# Revisiting Energy-Growth Hypothesis for Portugal Economy: A Case of Non-Linear ARDL in Production Function Framework

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## *Abstract*

*The role of energy consumption is crucial in determining economic growth of any economy. Its impact is different in different economies. Therefore, in the present study we have attempted to investigate the non-linear impact of energy consumption by taking natural resource rent and trade openness as control factors in a production function framework for Portugal economy to see whether energy consumption accelerate economic growth in the pre-production stages or it hampers it. Similarly, we are also interested to see how energy consumption influences economic growth in the mature-stages of production. In order to find the answer for our question, we will utilize ARDL approach by taking data series from 1980 to 2022. The estimated results reveal that energy consumption significantly expands economic growth in the pre-production stages while it hampers economic growth in the mature-production stages. This confirms the inverted U-shaped impact of energy consumption on economic growth. The results further show that capital formation, trade openness and natural resource rent significantly stimulate economic growth in Portugal. This concludes that natural resource rents are blessing for Portugal economy and trade led growth hypothesis is also valid for Portugal.*

**Keywords:** Primary Energy Consumption; Economic Growth; ARDL Bounds Test; Portugal.

## Introduction

The role of energy consumption in determining economic outcomes across nations is crucial, especially for optimal utilization of resources and achieving environmental sustainability. Considering Portugal's case, an economy which is technologically advanced and service-oriented member of the European Union therefore, investigating this non-linear nexus between energy consumption and economic growth will carry important and significant policy implications. The energy sector of Portugal has witnessed a transformation from a dependency on orthodox channels of energy like fossil fuels to a more demanding and environmentally friendly energy channels like renewable energy sources. It is important to assess the role of energy consumption whether it is leading economies of scale or it is leading diseconomies of scale. The research question has gradually switched from inquiring linear impact of energy consumption to non-linear impact of energy consumption in determining economic outcomes. The intuition behind this development is that at the early stages of production, enhanced consumption of energy propels domestic production while after a certain threshold level, the

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expanded consumption of energy lead to diseconomies of scale that hinder economic activities or reduce domestic output by expanding inefficiencies. These chains of events form an inverted U-shaped impact of energy consumption upon economic growth. This suggests that promoting consumption of energy beyond a certain threshold point may be harmful or counterproductive, therefore, its expansion may be monitored in any economy. The contribution of Hassan et al. (2018) suggested escalating role of energy for domestic output. In another research, Hassan et al. (2023) disclosed inverted U-shaped impact of energy consumption on economic outcomes.

There are some other macroeconomic indicators which may determine economic outcomes like labor; capital; trade openness and natural resource rent. Labor force is an important input which may accelerate economic activities through human capital; high productive capacity and capabilities and employment of healthy and skilled workers. Capital is another important input which may expand economic growth through physical capital in the form of advanced technology and developed infrastructure. Besides this, opening up borders for interacting with international communities on trade may help in expanding economic outcomes. The role of natural resource rent is also important because more natural resources are explored, more rents are earned, it will expand the size of investment in the country and leads to more production and industrial development. On the basis of this discussion, the present research is developed to investigate the non-linear impact of energy consumption on economic outcome of Portugal economy. The study considered natural resource rent; trade openness; labor and capital as important inputs along with energy consumption because in order to shape economic growth, these indicators complement consumption of energy in case of Portugal.

The remaining study will be organized by explaining literature review in the coming section. The sample, model and methods will be explained in third section. Results and their discussion will be highlighted in fourth section. The conclusion and policy implication will be discussed in the final section.

## Literature Review

The present section reveals a detailed discussion of the past studies conducted upon a similar topic. The literature section initiates from the contribution of Sarker (2024) who reported that money supply, trade liberalization and capital left significantly increasing effects on Bangladesh's economic growth. Afterwards, Oncel et al. (2024) disclosed significantly escalating role of exports, capital and financial development in the form of credit to private sector on economic growth in CIS economies. Financial development in the form of credit to private sector was significantly improving economic activities in African countries as reported by Manasseh et al. (2024). Primary energy consumption left inverted U-shaped impact while labor, capital and exports had significant and direct impact on Spain's economic growth according to Hassan et al. (2023). In another research Wang et al. (2022) reported that fossil fuel significantly escalated while renewable energy significantly reduced domestic output in the early stages of production while fossil fuel started reducing and renewable energy began to increase domestic output in the later stages of production in both composite and disaggregated forms. The study further highlighted that labor force, capital formation and tax revenue were also escalating economic activities in Pakistan. Exports did not escalate economic activities in Pakistan as exposed by Awan and Bibi (2021) while economic growth was expanding due to expansion in capital as reported by Azam et al. (2021). Subsequently, Abeka et al. (2021), economic growth was significantly following upward trend due to expansion in capital, financial development and trade openness in sub-Saharan African countries.

According to Paudel and Sun (2020), financial sector development and expansion of exports were significantly increasing economic activities of BRICS. Trade liberalization was significantly boosting domestic output in Botswana as discussed by Malefanel (2020). After this, domestic output was significantly improving as exports were promoted in India and Pakistan economies (Khan & Eminullah 2019)]. The contribution of Rani and Kumar (2018) highlighted short-term two-way causal relation between FDI inflows and economic growth while trade openness was significantly stimulating economic growth in the selected BRICS countries. The determining factors for economic growth were inquired by Bist (2018) for selected 16 non-African and African economies and empirical results showed that trade, capital and financial development were significantly stimulating economic growth. The contribution of Hassan et al. (2018) disclosed that labor force, capital formation and natural gas consumption were significantly stimulating Pakistan's economic growth in long run. In another research, trade, finance and capital were stimulating domestic output in Australia. The causality results showed finance caused domestic output while trade and domestic output reported feedback effect between each other as exposed by Rehman et al. (2015) in their research. Labor force inversely while capital formation directly influenced economic growth as highlighted by Nazir and Qayyum (2014) for Pakistan economy. The bidirectional causal link between coal consumption and economic growth was witnessed by Satti et al. (2014) for Pakistan economy. Considering Central American countries Apergis and Payne (2012) reported that both labor force and capital formation were significantly boosting domestic output.

After presenting the results of the previously researched studies upon the similar topic, the below provided section will outline the sample sources; model and methods to obtain empirical findings.

## Methodology

The sample comprises of multiple macroeconomic indicators like energy consumption, natural resources rent, capital, labor, GDP per capita and trade openness has been obtained from data bank of World Bank (2025). The annual observations or regular annual frequency is considered for the period from 1980 to 2022. In order to facilitate interpretation and ensure consistency, all the indicators are represented in the form of natural log. The proposed function for obtaining empirical results is provided as under:

$LnPCGDP = f (lnLBR; lnCAP; lnNRR; lnTRADE; lnENERGY; lnENERGY^2)$

**Table 1: Indicators and their Presentation**

| Indicators | Presentation | Data Source |
|---|---|---|
| GDP per capita as proxy for Economic Growth | lnPCGDP | World Bank (2025) |
| Total Labor Force | lnLBR | World Bank (2025) |
| Gross Fixed Capital Formation | lnCAP | World Bank (2025) |
| Total Natural Resource Rents | lnNRR | World Bank (2025) |
| Sum of Exports and Imports as proxy for Trade Openness | lnTRADE | World Bank (2025) |
| Primary Energy Consumption as share of Total as proxy for Energy Consumption | lnENERGY | World Bank (2025) |
| Square Term of Energy Consumption | $lnENERGY^2$ | World Bank (2025) |

The result section will be initiated with the demonstration of descriptive statistics in order to assess whether all the indicators follow assumptions of normal distribution or not. To detect whether explanatory indicators carry multicollinearity or not, the study will use the Variance Inflation Factor (VIF) test. Testing for unit root properties, KPSS (1992) test will be utilized. The null hypothesis of the test assumes that series is stationary and if the calculated LM-stats through KPSS (1992) test falls in the critical region will guide us to reject this null hypothesis. The unit root test if reports mixed results for all indicators obtained in this research, in this case we will proceed with using cointegration method proposed by Pesaran et al. (2001) which is efficient in case if data series is stationary at mixed order. The cointegration will be confirmed if F-test/W-stats will exceed the upper critical boundary. This will also confirm the presence of a long run connection between economic growth and its indicators. Following this, the impact of all the indicators on economic growth will be captured and reported for both long and short run. After this, all the possible diagnostics will be applied to see whether the estimated results are efficient to report for policy implications or not. Lastly, the stability test in the form CUSUM and CUSUM square graphs will be reported for testing structural stability of the coefficients over the selected time.

**Calculations and Arguments**

This section starts from the discussion of summary stats, as presented in the following Table 2. The findings demonstrate that the natural resource rent has the lowest average value -1.5279% while the capital carries the highest average value of 24.2345%. Following this, all the variables other than energy consumption and its squared term follow assumptions of normal distribution. This is concluded on the basis of insignificant probability values of the Jarque-Bera (JB) test. The results of summary stats are provided as under:

**Table 2: Descriptive Stats**

| Variables | Mean | Std. Dev. | Jarque-Bera | Probability | Observations |
|---|---|---|---|---|---|
| lnPCGDP | 9.7222 | 0.2337 | 4.5199 | 0.1044 | 43 |
| lnLBR | 15.4381 | 0.0713 | 4.3003 | 0.1165 | 43 |
| lnCAP | 24.2345 | 0.2923 | 3.0417 | 0.2185 | 43 |
| lnNRR | -1.5279 | 0.4565 | 2.2937 | 0.3176 | 43 |
| lnTRADE | 4.2048 | 0.1550 | 3.7140 | 0.1561 | 43 |
| lnENERGY | -0.1488 | 0.2868 | 7.5161 | 0.0233 | 43 |
| $lnENERGY^2$ | 0.1025 | 0.1767 | 26.8573 | 0.0000 | 43 |

To assess the presence of multicollinearity between explanatory indicators of economic growth, the Variance Inflation Factor (VIF) test is utilized. If this test reports a value greater than or equal to ten, confirming the presence of significant correlation between two explanatory indicators. The significant correlation between explanatory indicators confirms presence of multicollinearity. For proceeding further, it is important to assess this issue first. The results of VIF test are discussed in the Table 3 which represent that there is no VIF between explanatory variable which greater than or equal to 10. Therefore, this indicates absence of multicollinearity between explanatory indicators of economic growth obtained in the present study. The below shared Table 3 provides empirical results:

**Table 3: VIF Matrix**

| Variables | lnLBR | lnCAP | lnNRR | lnTRADE | lnENERGY |
|---|---|---|---|---|---|
| lnLBR | - | | | | |
| lnCAP | 2.9555 | - | | | |
| lnNRR | 2.1017 | 2.0671 | - | | |
| lnTRADE | 1.5826 | 1.2101 | 1.1191 | - | |
| lnENERGY | 5.5611 | 3.8296 | 2.9917 | 1.6684 | - |

The study proceeds further to find the status of unit root for all the indicators by taking into account KPSS (1992) unit root test. The LM-stats at zero difference suggests that all the indicators have unit root except capital; natural resource rent and squared term of energy consumption. The LM-stats for all these three indicators remain less than the 1% critical value of 0.739 therefore, for all these three indicators, we reject alternate hypothesis of series has a unit root. Other than these indicators, the LM stats for labor; trade, energy consumption and GDP per capita exceeds 1% tabulated value of 0.739 at zero difference. So, all these indicators have unit root at zero difference. After taking first difference, LM-stats for all these 7 indicators report that all these indicators turn stationary. This confirms evidence of mixed order of integration. The results are shared as under:

**Table 4: Stationarity-Test by KPSS**

| At Level | | At First Difference | |
|---|---|---|---|
| Variables | LM-Test | Variables | LM-Test |
| lnPCGDP | 1.9692 | d(lnPCGDP) | 0.2191 |
| lnLBR | 1.7728 | d(lnLBR) | 0.3233 |
| lnCAP | 0.4240 | d(lnCAP) | 0.1012 |
| lnNRR | 0.6535 | d(lnNRR) | 0.2541 |
| lnTRADE | 1.8303 | d(lnTRADE) | 0.0791 |
| lnENERGY | 0.8027 | d(lnENERGY) | 0.6478 |
| $lnENERGY^2$ | 0.7882 | $d(lnENERGY^2)$ | 0.6809 |

Following the mixed integrated series as reported in the above table, results for cointegration are obtained by using ARDL bounds testing approach. The test will provide long-run connection between per capita GDP and its indicators. The calculated value of F-test (7.9513) or Wald-test (55.6591) exceeds its corresponding 5% upper critical value which is 4.1397 for F-test and 28.9781 for Wald-test. This concludes the evidence of long-term cointegrating link between per capita GDP and its indicators. Going beyond F-test and Wald-test, the error term is tested for serial correlation; functional form, normality and heteroskedasticity. The empirical results of Table 5 disclose that all these tests have insignificant probabilities values which assist in accepting the null hypotheses of these tests. This confirms that there is no evidence of serial correlation, heteroskedasticity and misspecification of functional form. It is also witnessed that error term is normally distributed. The diagnostics suggest that the estimates of cointegration test are efficient. Based on this, long- and short-term coefficients are obtained and reported in the tables which are provided as under.

| Table 5: Cointegration Results of Bounds Test | | | | |
|---|---|---|---|---|
| **Estimated Model** | LnPCGDP = f (lnLBR; lnCAP; lnNRR; lnTRADE; lnENERGY; lnENERGY$^2$) | | | |
| **Lag Length of the Model** | (1, 0, 1, 0, 1, 0, 0) | | | |
| **F–test** | 7.9513** | | | |
| **W–test** | 55.6591** | | | |
| **Significance Level** | **Tabulated Values for F–Test** | | **Tabulated Values for W–Test** | |
| **5 percent** | 2.8056 | 4.1397 | 19.6392 | 28.9781 |
| **10 percent** | 2.3470 | 3.5622 | 16.4291 | 24.9352 |
| **Testing for Diagnostics** | | | | |
| **Serial Correlation** | 1.0376 [0.308] | | **Normality** | 0.6246 [0.732] |
| **Functional Form** | 1.5896 [0.207] | | **Heteroscedasticity** | 0.1333 [0.715] |

*Note:* ** (*) shows 5 (10) percent significance level.
The information shared in square braces is the p. values.

Besides discussing results of cointegration; long term impact of energy consumption; natural resource rent and trade openness on economic activities is captured and presented in the Table 6. The estimates reveal that both trade expansion and rents from natural resources have significant and accelerating impact on Portugal's domestic output. The magnitude suggests that a 1% expansion in rents from natural resources tend to increase economic growth by 0.0669% while a 1% increase in trading activities helps in escalating production activities by 0.4554%. The direct impact of both indicators suggests that more investments in exploring natural resources are encouraged to stimulate domestic output while expanded production activities give boost to the production of exporting industry which in turn expand export volume concluding acceleration in overall trade. The upward trend in trade will stimulate economic activities. The results further indicate that energy consumption has significant and non-linear effect on economic growth. As energy utilization is expanded, it boosts economic outcomes but when energy consumption is kept on increasing, it starts reducing economic output beyond a certain threshold level. Domestic output increases significantly by 0.3280% due to one percent increase in the linear term of energy while it diminishes significantly by 0.2729% as squared term of energy expands by 1%. This confirms an inverted U-shaped impact of energy consumption upon economic outcomes. After this, the results also indicate that increasing capital stock is also helpful in promoting economic activities like 1% increase in capital gives stimulus to domestic production by 0.2160%. These findings are presented in Table 6 which is shared as under:

| Table 6: Long Run Coefficients | | | | |
|---|---|---|---|---|
| **Dependent Variable =** lnPCGDP | | | | |
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| lnLBR | 0.1524 | 0.1941 | 0.7849 | 0.4383 |
| lnCAP | 0.2160 | 0.0302 | 7.1467 | 0.0000 |
| lnNRR | 0.0669 | 0.0179 | 3.7372 | 0.0007 |
| lnTRADE | 0.4554 | 0.0419 | 10.8719 | 0.0000 |
| lnENERGY | 0.3280 | 0.1057 | 3.1029 | 0.0040 |
| lnENERGY$^2$ | -0.2729 | 0.0995 | -2.7441 | 0.0099 |
| Constant | 0.4366 | 2.8484 | 0.1533 | 0.8791 |

Short run results are presented in Table 7 after discussing the results of long-run estimates. Unlike long run, labor force reports positive but statistically insignificant coefficient. Capital stock; rents from natural resources and trade openness have significant and encouraging effects on domestic output. As capital stock; natural resource rent and trade expand by 1% then domestic output significantly improves by 0.2500%; 0.0181% and 0.0745% respectively. Besides this, energy consumption demonstrates an inverted U-shaped impact on economic growth. The speed of adjustment suggests each year 27.12% errors will be corrected to attain long run equilibrium. In 3.69 years, the long run equilibrium will be attained again. In order to see our function's stability during the proposed period, mean and variance of error terms are tested after using CUSUM and CUSUM square graphs. These graphs are found within their critical lines which confirm the stability of both mean and variance of error term. Hence the estimated coefficients of both long and short-terms are structurally stable over the proposed time span of the study. The short-term coefficients and stability graphs are provided as under:

**Table 7: Short Run Coefficients**

**Dependent Variable** = d(lnPCGDP)

| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
|---|---|---|---|---|
| d(lnLBR) | 0.0413 | 0.0525 | 0.7876 | 0.4367 |
| d(lnCAP) | 0.2500 | 0.0156 | 16.0361 | 0.0000 |
| d(lnNRR) | 0.0181 | 0.0048 | 3.8016 | 0.0006 |
| d(lnTRADE) | 0.0745 | 0.0211 | 3.5283 | 0.0013 |
| d(lnENERGY) | 0.0890 | 0.0318 | 2.8003 | 0.0086 |
| d(lnENERGY$^2$) | -0.0740 | 0.0259 | -2.8600 | 0.0074 |
| ecm(-1) | -0.2712 | 0.0312 | -8.6879 | 0.0000 |
| **Diagnostic Tests** | | | | |
| Adjusted R- Square | | | 0.9350 | |
| F-Test (Probability Value) | | | 85.4759 (0.000) | |
| DW-Test | | | 1.6905 | |
| Akaike Information Criterion | | | 148.9770 | |
| Schwarz Bayesian Criterion | | | 140.2886 | |

**Figure 1: Cumulative Sum Plot**

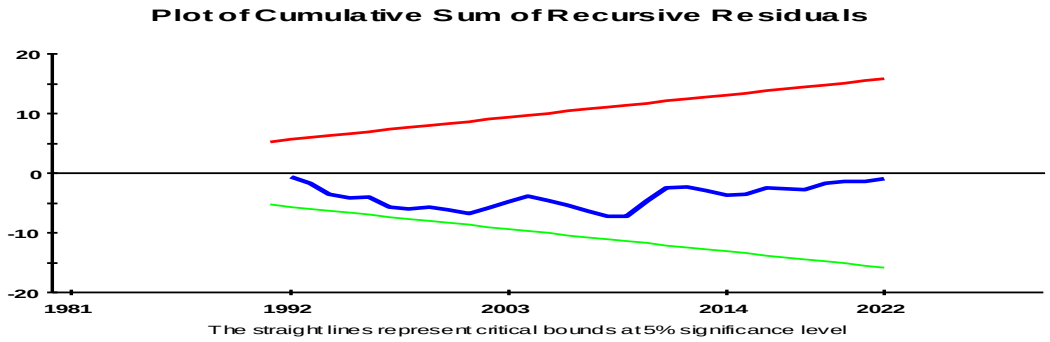
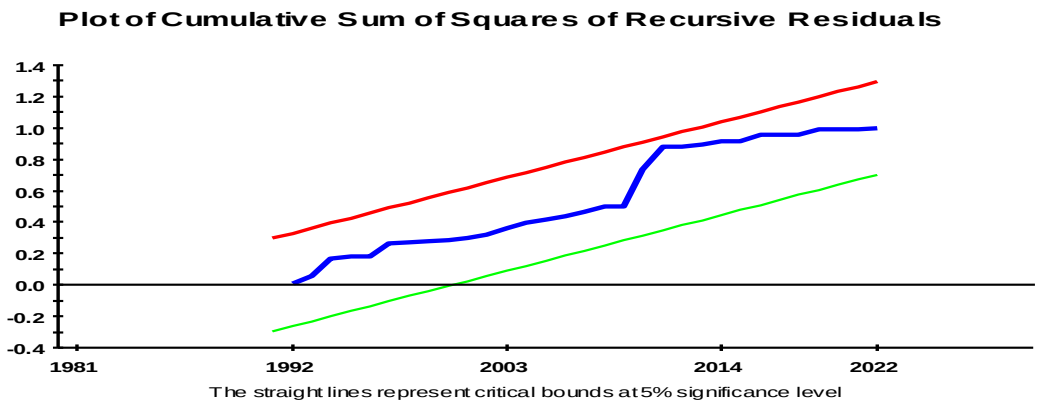


**Figure 2: Cumulative Sum of Squares Plot**




## Conclusion

The present research is organized to determine the non-linear impact of energy consumption and linear impact of rents from natural resources; trade openness and capital formation upon domestic output. After considering bounds test over a sample period from 1980 to 2022, empirical results suggest inverted U-shaped impact of energy consumption upon domestic output. The research further highlights significantly escalating effects of natural resource rent; trade openness and capital formation upon economic growth. This research also reports an insignificant impact of labor force on economic outcomes. The diagnostics and stability test confirm that the estimated coefficients are efficient and stable.

Based on these results, this research advocates for a strategic expansion of energy consumption should be expanded to an optimal threshold level, coupled with efficiency improvements and sustainable energy transitions, to drive economic growth. Policy implications include targeted investments in energy infrastructure and renewable sources. The study also emphasizes investment on physical capital of natural resource exploration, fostering domestic economic outcomes. It recommends multi-faceted export promotion strategies, including fiscal incentives, trade facilitation, and market diversification, to boost trade volume and accelerate Portugal's economic growth. These measures aim to escalate a sustainable and competitive economic environment.

## References


- Abeka, M. J., Andoh, E., Gatsi, J. G., & Kawor, S. (2021). Financial development and economic growth nexus in SSA economies: The moderating role of telecommunication development. *Cogent Economics & Finance*, *9*(1), 1-24. Article # 1862395 and DOI: https://doi.org/10.1080/23322039.2020.1862395
- Apergis, N. & Payne, J. E. (2012). The Electricity Consumption-Growth Nexus: Renewable Versus Non-Renewable Electricity in Central America. *Energy Sources, Part B: Economics, Planning, and Policy*, 7 (4), 423 – 431.
- Awan, A. G., & Bibi, S. (2021). Contribution of Exports in Economic Growth: A Case of Pakistan. *Global Journal of Management, Social Sciences and Humanities*, 7 (2), 501 – 519.
- Azam, A., Rafiq, M., Shafique, M. & Yuan, J. (2021). Renewable Electricity Generation and Economic Growth Nexus in Developing Countries: An ARDL Approach. *Economic Research-*

*Ekonomska Istraživanja,* 1 – 25. Online Available: https://www.tandfonline.com/doi/full/10.1080/1331677X.2020.1865180

- Bist, J. P. (2018). Financial development and economic growth: Evidence from a panel of 16 African and non-African low-income countries. *Cogent Economics & Finance*, *6*(1), 1-18. DOI: https://doi.org/10.1080/23322039.2018.1449780
- Hassan, M. S., Mahmood, H., & Yousaf, S. (2023). Energy-growth hypothesis: testing non-linearity by considering production function approach for Spanish economy. *Environmental Science and Pollution Research*, *30*(6), 16321-16332.
- Hassan, M. S., Tahir, M. N., Wajid, A., Mahmood, H., & Farooq, A. (2018). Natural gas consumption and economic growth in Pakistan: production function approach. *Global Business Review*, *19*(2), 297-310.
- Khan, R., & Emirullah, C. (2019). The Impact of Exports on Economic Growth of Pakistan and India. *Pakistan Journal of Humanities & Social Sciences Research,* 2 (2), 77 – 89.
- Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of econometrics*, *54*(1-3), 159-178.
- Malefanel, M. R. (2020). Trade Openness and Economic Growth in Botswana: Evidence from Cointegration and Error Correction Modeling. *Cogent Economics & Finance,* 8 (1), 1 – 21. Online Available at: https://www.tandfonline.com/doi/full/10.1080/23322039.2020.1783878
- Manasseh, C. O., Ngong, C. A., Logan, C. S., Okanya, O. C., & Olelewe, C. A. (2024). Financial deepening and economic growth nexus in emerging economies in Africa: does supply-leading or demand-following hold?. *International Review of Applied Economics*, 1-16.
- Nazir, S. & Qayyum, A. (2014). Impact of Oil Price and Shocks on Economic Growth of Pakistan: Multivariate Analysis. *MPRA Working Paper No. 55929, MPRA.* 1 – 24. Online Available at: https://mpra.ub.uni-muenchen.de/55929/1/MPRA_paper_55929.pdf
- Oncel, A., Saidmurodov, S., & Kutlar, A. (2024). Financial development, export and economic growth: Panel data evidence from Commonwealth of Independent States. *The Journal of International Trade & Economic Development*, *33*(1), 29-56.
- Pesaran MH, Richard J, Shin Y (2001) Bounds Testing Approaches to the Analysis of Level Relationships. J Appl Econom 16(3): 289-326.
- Paudel, R. C., & Sun, J. (2020). Financial development, export performance and economic growth in BRICS: New evidence from panel unit root and ARDL cointegration. *IOSR Journal of Economics and Finance*, *11*(6), 36-49.
- Rahman, M. M., Shahbaz, M., & Farooq, A. (2015). Financial development, international trade, and economic growth in Australia: new evidence from multivariate framework analysis. *Journal of Asia-Pacific Business*, *16*(1), 21-43.
- Rani, R., & Kumar, N. (2018). Panel data analysis of financial development, trade openness, and economic growth: Evidence from BRICS countries. *Emerging Economy Studies*, *4*(1), 1-18.
- Sarker, B. (2024). FDI-growth and trade-growth relationships during crises: evidence from Bangladesh. *Financial Innovation*, *10*(1), 1-29. DOI: https://doi.org/10.1186/s40854-023-00571-6
- Satti, S. L., Hassan, M. S., Mahmood, H., & Shahbaz, M. (2014). Coal consumption: An alternate energy resource to fuel economic growth in Pakistan. *Economic Modelling*, *36*, 282-287.
- Wang, J., Hassan, M. S., Alharthi, M., Arshed, N., Hanif, I., & Saeed, M. I. (2022). Inspecting non-linear behavior of aggregated and disaggregated renewable and non-renewable energy consumption on GDP per capita in Pakistan. *Energy Strategy Reviews*, *39*, 100772. https://doi.org/10.1016/j.esr.2021.100772
- World Bank (2025) World Development Indicators. World Bank, Washington, D.C.