a distinct dispersion in certain variables, such as GDP and FDI, as demonstrated by their high SDs, signifying considerable variance in values across time or across different instances. Conversely, the dispersion in capital formation and trade openness was comparatively lower, suggesting greater stability in these measures relative to the other variables.

Most variables exhibited a skewness value near zero, either marginally positive or negative, suggesting that the distribution did not significantly favor one side. The capital formation and degree of openness exhibit a negative skewness coefficient, suggesting a modest inclination of values towards the left side, indicative of the presence of some low values. The other variables exhibited a minor positive skewness, indicating a slight inclination towards high values. The kurtosis values for all variables were near the optimum value for a normal distribution (3), suggesting that the concentration around the mean is not severe.

Except for the FDI variable, all Jarque-Bera values were statistically insignificant ($P > 0.05$), suggesting that there was no significant deviation from the normal distribution. This further suggests that the data is appropriate for statistical applications that presume normal distribution, such as classical regression analysis.

The four variables exhibit balanced distribution characteristics, with varying degrees of dispersion, and essentially follow an acceptable normal distribution, as indicated by the statistical indicators. This equilibrium improves the validity of incorporating these variables into conventional economic models, without necessitating additional distributional transformations.

6.2. Stability test for time series data (unit root tests)

Prior to estimating the relationships among the variables, the characteristics of time series were initially assessed using the Augmented Dickey Fuller (ADF) test to check for stationarity.

Initial findings demonstrated that all variables are non-stationary at the level, since the statistical test values were inadequate to exclude the null hypothesis of the unit root's existence. Upon computing the first difference, all variables exhibited stationarity at a high significance level, as the ADF statistics were negative with p-values below 0.01, hence supporting the rejection of the null hypothesis and the acceptance of the variables' stationarity after the first difference. Consequently, it may be asserted that all variables are integrated of the first order (I (1)), so permitting the application of cointegration tests to ascertain the presence of a long-term equation relationship among them. The conclusion is crucial from a methodological standpoint, as the verification that all variables are integrated into the same order (I (1)) is a prerequisite for advancing to the subsequent phase, which involves testing for the presence of a long-term relationship via the Johansen cointegration test. Table (2) presents the results of the ADF test.

Table 2: Results of the unit root test for the variables

Variables	Level		First difference	
	P. value	ADF	P. value	ADF
GDP	0.8690	0.2264	0.0004	-5308
FDI	0.2407	- 2.115	- 0.0295	- 3.648
Capital formation	0.9394	- 0.0868	0.0001	- 6.083
Trade openness	0.9036	- 0.3398	0.0409	- 3.113

Source: Researchers of the study data based on program findings, E. Views 12, 2025

6.3. Bounds Testing Approach

It was necessary to verify the existence of a long-term equilibrium relationship between the studied variables by applying the Johansen Co-integration Test.

Table 3: Boundary test results for the joint integration between the variables

Hypothesized		Trace	0.05	Prob.**
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Critical Value
None *	0.889553	85.48536	47.85613	0.0000
At most 1 *	0.679108	39.21771	29.79707	0.0031
At most 2	0.408922	15.34806	15.49471	0.0526
At most 3 *				

Source: Researchers of the study data based on program findings, E. Views 12, 2025

The findings in table (3) indicate a rejection of the null hypothesis (no cointegration), given that the impact value surpassed the critical value at the 5% significance level. The subsequent hypotheses regarding the presence of one or more cointegration vectors were not rejected, suggesting that there is a single common cointegration vector that connects the variables.

Moreover, the findings indicate a stable and enduring equilibrium relationship among real GDP, (FDI), trade openness, and fixed capital formation throughout the study period.

The identification of a cointegration relationship among the variables supports the appropriateness of employing the FMOLS method.

The findings facilitate a clear differentiation between the short-term relationship, characterized by potential volatility, and the long-term relationship, which embodies stable economic trends.

6.4. Results of the model estimation

FMOLS approach was employed to estimate the long-term relationship coefficients between GDP as the dependent variable and FDI, trade openness, capital formation, and the inflation rate as independent variables.

Table 4: Results of FMOLS

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(FDI)	0.181965	0.024381	7.463364	0.0000
LOG(FC)	0.378429	0.074732	5.063845	0.0001
LOG(OPEN)	0.107128	0.046405	2.308565	0.0330
C	13.61159	0.324898	41.89499	0.0000

Source: Researchers of the study data based on program findings, E. Views 12, 2025

Whereas: R-squared= 0.81 and adjusted R-squared=0.78.

Table (4) concludes the following:

1. FDI: The coefficient of (0.181) showed statistical significance at 1% level, confirming the existence of a long-term positive relationship between FDI flows and economic growth. In other words, a 1% increase in FDI flow leads to a 0.181% increase in real GDP. This result supports the hypothesis that foreign investment contributes to technology transfer, job creation, and the enhancement of overall productivity.
2. Trade openness: The trade openness coefficient reached (0.378) and was significant at the (1%) level, reflecting the positive impact of integration into international trade on growth. The result indicates that an increase in the degree of openness by 1% contributes to a growth in GDP by 0.378%, highlighting the importance of flexible trade policies and encouraging exports.
3. Capital formation: The recorded coefficient was 0.107, statistically significant at the 1% level, indicating that an increase in domestic investments in fixed capital (infrastructure, equipment, productive assets) fosters economic growth, with a 1% rise in capital formation resulting in a 0.107% increase in GDP.
4. The Constant (C): The attained number 13.611 is statistically significant, indicating the anticipated level of GDP in the absence of other explanatory variables.
5. Model suitability: The coefficient of determination (R-squared = 0.81) signifies that nearly 81% of the variation in economic development is elucidated by the input variables (FDI, trade openness, and capital formation). The adjusted (R-squared = 0.78) is comparable to the prior value, signifying the model's robustness and the lack of overfitting issues. The FMOLS estimation results indicate a favorable and significant long-term association between FDI and economic growth, as well as trade openness and capital formation. These findings confirm that attracting foreign investments, broadening the international trade base, and fostering local investment policies are essential pillars for attaining sustainable economic growth.

6.4. Model validity test

Model Diagnostic Assessments: Following the estimation of the long-term relationship via the FMOLS method, several diagnostic tests were performed to validate the model's hypotheses and confirm the dependability of the results. The tests encompass the following:

a. Examination of multicollinearity: The Variance Inflation Factor (VIF) was employed to identify the existence or intensity of multicollinearity among the independent variables. Findings in Table (5) indicated that the VIF values varied from (2.47) for capital creation to (2.43) for trade openness, whilst the FDI value was approximately (1.03). All values were below the acceptable level (5), signifying that multicollinearity exists to a moderate extent but does not substantially impact the model's accuracy. Consequently, the impact of each variable on economic growth may be assessed with considerable confidence.

Table 5: Variance Inflation Factor (VIF) test

Variables	VIF	Coefficient variance
FDI	1.031509	0.000594
Trade openness	2.431336	0.005585
Fixed capital formation	2.476272	0.002153

Source: Researchers of the study data based on program findings, E. Views 12, 2025

b. Autocorrelation Test: The Q-Statistic test was applied to verify the independence of the residuals. The results showed that the autocorrelation coefficients ranged between (-0.095) and (0.082) across different time periods, with p-values greater than

(0.10) in all periods. This confirms the absence of serial correlation in the model errors, which enhances the accuracy of the estimates and the efficiency of the coefficients.

Table 6: Q-Statistic Test

Prob*	Q-Stat	PAC	AC		Partial Correlation	Autocorrelation
0.533	0.3883	-0.102	-0.102	1	.*| . |	.*| . |
0.817	0.4038	0.010	0.020	2	. | . |	. | . |
0.921	0.4920	0.051	0.047	3	. | . |	. | . |
0.974	0.4921	0.011	0.001	4	. | . |	. | . |
0.972	0.8806	0.097	0.096	5	. |*. |	. |*. |
0.984	1.0345	-0.043	-0.059	6	. | . |	. | . |
0.990	1.2265	0.052	0.065	7	. | . |	. | . |
0.990	1.6231	-0.091	-0.092	8	.*| . |	.*| . |
0.992	1.9968	0.074	0.087	9	. |*. |	. |*. |
0.994	2.2422	-0.070	-0.069	10	.*| . |	.*| . |

Source: Researchers of the study data based on program findings, E. Views 12, 2025

c. Hansen Parameter Instability Test: To ensure the stability of the long-term association and the lack of structural breaks, the Hansen test was employed. The findings indicated that the statistic value (Lc) attained (0.272) with statistical significance below (0.05), affirming the presence of a steady cointegration relationship among economic development, FDI, trade openness, and capital formation, indicates that the variables exhibit long-term co-movement without instability in the parameters, hence augmenting the dependability of the conclusions derived from FMOLS.

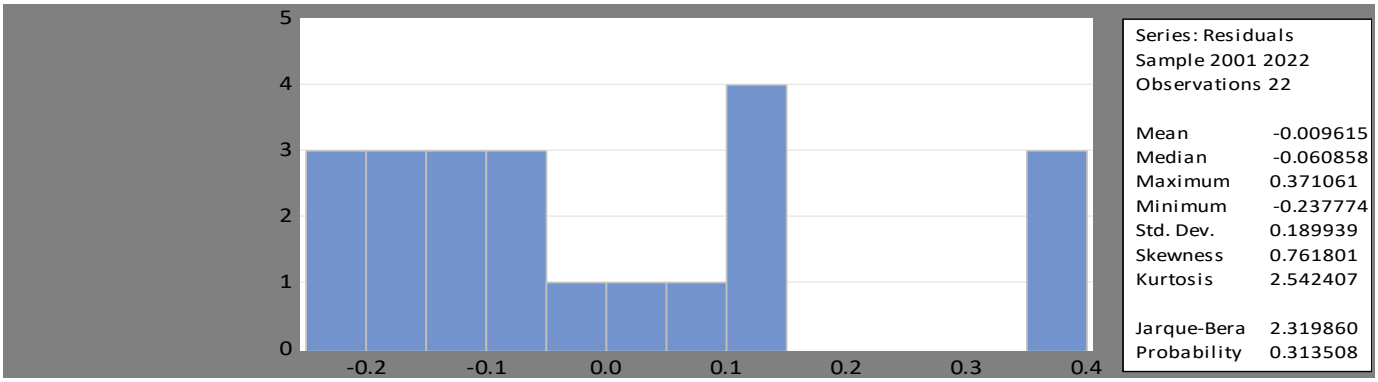
Table7: Hansen Parameter Instability Test

Lc statistic	Stochastic (trends m)	Deterministic (trends K)	Excluded Trends (p2)
0.272	3	0	< 0.01

Source: Researchers of the study data based on program findings, E. Views 12, 2025

d. Normality test for the error limit: The normality condition was verified using the Jarque-Bera Test, the value (2.319) with a probability value of (0.313), which is greater than the 5% significance level, indicates that the residuals follow a normal distribution at the 5% significance level.

Figure 2: Normality test for the error term



Source: Researchers of the study data based on program findings, E. Views 12, 2025

6.5. Discussion of the results

The empirical findings of the current study verify the existence of a statistically significant long-term relationship between economic growth and FDI, as well as trade openness and capital formation. These findings are largely in accordance with classical and contemporary economic literature, which indicates that accelerated growth is facilitated by foreign capital flows and trade integration, as well as enhanced productive efficiency and market expansion by technology transfer, with the following conclusions:

a. FDI as a growth catalyst: The results showed that the FDI coefficient (0.214) was the highest in terms of its impact. This aligns with the results of studies, i.e., Borensztein et al. (1998) [17] which confirmed that foreign investment represents a key channel for transferring technology and technical knowledge to developing countries. In the Sudanese context, foreign investment also plays a dual role by creating direct job opportunities, supporting infrastructure projects, and enhancing tax revenues.
b. Trade openness and enhancing economic efficiency: The trade openness coefficient (0.175) was statistically significant and positive, reflecting the importance of foreign trade in stimulating growth by expanding market scope and diversifying the production base. This aligns with Edwards (1998) [18] thesis that more open economies tend to achieve higher growth rates due to competition and increased flows of goods and investments.
c. Capital formation as a source of local growth: Capital formation (0.129) was statistically significant, indicating that increasing local investments in infrastructure and productive sectors directly contributes to improving economic performance. This aligns with studies that confirm local investment forms the fundamental basis for sustainable growth, while foreign investment complements this role through technological and financial flows.
d. The structural stability of the model: The Hansen test validated the stability of the long-term association between the variables, indicating that economic and political shocks in Sudan throughout the research period did not alter the intrinsic character of the relationship between FDI and economic development. This improves the dependability of the results and provides higher explanatory power for policymakers.
e. Alignment with Development Plans in Sudan: The findings correspond with the objectives of Sudan's economic development plans, which advocate for the promotion of foreign investment, the facilitation of regional and international trade, and the encouragement of local investment. The report presents empirical evidence that improving these parameters is a crucial mechanism for economic growth in Sudan.

7. Findings and recommendations

7.1. Findings

Based on the analysis conducted using the method of FMOLS, the study reached several key findings regarding the long-term relationship between FDI and economic growth:

a. The existence of a long-term relationship between FDI and real GDP, where the results have proven that FDI is one of the main drivers of economic growth in Sudan.
b. (FDI showed a positive and significant impact on GDP (coefficient = 0.214), reflecting the role of foreign capital flows in financing productive projects and stimulating long-term growth.
c. Trade openness was positively associated with growth (coefficient = 0.098), reflecting the role of foreign trade in enhancing specialization and increasing economic efficiency, despite the challenges of a weak trade balance.
d. The results indicate that FDI flows do not operate in isolation but interact with other macroeconomic factors such as fiscal and trade policies, and monetary stability conditions, to determine the growth trajectory in Sudan.

7.2. Recommendations

Based on the findings, the study proposes a set of policies and strategic recommendations aimed at enhancing the role of FDI in supporting economic growth:

a. Improving the environment for local and foreign investment.
b. Simplifying bureaucratic procedures and providing an attractive legal and legislative environment.
c. Strengthening the independence of judiciary system and ensuring the protection of investors' rights.
d. Developing infrastructure and support services for investment.
e. Expanding the use of digital technology in the registration and licensing of investments.
f. Adopting stricter monetary policies to control inflation.
g. Directing investments towards agriculture, manufacturing, and sustainable mining.
h. Providing tax and financial incentives for companies that invest in high value-added sectors.

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