

Revisiting Trade, Energy and Growth Nexus in Portugal: An Empirical Evidence from ARDL Approach

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Abstract

This research is aimed at revisiting the trade, energy, and growth nexus for Portugal. This nexus will be tested by considering the cointegration test developed by Pesaran et al. (2001). An annual data series from 1986-2022 will be used for analysis. The empirical results suggest that trade openness significantly increases economic activities in Portugal. The results further show that capital formation, energy consumption, and consumer prices also elevate domestic production. Among all these factors, trade openness strongly impacts economic growth. It is further stated that these findings are robust based on all the applied diagnostic tests. Based on these findings, investments should be enhanced to boost trade, capital, and energy so Portugal can enjoy increased economic activities. Besides this, domestic prices may be boosted in such a way that it may not harm the buying power of the buyers but may help improve domestic production and economic growth.

Keywords: Economic Growth; Trade; Energy; Consumer Prices; Portugal, ARDL Approach.

Introduction

The factors that influence domestic production change as time passes. This teaches the rationale for modifying the function of domestic production in various economies as per the given circumstances and challenges to the economies. The labour force appears to be the most significant contributor to the national output in developing economies. In contrast, in developed economies, literature suggests that capital accumulation drives national output. Besides these fundamental inputs, some studies provide the significance of the role of energy consumption in targeting economic activities. Besides these studies, we find some studies which shed light on the importance of liberalized trade in expanding economic growth. Afterwards, some scholars express their views about the significance of the labour force and capital stock in finding changes in domestic production.

The trends of domestic output, energy consumption, and trade openness in Portugal are increasing during the selected period, while the growth rates of these indicators reveal a mixed pattern. The output growth rate remained the lowest during 2020, which was witnessed as -5.46 per cent, while it was witnessed as highest during 1988, which was observed to be 7.60 per cent. Besides this, we witnessed the growth rate of primary energy consumption, which was seen as

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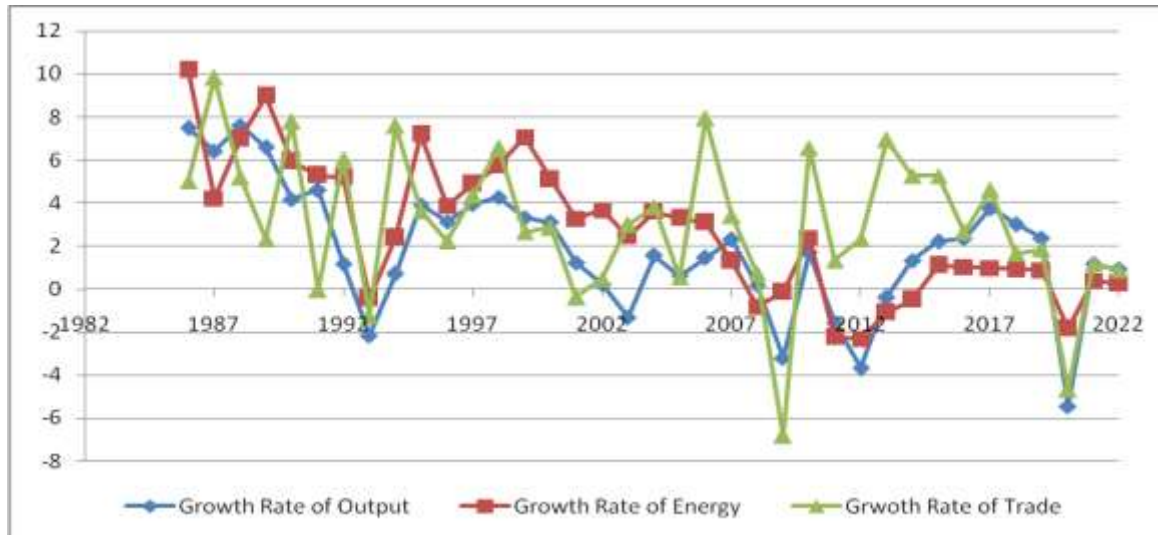
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lowest during 2012 and recorded as -2.31 per cent, was experienced as the highest during 1986, which was almost 10.18 per cent.

Figure 1: Growth Rates of Output; Energy and Trade in Portugal



Source: Author's Estimates using World Bank (2023).

After this, the growth rate of trade openness was presented, and from the graph, we can see that it hit the bottom during the year 2009, which was almost 6.83 per cent, while it hit a peak during the year 1987, which was almost 9.82 per cent.

Based on the above discussion, this research is conducted to revisit the contribution of liberalized trade, consumption of energy, and capital accumulation in targeting domestic production in Portugal's economy. This study also considers the role of domestic prices as a control variable for economic growth.

The research will be organized so that a review of the contributions of the scholars will be shared in the next section. The information about data and possible methods will be shared in section 3. Empirical results and their discussion will be carried out in section 4. In the final section, the conclusion and policy implications will be highlighted.

Literature Review

The review of past studies will provide us with information on how the scholars have conducted their studies to explore the role of multiple macroeconomic factors in finding their effects on economic growth in various countries. The discussion is provided below:

Apergis and Payne (2012) inquired about the determinants of economic growth for Central American economies. They disclosed the significantly positive role of the labour force and capital accumulation on economic growth in the selected sample. The labour force was found to reduce domestic output while the capital stock was helping to improve it in the case of the Pakistani economy (Nazir & Qayyum, 2014). The contribution of Dogan (2015) suggested that expanding the role of capital stock was significantly encouraging production activities in the Turkish economy. According to Ikegami and Wang (2016), the consumption of electricity and

stock of capital had a positive impact on economic growth in the case of Japanese and German economies. Economic growth responded inversely to changes in the labour force, as in the case of Japan.

In contrast, it responded directly to the changes in the labour force in the case of the German economy. In another study, we found expansionary effects of electricity consumption on economic growth in the case of Taiwan Lu (2017). Later on, we saw the contribution of Sek (2017), who exposed similar findings on the consumption of primary energy for economic growth in the case of the Chinese economy. Economic growth directly responded to the changes in the consumption of electricity in China (Zhong et al., 2019). It is further found that trade openness was insignificant, but electricity consumption left a significant positive influence on economic growth in Bangladesh (Dey & Tareque 2020). The contribution of Su et al. (2019) highlighted that expansion in international trade significantly escalated economic activities in the case of Vietnam.

A study conducted by Khan and Emirullah (2019) in which they concluded that exports improved the growth of domestic production in the Indian and Pakistani economies. In another study, liberalized trading activities were found to expand economic growth in the case of Botswana (Malefanel, 2020). Afterwards, the adverse effects of exports on domestic output were witnessed in the Nigerian economy (Duru & Ezenwe, 2020). Later on, we witnessed domestic output increase due to increased export activities in Vietnam (Nguyen, 2020). In another study, Awan and Bibi (2021) highlighted an insignificant effect of export activities on domestic production in the Pakistani economy. Besides this, we found the significantly increasing role of capital accumulation in economic activities in the contribution of Azam et al. (2021). The contribution of Njenga (2024) suggested significantly elevating the influence of electricity consumption on economic growth in the case of Kenya. In another study, exports increased domestic output in Pakistan (Ahmed & Shaikh, 2024). Inflation had an adverse impact on economic growth in the Pakistani context (Iqbal et al., 2024). After this, we see Akkutay (2024), who reported the accelerating role of capital stock while the adverse role of the stock market in controlling economic growth for the Turkish case.

After briefly presenting a discussion with the scholars on the relation between economic growth and its determinants, we will discuss the data and the possible methodology in the next section.

Data and Methodology

The information related to the sample period for the selected factors of this research is obtained from the World Bank's data bank (2024). The data structure is a time series, and its frequency is annual. We used the World Bank's data bank for all the data series, such as per capita output, labour force total, capital formation, per capita electric power consumption, trade liberalization, and consumer prices. This research considers the sample range from 1986 to 2022. We will be using the data series in natural log form. The following function is considered for obtaining empirical results:

$$\ln \text{PC Output}_t = f (\ln \text{Labor}_t, \ln \text{Capital}_t, \ln \text{ECon}_t, \ln \text{TLib}_t, \ln \text{CPrices}_t)$$

Table 1: Variables, name & representation

Name	Representation	Data Source
Output Growth	$\ln \text{PC Output}_t$	World Bank (2024)
Total Labor Force	$\ln \text{Labor}_t$	World Bank (2024)

Capital Formation	$\ln\text{Capital}_t$	World Bank (2024)
Energy Consumption	$\ln\text{ECon}_t$	World Bank (2024)
Trade Liberalization	$\ln\text{TLib}_t$	World Bank (2024)
Domestic Prices	$\ln\text{CPrices}_t$	World Bank (2024)

The empirical results will start by presenting a discussion of basic statistics. Any suitable unit root test will be used to inquire about the presence or absence of the status of the data series. The possible unit root test will be the KPSS (1992) unit root test. This test provides efficient estimates in the case of small data series. After this, any suitable cointegration methodology will be considered based on the order of integration of the data series. Preferably, it will be a bounds-testing approach, as suggested by Pesaran et al. (2001). This method is preferred because the data series reports a mixed order of integration. Afterwards, long and short-run coefficients will be estimated. In the last and final step, the structural stability graph will be presented as CUSUM and CUSUM Square graphs. All the findings will be cross-verified with the help of possible diagnostic tests. If the results are robust to the diagnostics, such estimates will be carried out for possible policy outcomes. The next section presents the results and their discussion.

Empirical Results and Discussion

In this section, empirical results are estimated, and their discussion will be presented. The basic statistics will highlight the average values of the selected variables. Along with it, we will also see the normality status of the indicators. From the results presented in table 2, the labour force average is relatively high, while the average capital is minimal and insignificant. The JB test concludes that the indicator meets the normal distribution criteria.

In contrast, a significant JB test reveals vice versa. The results indicate that the labour force, capital formation, liberalized trade and domestic prices follow the attributes of normal distribution. The summary of the results is shared below in table 2:

Table 2: Descriptive stats

Variables	Mean	Standard Deviation	Jarque-Bera	Probability	Obs.
Output Growth	20492.3900	2981.4130	4.8285	0.0894	37
Total Labor Force	5153990.0000	311688.0000	3.2424	0.1977	37
Capital Formation	22.0050	4.3081	2.9599	0.2276	37
Energy Consumption	3975.5100	1001.4850	4.7515	0.0929	37
Trade Liberalization	61.8492	18.3736	2.0934	0.3511	37
Domestic Prices	83.7345	24.4964	3.6633	0.1602	37

After expressing basic statistics, the discussion of the unit root test is now shared in table 3. The summary of the results reveals that the LM test for energy consumption at the level is witnessed as 0.6421, while the LM test for consumer prices at the level is found as 0.6688. Both LM-tests have less than their one per cent critical value of 0.739. This helps us accept the null hypothesis that the series is stationary or has no unit root. Therefore, these two series are stationary at this level. At the same time, all the other indicators, such as domestic output, labor force, capita and

liberalized trade, are non-stationary because their corresponding LM-tests are greater than the one per cent critical value. Afterwards, when applied to the first difference, the LM-test for all the indicators reported that all the variables had LM-stats of less than one per cent critical value. Therefore, it is concluded that the selected indicators of this study carry mixed order of integration as two series are stationary at a level while the rest are stationary at first difference. The summary of the results is presented in the table 3:

Table 3: KPSS unit root test

At Level		At First Difference	
Variables	LM-Test	Variables	LM-Test
$\ln PC Output_t$	0.8824	$\Delta \ln PC Output_t$	0.4533
$\ln Labor_t$	0.8606	$\Delta \ln Labor_t$	0.5975
$\ln Capital_t$	1.4620	$\Delta \ln Capital_t$	0.1419
$\ln Econ_t$	0.6421	$\Delta \ln Econ_t$	0.6015
$\ln TLib_t$	1.0121	$\Delta \ln TLib_t$	0.3208
$\ln CPrices_t$	0.6688	$\Delta \ln CPrices_t$	0.5788

The critical values for the suggested test at 1%=0.739; at 5%=0.463 and at 10%=0.347.

From the above results, we have reached to the conclusion the indicators of this research report mixed order of integration. Therefore, the bounds test for obtaining cointegration between economic growth and its factors will be carried out and results are shared as below in table 4:

Table 4: ARDL bounds testing approach

Estimated Model	$\ln PC Output_t = f(\ln Labor_t, \ln Capital_t, \ln Econ_t, \ln TLib_t, \ln CPrices_t)$		
Optimal lags	(1, 0, 0, 0, 1, 1)		
F – statistics	11.8560**		
W – statistics	71.1362**		
Significance of the Test at	F – Test	W – Test	
	Critical Bounds	Critical Bounds	
5% Level	3.0647	4.3919	18.3884
10% Level	2.5355	3.7211	15.2129
Diagnostic tests			
Serial Correlation	0.7200 [0.396]	Normality	1.2958 [0.523]
Functional Form	2.2956 [0.130]	Heteroscedasticity	0.3945 [0.530]

The double steric highlight significance of the test at 5% level and single steric highlights significance of the test at 10% level. The p-values are demonstrated in parenthesis.

The above table highlights that the F-test for the proposed model is obtained as 11.8560 which is greater than the five percent upper critical bound which is 4.3919. This concludes that per capita output has long run cointegrating relation with all its selected indicators in this research. These results are consistent with all the diagnostics considered in this research. For instance, serial

correlation, functional form, normality and heteroskedasticity tests are found to be insignificant. These reveal that there is no serial correlation; no misspecification, no abnormality and no heteroskedasticity prevail in this research. Now we may proceed for obtaining long and short run coefficients for the selected ARDL model. The long run results are shared in the below table 5:

Table 5: Long run coefficients

Dependent Variable = lnPC Output_t				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
lnLabor _t	-0.2869	0.2137	-1.3426	0.1910
lnCapital _t	0.2999	0.0183	16.4277	0.0000
lnECon _t	0.2183	0.0968	2.2555	0.0320
lnTLib _t	0.3113	0.0310	10.0466	0.0000
lnCPrices _t	0.2111	0.0344	6.1348	0.0000
Intercept	9.4193	2.6967	3.4929	0.0020

The above table exposes the effects of indicators of domestic output in the long run. The labour force's coefficient is negative and insignificant, confirming firms that labour remains insignificant in capital-rich economies. Besides this, we see the coefficient of capital accumulation, which shows that if the Portuguese government enhances capital by one per cent, it will significantly escalate output by almost 0.30 per cent. This result is similar to Awan and Bibi's (2021) and Akkutay (2024) findings. Similarly, the coefficients of energy consumption, liberalized trade and domestic prices are positive and significant. The direct response of domestic output to the changes in energy consumption is supported by the contribution of Njenga (2024). Moreover, the finding of expansion of trade is consistent with Su et al. (2019)'s contribution. This means that due to a one per cent increase in energy utilisation, we will see a 0.2183 per cent significant increase in domestic production. In comparison, efforts to liberalise trade by one per cent may encourage domestic output by 0.3113 per cent. The increased domestic prices are also motivating the manufacturers to raise production activities to reap higher returns; hence, more supplies will be sent to markets. One per cent increase in domestic prices would increase domestic output by 0.2111 per cent. The findings confirm that capital, energy, trade and domestic prices are production-friendly inputs in Portugal. Still, among these, trade liberalization contributes the most to boosting the performance of domestic production.

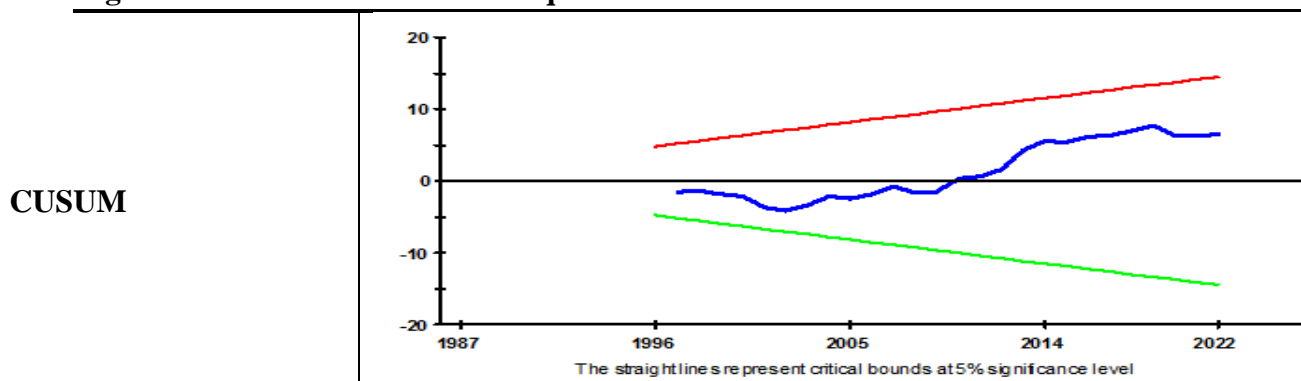
After discussing the long-term performance of the indicators of domestic production, we will now highlight the impacts of all these indicators for the short-term periods. The results presented in table 6 show that capital, energy consumption, trade liberalization and domestic prices are significantly accelerating economic growth in Portugal. These findings are similar to long-run findings. However, in the short term, we have witnessed that the coefficient of consumer prices is the highest among the remaining coefficients. This shows that if domestic prices increase by one per cent, domestic production will significantly increase by 0.7079 per cent. Besides domestic prices, the coefficient of capital shows that due to a one per cent capital, radomes themes the tic out, ut will significantly grow by per cent. Similar centres may see the role of energy and trade openness.

Moreover, the speed of adjustment to achieve long-term equilibrium is 86.52 per cent each year. This means Portugal's economy will achieve long-term and stable equilibrium in about 1.16 years. After discussing both long and short-term results, the stability of these results depends upon the stability of mean and variance of error terms, which may be checked through the CUSUM and CUSUM square figures. If both estimated lines are found within their critical bounds, these will reflect the stability of the error term's mean and variance. This will ensure the stability of estimated long and short short-terminates for the selected period obtained in the study. The estimates for the selected model for the short-term are presented in the below-provided table 6, and the figure is presented afterwards:

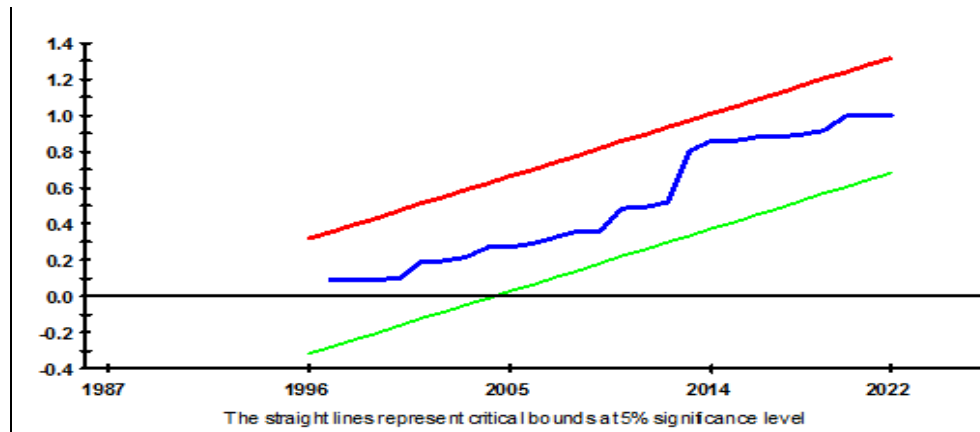
Table 6: Short run coefficients

Dependent Variable = $\Delta \ln PC Output_t$				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta \ln Labor_t$	-0.2483	0.1825	-1.3603	0.1840
$\Delta \ln Capital_t$	0.2595	0.0194	13.4080	0.0000
$\Delta \ln ECon_t$	0.1889	0.0838	2.2528	0.0320
$\Delta \ln TLib_t$	0.1529	0.0531	2.8823	0.0070
$\Delta \ln CPrices_t$	0.7079	0.1103	6.4187	0.0000
CoIntEq (-1)	-0.8652	0.0781	-11.0787	0.0000
Diagnostic Tests				
R-Bar-Squared			0.9328	
F-Test (Probability Value)			82.2526 (0.000)	
DW-Test			2.2124	
Akaike Information Criterion			122.6088	
Schwarz Bayesian Criterion			115.4830	

Figure 2: CUSUM and CUSUM Square



CUSUM Square



Conclusion

In this study, we have inquired about the role of capital accumulation, energy consumption, liberalized trade and domestic prices on the output of Portugal's economy. A unit root test using the KPSS test is found to test this nexus, and the results confirm the evidence of a mixed integrated data series. The long-term cointegrating relation is confirmed by the method constructed by Pesaran et al. (2001). The empirical results confirm that capital stock, energy consumption, liberalized trade and domestic prices are output-friendly inputs in Portugal. This means all these inputs significantly boost domestic output. Liberalized trade in the long term while domestic prices in the short term largely and strongly boost domestic production among all indicators in Portugal. These results are structurally stable and consistent with the diagnostics. Based on these results, we propose that efforts be made to expand the performance of liberalized trade, capital stock, consumed energy, and domestic prices to expand domestic output in Portugal.

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