# Using Nonlinear Autoregressive Models to Investigate the Impact of Foreign Trade on Economic Growth in Sudan

BADRELDIN MOHAMED AHMED ABDULRAHMAN[1,a],
ANAS GAREEBALLAH AHMED IBRAHIM[2], HASHIM ABDALLAH ADAM DAWALBAIT[3]
[1]Department of Business Administration,
College of Business, Jouf University,
SAUDI ARABIA

[2]Department of Econometrics, Faculty of Economics and Management Science,
University of Bakht Al-Ruda,
SUDAN

[3]Department of Statistics and Population Studies, Faculty of Economics and Social Studies,
University of EL Fasher,
SUDAN

[a]ORCiD: https://orcid.org/0000-0003-2174-1150

*Abstract:* - Foreign commerce is the term for the exchange of goods and services between nations, and it is subject to a wide range of laws, rules, and agreements. The purpose of the study was to evaluate the link between Sudan's economic growth, imports, and exports from 2005 to 2022. Based on a descriptive, analytical, and econometrics methodology, the study estimated the relationship between the study variables using a nonlinear autoregressive model (NARDL). The study's conclusions indicate that, during the study period, exports had a short-term negative influence on the rate of growth in the economy but a positive long-term impact. Additionally, imports have a short-term favorable effect on economic growth rates but a long-term negative one.

*Key-Words:* - exports, imports, economic growth, self-regression, long run, foreign trade, autoregressive model, nonlinear, international trade.

## 1 Introduction

Theories about the process of international trade have emerged because of decades of interest in and need for it. As argued by [1], a country is considered to have a deficit if its exports exceed its imports; thus, a nation with a surplus in its trade balance is one whose imports exceed its exports. This means that an increase in exports is a sign of the nation's growth and prosperity, as well as the revival of its commercial activity, and the more heavily a country depends on imports, the more this is an indicator of growth. [2], defined both visible and invisible international transactions as the transfer of goods to individuals and capital as well as international trade transactions in their various forms that take place between individuals or between governments and economic organizations residing in different political units. Concerning the economy of Sudan to

determine the shape of a variable connection and to empirically analyze the import demand function from 1998 to 2017, [3], used an econometric model to determine critical factors that impact the degree of import demand and also showed that relative pricing and national income have a favorable effect on the overall amount of imports. Comparatively speaking, the exchange rate has less of an effect than other factors. Additionally, [4], processed agricultural exports are positively correlated with economic expansion, while unprocessed agricultural exports are negatively correlated with the economy's expansion.

This study aims to:

A. measure Sudan's exports, imports, and economic growth using the NARDL model.

B. recognize how exports and economic expansion are related.

Badreldin Mohamed Ahmed Abdulrahman,
Anas Gareeballah Ahmed Ibrahim,
Hashim Abdallah Adam Dawalbait

C. recognize the connection between economic expansion and imports.

In keeping with the goal, we attempt to respond to the following queries in this research:

- How do exports impact Sudan's economic growth over the short and long terms?

- What are the short- and long-term effects of imports on Sudan's economic growth?

The rest of the research paper is organized as follows: The literature is reviewed in Section 2. The model, hypothesis, and research methodology are covered in Section 3. The findings and results are covered in Section 4. Finally, section five reports the conclusion remarks.

## 2 Review of Literature

At the top of the list of priorities for both developed and developing nations is long-term economic growth, which is defined as enhancing the economy's capacity to produce as indicated by an increase in the absolute or relative value of the gross domestic product or per capita income over time. A state's ability to offer a varied range of economic goods to its citizens is referred to as economic growth. This growing increase in productive capacity is based on institutional adjustments that are required as well as technological advancements and necessary ideological shifts, [5], [6].

Foreign aid, exports of goods and services, and foreign direct investment (FDI) all have a significant impact on a country's socioeconomic growth; both developing and underdeveloped countries place a high priority on these sources. The links between several variables, such as exports, foreign aid, FDI, and economic expansion in Vietnam, are examined in this study. Vietnam's economic growth was examined empirically by applying a linear technique using a time-series data set covering the years 1997 to 2018. The effects of exports, foreign aid, and FDI were assessed. The World Bank and pertinent Vietnamese authorities provided data for this study, [7]. As mentioned by [8] and [9], development enthusiasts have been thinking about the connection between export success and growth in the economy in recent years. In [10], the author made the case that exports of both petroleum and other products were essential to Saudi Arabia's economy between 2005 and 2019, the investigation used an empirical approach to examine how exports affected Saudi Arabia's economic performance. The outcomes showed how exports, both non-oil and oil, advantageously impact economic performance.

Authors in [11], looked at the impact of imported goods, exported goods, and domestic investment on Peru's GDP utilizing data from 1970 to 2017. Imports, exports, and domestic investment have minimal impact on the economy, either in the short or long term, according to the analysis. These results demonstrate that trade liberalization and domestic investment, despite various problems and an unsuitable economic framework, are not the causes of Peru's sustained economic expansion.

The research made by [12], revealed a dual causal connection between imports and exports, as well as a long-term balanced relationship between exports, imports, and economic development in Algeria. [13], also revealed that there is a morally important relationship between oil exports and economic progress in the Republic of Iraq. Furthermore, [14] and [15], examined the asymmetric relationship between Turkey's growth rate and the growth rate of imported goods and services from 1988 to 2019 using the NARDL model and two distinct measures of economic growth rate. The estimation results demonstrated a nonlinear positive correlation between the growth rates of imports and the economy. Meanwhile, [16], examined the impact of foreign direct investment (FDI) on economic growth in lower-middle-income developing countries between 2000 and 2014 and provided fresh and relevant quantitative data. According to research by [17], there is no set threshold value for capital inflows about manufacturing exports in Nigeria. The study used threshold regression econometric techniques to examine the most effective amount of capital inflows for the growth of manufacturing exports and the economy in Nigeria from 1981 to 2017.

The export of goods and services can have a significant impact on society's overall demand, [18], [19], therefore, a rise in income levels can result from an increase in demand, and this increase can then be further amplified through the multiplier effect. All macroeconomic variables and exports were found to be positively correlated in the study, except the exchange rate, which negatively affects Sudan's low-income, agriculture-based economy. In the meantime, between 2000 and 2016. Meanwhile, [20], used the Generalized Method of Moments model to investigate the consequences of technology and exports on the performance of rising Asian countries in terms of their economies.

Based on the Solow growth equation model, the findings demonstrated that technology and exports had a major and beneficial influence on economic growth. Thus, [21], evaluated how decentralized

Badreldin Mohamed Ahmed Abdulrahman,
Anas Gareeballah Ahmed Ibrahim,
Hashim Abdallah Adam Dawalbait

fiscal management affects the economic performance of developing federations by assessing the effects of tax income and expenditure decentralization on economic growth. The findings showed that the perceived levels of corruption and the caliber of the nation's institutions have an impact on the relationship between fiscal decentralization and economic growth.

According to [22], exporting high-tech goods is crucial for an entire nation's prosperity. This study used a causality analysis to look at how high-tech exports affected Turkey's economic growth. The results showed that Turkey's industrialization policies had shifted from import substitution to export-oriented, with the liberalization process having been virtually finished in the 1990s. Turkey has implemented significant industrialization programs, with a focus on fortifying the export system, to support its competitive advantages. When one considers the results of the Granger Causal Analysis Test in conjunction with the impulse-response and variance decomposition studies, exports of high-technology items increase GDP.

The rate of economic growth of a nation has a significant impact on its economic development, [23], [24], [25], economic growth measures are useful tools that a country can utilize to guide its economic policy decisions and progress its economic objectives, the technique's calculations explain the long-term negative association between price increases and economic expansion, [26], [27]. So that high economic development and recovery are possible outcomes, as mentioned by [28], if trade is liberalized, natural resource prices are stabilized, green financing is encouraged, and energy investment is increased. In contrast authors in [29], found that Trade openness and economic growth do not have a two-way causal relationship. This study distinguishes itself from other research by employing non-linear autoregressive models to examine the influence of foreign trade (exports and imports) on economic growth in Sudan from 2005 to 2022.

## 3 Methodology

The interaction across exports, imports, and growth in the economy in Sudan over the study period (1990–2022) has been explored utilizing a descriptive, analytical, and econometric approach. The nonlinear autoregressive technique (NARDL) was utilized to estimate the association between the research variables. As Sudan works to encourage exports, which increase the nation's gross domestic product, the study focuses on the importance of imports and exports for Sudan. It is believed that one of the primary goals of economic policy is exports. The following are the research hypotheses to fulfill the following objectives:

a. exports have an adverse long-term impact on economic growth.
b. exports have an encouraging short-term contribution to growth.
c. imports have a favorable long-term impact on economic growth, but they also have a short-term negative impact.

The study model takes the following general form:

$$GDP = f \text{ (Export, Import)} \qquad (1)$$

The specific form takes the form:

$$GDP = \alpha + \beta 1 \text{ Export} + \beta 2 \text{ Import} + \varepsilon \qquad (2)$$

Where:
GDP: represents the economic growth rate;
EXPORT: represents the volume of exports;
IMPORT: represents the volume of imports.
According to economic theory, export and import activities are essential to a country's economic growth. These activities not only facilitate international trade but also make significant contributions to a country's GDP, employment, and overall development.

## 4 Results

### 4.1 Bound Test

A bound test is conducted to determine whether a long-term equilibrium relationship (co-integration) exists between variables (exports and imports) and the rate of economic growth. It is compared to the critical f value set by [30] and the F values that were found for the coefficients of the slowed independent variables. The test will be conducted based on the following null hypothesis: There is no long-term equilibrium link between the variables.

Table 1. Bounds test results

| Test Statistic | Value | Signif. | I(0) | I(1) |
|---|---|---|---|---|
| | | | Asymptotic: n = 1000 | |
| F-statistic | 3.696109 | 10% | 1.9 | 3.01 |
| k | 4 | 5% | 2.26 | 3.48 |
| | | 2.50% | 2.62 | 3.9 |
| | | 1% | 3.07 | 4.44 |

Badreldin Mohamed Ahmed Abdulrahman,
Anas Gareeballah Ahmed Ibrahim,
Hashim Abdallah Adam Dawalbait

Table 2. NARDL results

| Variable | Coefficient | S.E | t-stat | Prob. |
|---|---|---|---|---|
| GDP(-1)* | 0.046582 | 0.051245 | 0.909 | 0.3936 |
| EXPORT_POS (-1) | - 0.00072 | 0.000241 | - 2.99022 | 0.0202 |
| EXPORT_NEG (-1) | - 0.00056 | 0.000148 | - 3.77302 | 0.007 |
| IMPORT_POS** | 0.000317 | 0.000196 | 1.618497 | 0.1496 |
| IMPORT_NEG** | 0.00038 | 0.000196 | 1.938594 | 0.0937 |
| D(GDP(-1)) | 0.634545 | 0.209249 | 3.032493 | 0.019 |
| D(EXPORT_POS) | 0.000186 | 0.000209 | 0.892428 | 0.4018 |
| D(EXPORTX_NEG) | -0.00079 | 0.000188 | - 4.2125 | 0.004 |
| ** Variable interpreted as Z = Z (-1) + D (Z) . | | | | |
| Levels Equation | | | | |
| Case 1: No Constant and No Trend | | | | |
| Variable | Coefficient | S.E | t-stat | Prob. |
| EXPORT_POS | 0.015498 | 0PPPP0.013933 | 1.112349 | 0.3027 |
| EXPORT_NEG | 0.011996 | 0.012098 | 0.991529 | 0.3545 |
| IMPORT_POS | - 0.00681 | 0.008328 | - 0.81789 | 0.4404 |
| IMPORT_NEG | - 0.00816 | 0.009837 | - 0.82989 | 0.434 |

The Equation:

$$EC = GDP - (0.0155 * EXPORT\_POS + 0.0120 * EXPORT\_NEG - 0.0068 * IMPORT\_POS - 0.0082 \qquad (3)$$

According to Table 1, the model's estimated Fisher F-statistic value of 3.696 transcends the upper boundaries at 5% significance, hence leading to the rejection of the null hypothesis that a stable long-term connection exists. The alternative hypothesis, which contends that the research variables have a long-term balanced relationship, is accepted as we move from the explanatory factors to the dependent variable, GDP.

Referred to in the NARDL model are the long-run estimation results. As Table 2 above makes evident, over time, the positive shock to the variable (EXPORT_POS) had a positive impact on the dependent variable, gross domestic product (GDP). This effect was statistically significant (0.3027), meaning that a 1% increase in GDP resulted in a 1.5% increase in GDP.

With a significant value of 0.3545, which is larger than 5%, the positive shock to the variable (EXPORT_NEG) had a long-term positive impact on the dependent variable, GDP, when a 1% rise resulted in a 1.1% increase in GDP.

A positive shock to the variable IMPORT_POS has long-term negative effects on the dependent variable, gross domestic product (GDP). These effects are significant (0.4404), which is more than 5% because a 1% increase in GDP leads to a 0.681% drop in GDP. A long-term negative impact of the positive shock to the variable (IMPORT_NEG) on the dependent variable, gross domestic product (GDP), was observed , with a significant value (0.434) greater than 5%. This is because a 1% increase in GDP results in a 0.681% decrease in GDP.

A brief tribute to the NARDL model is mentioned in the results. Therefore, the short-term impact of the positive shock to the variable (EXPORT_POS (-1)) on the dependent variable, GDP, was negative and had a significant value (0.020). The short-term impact of the positive shock to the variable (EXPORT_NEG (-1)) on the dependent variable, GDP, was negative and had a significant value (0.007), less than 5% since a 1% increase in GDP causes a 0.056% decrease in GDP.

As an increase of 1% results in an increase in GDP of 0.0317%, the positive shock to the variable (IMPORT_POS) had a positive short-term effect on the dependent variable, gross domestic product (GDP), with a significant value (0.419), which is greater than 5%. Short-term effects of the positive shock to the variable (IMPORT_NEG) included a 1% increase in GDP, which had a significant value (0.0937), more than 5%, on the dependent variable.

The model suffers from the problem of a non-normal distribution of errors, as its Jarque-Bera test statistic reached 0.580 with a significance level of 0.748, which is greater than 5%. Therefore, we accept the null hypothesis that the data is normally distributed.

## 4.2 Serial Link Test

It is a test related to the extent of correlation between model errors in slower periods. We can test this problem through the Breusch-Godfrey Serial Correlation LM Test. The test results were as follows:

Table 3. Serial correlation test

| Breusch-Godfrey Serial Correlation LM Test: | | | |
|---|---|---|---|
| F-statistic | 0.310147 | Prob. F(2,5) | 0.7465 |
| Obs*R-squared | 1.655503 | Prob. Chi-Square (2) | 0.437 |

Table 4. Variation of error term variance

| Heteroskedasticity Test: Breusch-Pagan-Godfrey | | | |
|---|---|---|---|
| F-statistic | 2.74707 | Prob. F (8,6) | 0.1174 |
| Obs*R-squared | 11.78302 | Prob. Chi-Square (8) | 0.1612 |
| Scaled explained SS | 1.997237 | Prob. Chi-Square (8) | 0.9811 |

Given that the test's probability value was larger than 5% and there is no serial correlation issue, Table 3's test results support the null hypothesis, indicating that the model is not plagued by a serial correlation issue. Table 4 shows that, when the test's (P-value) is compared to 5%, there is no difficulty with changing the variance of the random error. Given that the chi-square test value is 0.1612 and that there is no change in the variance of the error term if it is more than 5%, we accept the null hypothesis. This entails adopting the null hypothesis, which states that there is absolutely nothing wrong with changing the random error term's variance.

## 5 Conclusion Remarks

The study results indicate that model (2, 1, 1, 0, 0) is the most effective modified model that satisfies the AIC requirement for evaluating the impact of imports and exports on Sudan's economic growth rate. The economic growth rate, the dependent variable, and the imports and exports, the independent variables, have a cointegration connection, according to the limits test for cointegration. The results of the study showed that exports had a long-term beneficial impact on the pace of economic growth and a short-term negative influence throughout the examination. The study's conclusions showed that imports had a negative long-term impact on the pace of economic expansion.

*References:*
[1] Ricardo, D. (2017). On Foreign Trade. In: Jones, R., Weder, R. (eds) 200 Years of Ricardian Trade Theory. Springer, Cham. https://doi.org/10.1007/978-3-319-60606-4_20.
[2] Bushra, M and Yaeshi, H. (2021). The impact of imports on economic growth, a comparative study between Algeria and China during the period (1970-2018). M.sc dissertation. Adrar, Algeria.
[3] Ibrahim, Y. A., Abdel-Magid, H., & Ali, H. A. (2023). Development of the Sudan agricultural sector model for policy impact analysis. Irrigation and Drainage, 72(1), 240-258.
[4] Mlambo, C., Mukarumbwa, P., & Megbowon, E. (2019). An investigation of the contribution of processed and unprocessed agricultural exports to economic growth in South Africa. *Cogent Economics & Finance, 7(1),* 1694234. https://doi.org/10.1080/23322039.2019.1694234
[5] Shadi, S. A., Atbiga, S., & Khalafalla, M. (2022). Measuring the relationship between exports and imports in the long run. An econometric study on the Libyan economy using an error correction model during the period 1970-2019. *Journal of Economic Studies, 5(2)*, 300–323.
[6] Saouli, M., Abdulrahmani, F., & Boumaraf, L. (2020). Analysis of the relationship between trade liberalization and economic growth rates in Algeria: an econometric study using the ARDL autoregressive distributed lag model during the period 1974-2016. *Journal of Regional Studies, vol. 13, no. 44,* 35-63, https://doi.org/10.33899/regs.2020.164424.
[7] Nguyen, C. H. (2020). The Impact of Foreign Direct Investment, Aid and Exports on Economic Growth in Vietnam. *Journal of Asian Finance, Economics and Business,7*(10), 581-590,

https://doi.org/10.13106/jafeb.2020.vol7.no10.581.

[8] Feder, G. (1983, February). On exports and economic growth. *Journal of Development Economics, 12*(1–2), 59–73. https://doi.org/10.1016/0304-3878(83)90031-7.

[9] Elbachir, A and Alhumaid, H. (2018). An econometric study of the closeness of exports to economic growth in Algeria (1966-2015), *North African Economics Journal, Volume 14, Issue 19*, p. 148.

[10] Abdulrahman, B. M. A. (2021). Oil and non-oil exports and its impact on economic performance in Saudi Arabia. *International Journal of Energy Economics and Policy*, *11*(1), 88–92, https://doi.org/10.32479/ijeep.10311.

[11] Bakari, S., Fakraoui, N., & Mabrouki, M. (n.d.). *The Contribution of Domestic Investment, Exports and Imports on Economic Growth: A Case Study of Peru.*

[12] Osama, K and B. Y. Imad Al-Din (2021). Exports and Imports Economic Growth in Algeria, Economic Notebooks Journal, No. 12.

[13] Abdulla, S., & Ali, H. (2019). An Analysis of Exports and Imports and Their Effect on the Economic Growth in Iraq. UKH Journal of Social Sciences (UKHJSS), Issue Five, 3(2), 68–76. https://doi.org/10.25079/ukhjss.v3n2y2019.pp68-76.

[14] Koyuncu, J. Y., & Ünver, M. (2020). Long-run Asymmetric Association between Imports and Economic Growth in Turkey. *Balkan Sosyal Bilimler Dergisi*, 9(18), 58-64, [Online]. https://dergipark.org.tr/en/pub/bsbd/issue/59353/842712 (Accessed Date: February 6, 2024).

[15] Erdil Sahin, B., (2019). Impact of high technology export on economic growth: an analysis on Turkey. *Journal of Business, Economics and Finance (JBEF), V.8(3),* p.165-172, http://doi.org/10.17261/Pressacademia.2019.1123.

[16] Dinh, T. T. H., Vo, D. H., The Vo, A., & Nguyen, T. C. (2019, November 25). Foreign Direct Investment and Economic Growth in the Short Run and Long Run: Empirical Evidence from Developing Countries. *Journal of Risk and Financial Management, 12(4)*, 176. https://doi.org/10.3390/jrfm12040176.

[17] Kehinde, E. J., Abiodun, S. O., & Dauda, O. Y. (2019). Capital inflows, manufacturing Exports and economic growth in Nigeria: A threshold regression analysis. *Journal of Economics and International Finance*, *11*(5), 52, https://doi.org/10.5897/jeif2019.0982.

[18] Lazarov, D., & Petreski, G. (2023, December 28). Export Complexity and Economic Growth: Empirical Analysis for Selected CEE Countries. *Croatian Economic Survey*, *25*(2), 41–65, https://doi.org/10.15179/ces.25.2.2.

[19] Abdulrahman, B. M. A., Yahia, A. E., Abdalrhman, H. A., & Helal, T. O. A. (2020). The Effect of Debts On Economic Development. *Academy of Accounting and Financial Studies Journal*, *24*(3), 1-8.

[20] Sultanuzzaman, M. R., Fan, H., Mohamued, E. A., Hossain, M. I., & Islam, M. A. (2019). Effects of export and technology on economic growth: Selected emerging Asian economies. *Economic Research-Ekonomska Istrazivanja, 32*(1), 2515–2531, https://doi.org/10.1080/1331677X.2019.1650656.

[21] Hanif, I., Wallace, S., & Gago-de-Santos, P. (2020). Economic Growth through Fiscal Decentralization: An Empirical Study for Federal Developing Countries. *SAGE Open*, *10*(4), https://doi.org/10.1177/2158244020968088.

[22] Sahin, B. E. (2019). Impact of high technology export on economic growth: An analysis on Turkey. *Journal of Business Economics and Finance*, *8*(3), 165-172, http://doi.org/10.17261/Pressacademia.2019.1123.

[23] Rangkuti, L. E. (2021, December 10). The Impact of the Rupiah/Dollar Exchange Rate, Inflation Against the SBI Interest Rate During the New Normal Period. *International Journal of Multidisciplinary Research and Analysis*, *04*(12), https://doi.org/10.47191/ijmra/v4-i12-11.

[24] Abdulrahman, B. M. A., Benlaria, H., Yahya, H. A. A., Abdallah, A. E. Y., Helal, T. O. A., Eltahir, I. A. E., Elkarim, S. H. E. H., & Elkhalifa, B. E. (2023). The Impact of Tax Reform on Economic Growth in Sudan. *WSEAS Transactions on Business and*

*Economics*, vol. 20, pp. 1237–1243, https://doi.org/10.37394/23207.2023.20.109.

[25] Modak, K. C., & Mukherjee, P. (2011, October 1). Impact of Trade Liberalization on Economic growth in India. *Indian Journal of Applied Research*, *4*(5), 351–352, https://doi.org/10.15373/2249555x/may2014/105.

[26] Firdaus, E. N., & Septiani, Y. (2022). Effect Analysis of Inflation, Exports And Imports On Economic Growth In Indonesia. In *Journal of Humanities, Social Sciences and Business (JHSSB)* (Vol.2), [Online]. https://ojs.transpublika.com/index.php/JHSSB/ (Accessed Date: February 6, 2024).

[27] Dinh, T. T. H., Vo, D. H., The Vo, A., & Nguyen, T. C. (2019). Foreign direct investment and economic growth in the short run and long run: Empirical evidence from developing countries. *Journal of Risk and Financial Management*, *12*(4), 176, https://doi.org/10.3390/jrfm12040176.

[28] Hasan, M. M., & Du, F. (2023). The role of foreign trade and technology innovation on economic recovery in China: The mediating role of natural resources development. *Resources Policy*, *80*, 103121, https://doi.org/10.1016/j.resourpol.2022.103121.

[29] Kumari, R., Shabbir, M. S., Saleem, S., Yahya Khan, G., Abbasi, B. A., & Lopez, L. B. (2023). An empirical analysis among foreign direct investment, trade openness and economic growth: evidence from the Indian economy. *South Asian Journal of Business Studies*, *12*(1), 127-149.

[30] Pesaran, M. H., & Shin, Y. (2002). Long-run structural modeling. Econometric reviews, 21(1), 49-87.

**Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)**
The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solution.

**Conflict of Interest**
The authors have no conflicts of interest to declare.