Journal of Posthumanism
2025
Volume: 5, No: 12, pp. 290–313
ISSN: 2634-3576 (Print) | ISSN 2634-3584 (Online)
posthumanism.co.uk

DOI: https://doi.org/10.63332/joph.v5i12.3766

# Diversification and Development as a Tool for Structural Transformation in the Kingdom of Saudi Arabia

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***Abstract***

*This paper examines how economic diversification drives structural transformation in Saudi Arabia, tackling the challenges of oil dependency that threaten long-term economic stability. Based on annual data from 1991 to 2022, the analysis employs the Structural Transformation Index, incorporating key variables such as diversification, economic complexity, investment, GDP growth, and oil prices. The asymmetric relationship brought about by oil price increases is larger compared to the drops, according to the Nonlinear ARDL methodology. These results indicate a stable long-run relationship, where diversification, investment, and growth positively contribute to transformation, while economic complexity exhibits paradoxical negative long-term effects. The study suggests the following: the intensification of successful diversification policy, strategic investment of oil revenues, encouragement of economic complexity, creation of conducive investment environments, and nonlinear policy frameworks that account for these asymmetric dynamics.*

***Keywords:*** *Economic Complexity; Economic Diversification; NARDL Models; Nonlinear Modeling; Structural Transformation.*

***JEL Codes: C23, F43,F63, O47,O11.***

## 1. Introduction

The Kingdom of Saudi Arabia leads the world in oil production and export, which is reflected in its Economy. The country relies heavily on oil exports, contributing approximately 64% of government revenues, 42% of GDP, and 80% of total exports. In 2019 (Saudi General Authority for Statistics).

With fluctuations in oil prices and the inevitability of its depletion, numerous studies and international institutions recommend economic diversification. The International Monetary Fund believes it is imperative for oil-exporting countries, including those in the Arab region, to pursue economic diversification to mitigate the impact of external shocks on oil markets. Oil on the Economy (Al Naimi, 2022).

Saudi Arabia has been actively implementing efforts to develop its Economy and achieve high levels of structural transformation. This is achieved by implementing policies such as increasing private-sector involvement in major projects, stimulating growth in non-oil sectors, enhancing the business environment, introducing privatization initiatives, and encouraging foreign direct investment. Additionally, infrastructure and technology development are necessary to promote

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sustainable economic growth. These measures can help create a more resilient, diversified economy that thrives despite reduced reliance on oil revenues.
Structural transformation in economics refers to the shift from an economy dominated by agriculture and low-level manufacturing to one characterized by services and modern industrial production. Several factors, including technological advancements, globalization, and policy reforms, impact the pace of structural transformation. This shift involves changes in the Economy's structure and the activities people are engaged in. Several significant contributions to structural transformation have been made, including those of Clark (1957), Chenery (1960), and Kuznets (1966).
Diversification and development can achieve structural transformation in Saudi Arabia. Diversification means expanding a country's economic base by developing new industries and sectors. It can help to reduce dependence on a single industry, such as oil, and create new opportunities for economic growth (Hvidt, 2013). Additionally, economic diversification is a means of ensuring stable and sustainable income levels in the future. This process can drive economic development by increasing productivity, reducing dependence on a single industry or resource, and enhancing resilience to external shocks.
Economic Development refers to improving society's overall well-being through investments in infrastructure, education, and other areas. Both diversification and development can play a key role in transforming Saudi Arabia's Economy and society by creating new jobs, increasing productivity, and improving living standards. The Kingdom has been working on these goals through its Vision 2030 plan, which aims to reduce the country's dependence on oil, create new economic opportunities, and improve the well-being of its citizens.
Saudi Arabia's Economy has grown across many sectors, building a solid economic base and becoming a member of the G20. Saudi Arabia is among the most prominent players in the global economy and oil markets, supported by a robust and effective banking sector, a well-functioning financial system, and giant government companies staffed by highly qualified Saudi talent. The Kingdom has implemented several structural reforms to promote economic growth and maintain financial sustainability and stability.
Vision 2030 is a strategic transformation plan that aims to turn the Kingdom into a distinguished global model by harnessing the energy of youth, promoting economic diversification, and building an integrated society. This is based on its three pillars: a vibrant society, a thriving economy, and an ambitious nation.
Kuznets and Murphy (1966) mentioned six main features of modern economic growth. They are increasing real per capita income, structural transformation, urbanization, technological change, investment in physical and human capital, and international economic integration.
Structural transformation is one of the key causes of economic development, as it enables a country to diversify its Economy, reduce dependence on a single sector, and create new sources of growth and employment. For example, Industrialization leads to the development of new industries and the production of higher-value goods, which can increase productivity, raise wages, and improve living standards.
Fluctuations in the prices of raw materials can lead to economic crises in economies that heavily depend on the export of raw materials, such as oil, natural gas, and minerals, necessitating structural transformations.
So, structural transformation is a critical component of economic development. Countries that achieve advanced levels of structural transformation will be better positioned to sustain economic growth and improve their citizens' well-being over time.

In general, economic diversification and development are critical tools for structural transformation and key factors in achieving sustainable, comprehensive, and equitable economic growth. This is why the study focuses on the role of economic diversification and development in driving structural transformation in the Kingdom of Saudi Arabia.
The primary objective of this study is to investigate whether diversification and development serve as a Tool for structural transformation in the Kingdom of Saudi Arabia. To achieve this aim, the study will utilize a time series spanning from 1990 to 2022.
The research will consist of five main sections. It begins with the introductory section, followed by a brief review of theoretical and empirical literature, then the methodology section, and concludes with the presentation of findings and recommendations.

## 2. Brief theoretical and empirical literature review

### 2.1. Brief theoretical

Numerous empirical studies suggest that economic diversification is an effective strategy for countries seeking long-term, stable economic growth, particularly those that rely on a single source of income, such as Saudi Arabia. However, for this strategy to succeed, the authority should consider various challenges, steps, and drivers.
It is possible to distinguish between three stages that the Saudi Economy has gone through during the past few decades, namely:
The first period: dependence on oil. In the 1960s and 1970s of the last century, the Saudi Economy relied heavily on oil as a significant source of revenue. Efforts then focused on developing the oil sector and achieving self-sufficiency in essential goods and services.
The second period: striving to achieve economic diversification. In the 1980s, the Saudi government began to focus on economic diversification and shift away from its heavy reliance on oil. They implemented several measures to develop other sectors, such as industry, agriculture, tourism, and financial services, established numerous national companies and institutions, and attracted foreign investment.
The third period: the launch of Vision 2030. In 2016, the Kingdom of Saudi Arabia announced Vision 2030, a comprehensive economic and social transformation strategy. The vision aims to diversify the Economy, develop non-oil sectors, and achieve sustainable development. The vision encompasses measures such as developing tourism, enhancing the business environment, attracting foreign investment, and expanding the petrochemical and manufacturing industries.
These stages represent continuous efforts to diversify the Economy and rely on diversified sources of revenue rather than relying heavily on oil. It aims to enhance economic sustainability and improve the quality of life for Saudi citizens.

#### 2.1.1. Challenges to Production Base Diversification in Saudi Arabia

The Kingdom of Saudi Arabia sought to capitalize on the boom in oil prices in the mid-1970s by implementing initial five-year development plans to diversify its Economy. In continuation of efforts to achieve sustainable growth through economic diversification, the Kingdom announced its Vision 2030 in 2016. There are several challenges to production-based diversification in Saudi Arabia, including (Al Bakr, 2015):

1) Dependence on oil: The Saudi Economy heavily depends on oil exports, which comprise the majority of government revenue and exports. Diversifying the Economy away from oil is challenging due to the substantial investment and infrastructure already in place for the oil industry.

2) Skilled Labor Shortage: Saudi Arabia faces a shortage of skilled labor in non-oil industries, which hinders the development of new industries and economic diversification.
3) Bureaucratic hurdles: The bureaucratic process for setting up and operating a business in Saudi Arabia can be time-consuming and complex, deterring potential investors and entrepreneurs from entering new industries.
4) Lack of diversification plan: Saudi Arabia has announced diversification plans, but they still need to be implemented because there is no clear vision or action plan.

The Kingdom's vision encompasses a set of social and economic policies designed to reduce its dependence on oil exports. The vision sets several goals, such as raising the share of non-oil exports, the private sector, and medium and small companies in the GDP from 16%, 40%, and 20% to 50%, 65%, and 35%, respectively. The vision also aims to increase the volume of foreign direct investment to the international level of 5.7% of GDP, up from the current 3.8%. The vision also aims to increase non-oil government revenues from approximately 170 billion Saudi riyals to nearly one trillion Saudi riyals.

Van Neuss, L. (2019) identified four determinants of structural change: changes in relative (sectoral) prices, changes in income, changes in comparative advantage(s) through globalization and trade, and changes in input-output linkages.

#### 2.1.2. Steps to achieve economic diversification

There are main steps that should be taken to achieve economic diversification (Al Naimi, 2022; Euchi et al., 2018; Matallah, 2020):

1) Assess the current economic structure: This assessment will help identify the strengths, weaknesses, and opportunities for diversification. This step involves understanding the existing economic conditions, employment rates, regional disparities, and the dominant industries, as well as their contributions to GDP.
2) Identify potential sectors for diversification by identifying sectors with potential for growth and development. These sectors may be related to existing industries or entirely new areas of economic activity.
3) Developing a strategic plan: to define the vision, goals, and objectives to achieve economic diversification, and this plan must include specific policies and programs to promote the growth of the targeted sectors.
4) Investing in education and developing the workforce: A diversified economy requires a skilled workforce. To achieve this, it is necessary to invest in education and training programs to develop the population's skills and capabilities. Also, focus on science, technology, engineering, mathematics, entrepreneurship, and vocational training.
5) Encouraging innovation and research: This is done by supporting research institutions, providing grants and tax incentives, and promoting cooperation between academia and industry. It will help create an environment that fosters technological progress and stimulates economic growth.
6) Improving infrastructure and connectivity: To facilitate the growth of new industries, investment is made in infrastructure projects such as transportation, communication networks, and energy systems.
7) Enhance access to capital: Facilitate access to finance for small and medium-sized enterprises (SMEs) through loan guarantees, grants, and venture capital funding.
8) Create an enabling business environment: Streamline regulations, reduce bureaucracy, and improve the ease of doing business to attract local and foreign investments, simplify tax systems,

reduce trade barriers, and protect intellectual property rights.
9) Support local and regional development: Through targeted investments, incentives, and capacity-building initiatives, lead to promote the growth of local and regional industries and then establish balanced and inclusive economic development.
10) Monitor progress and adapt: to ensure that the diversification process remains on track and is responsive to changing economic conditions. The progress and effectiveness of diversification efforts are regularly evaluated, and policies and strategies are modified as necessary.

### 2.1.3. Drivers of structural change in the Economy

Many applied studies investigated several drivers of structural change in the Economy, including technological advancements, changes in consumer preferences, shifts in global economic power, and government policies (Mijiyawa, 2017; Van, 2019; Sen, 2019; Chateau et al., 2020).

1) Technological progress leads to the creation of new industries and the decline of old ones. The advent of the Internet and digital technology has led to the growth of the technology industry and the decline of traditional retail trade.
2) Changes in consumer preferences can also lead to structural change. For example, the shift towards healthy eating habits has increased the demand for organic and local foods.
3) Shifts in global economic power can also lead to structural change. For example, as developing countries continue to grow and become more industrialized, they can become significant players in the global Economy and lead to changes in the types of goods and services in demand.
4) Government policies, such as fiscal stimulus, trade agreements, and deregulation, can also drive structural change in an economy.

### *2.2. Empirical Literature Review*

The current literature on structural transformation and economic diversification constitutes a fundamental knowledge base for understanding the challenges and opportunities facing resource-rich economies, with particular focus on the Kingdom of Saudi Arabia. The literature has approached the subject from several complementary perspectives:
Groundbreaking global research on the concept of structural transformation was conducted by McMillan and Rodrik (2011), who provided a comparative analytical framework highlighting the heterogeneity of structural transformation patterns across economic regions. Their article demonstrated that labor relocation to higher-productivity sectors, such as manufacturing, was the key driver of growth in Asian economies. In contrast, the shift to low-productivity service sectors retarded the growth in Latin American and African economies.
Further studies addressed the concept of the resource curse, with Gylfason (2017) and Bah and Brada (2009) confirming the prevalence of the "resource curse" and its negative impact on structural transformation. These studies have demonstrated that excessive reliance on natural resources creates structural distortions, diverting resources away from productive and traditional sectors and thereby thwarting economic diversification efforts.
Studies on the determinants of structural transformation have highlighted that international trade factors and commercial determinants play a pivotal role in the reallocation of labor across economic sectors (Comunale and Felice, 2019). Studies by Matsuyama (2017) and Uy et al. (2015) also support this, as do studies by Uy et al. (2015), who underscore the importance of trade policies in triggering structural transformation.
Research, with particular reference to the Gulf and Saudi contexts, demonstrated that early studies by Hvidt (2013) and Cochrane et al. (2024) depicted the continuation of oil-sector

dominance and the difficulty of achieving successful diversification in Gulf economies. Later research by Alshahrani and Alsadiq (2014) and Van der Eng (2019) indicated the importance of structural reforms and the role of government institutions and state-owned enterprises in spearheading the transformation process, particularly under Saudi Vision 2030.
In terms of evaluative and applied studies, research by Guendouz and Ouassaf (2020) and Banafea and Ibnrubbian (2018) confirmed positive relationships between economic diversification and macroeconomic variables such as foreign direct investment and gross fixed capital formation. Abu Shakra et al. (2008) explained economic diversification as a means to achieve economic stability and reduce fluctuations.
In terms of policy research and future visions, the International Monetary Fund (2017) and Callen et al. (2014) presented comprehensive reviews of economic policies needed to support diversification, while Alhowaish's study (2016) was concerned with analyzing promising industries such as tourism and its role in achieving economic diversification in the Kingdom.
Despite the breadth of past studies, there remains an urgent need for more studies to evaluate the impact of policy interventions undertaken under Vision 2030, measuring the actual impact of government investments in achieving structural transformation, analyzing the role of digital transformation and knowledge economy in the diversification push, exploring ways to enhance integration in non-oil sectors, and establishing the impact of institutional factors and governance on the pace of this transformation.

## 3. Methodology: Specifications and Estimates

### 3.1. Structural Change Measurements

In this section, we aim to demonstrate the role of diversification and development as tools for structural transformation in Saudi Arabia through an econometric analysis. Structural transformation indicators will be used to measure changes in the structure of the Saudi Economy. These indicators provide an overview of economic production, employment, and transformations in sectoral composition.
The following model illustrates the role of diversification and development as tools for structural transformation in the Kingdom of Saudi Arabia.

$$STI = \beta_0 + \beta_1 NHHI + \beta_2 ECI + \beta_3 GDPg + \beta_4 GFCF + \beta_5 Oil\ Price + \beta_6 WGDPg$$

The dependent variable reflects the degree of structural transformation (STI). It calculates according to Dietrich (2012) and Cortuk and Singh (2011),
According to Dietrich (2012) and Cortuk and Singh (2011), two indices for structural change measurements are calculated. The first index is the most straightforward measure of structural change, the norm of absolute values (NAV):

$$NAV = 0.5 \sum_{i=1}^{n} |x_{it} - x_{is}|$$

According to Zulkhibri et al. (2015), this index measures the extent to which economic resources are reallocated across different sectors. A key consideration is that the index value can be sensitive to the chosen level of industry aggregation used in its calculation. The computational process involves determining the differences in sectoral shares ($x_i$) at two distinct points in time, s and t. The absolute values of these differences are then summed and divided by two to account for the fact that each change is effectively counted twice in the summation.
In a separate approach, Lilien (1982) developed an index to quantify structural transformation, known as the Lilien Index (MLI). This index is calculated as the standard deviation of

employment growth rates across sectors between an initial period (s ) and a later period (t), thereby capturing the pace of structural change. Stamer (1998) later refined this index to better align with the scale's properties. Elevated MLI values indicate rapid structural shifts and a substantial reallocation of resources across sectors. The MLI is constructed as follows:

$$MLI = \sqrt{\sum_{i=1}^{n} x_{it} . x_{is} \left(ln \frac{x_{it}}{x_{is}}\right)^2}$$

The amount of structural change refers to movements in the contribution of sectors as a percentage of the entire Economy. If the structure remains unchanged, the index equals zero. If all sectors change maximally, meaning the entire Economy has an overall change, the index equals one.

According to Chenery's model, the structural transformation process contains five main dimensions: the structure of aggregate output, the structure of aggregate employment, the structure of aggregate demand, the structure of foreign trade, and the structure of population. Each of these dimensions has its own measurement indicators as follows:

1) Structural change in production:
- Percentage of value added by the agricultural sector to gross domestic product.
- The ratio of the value added by the industrial sector to the gross domestic product.
- Percentage of value added by the services sector to gross domestic product.

2) Structural change in employment:
- The Percentage of employment in the agricultural sector of the total workforce
- The Percentage of employment in the industrial sector of the total workforce
- The Percentage of employment in the service sector of the total workforce

3) Structural change in trade:
- Percentage of food imports' contribution to goods imports
- Percentage of trade's contribution to GDP
- Percentage of contribution of manufactures imports to goods imports
- Percentage of contribution of manufactures' exports to merchandise exports

4) Structural change in aggregate demand:
- The Percentage of final expenditures for public consumption of the government's contribution to GDP.
- The Percentage of contribution of private consumption to GDP.
- Percentage of contribution of gross fixed capital formation to GDP.

5) Structural change in population:
- Age dependency ratio as a proportion of the working-age population.
- Population in the labor force aged 14-65 years, as a percentage of the total population

In light of the theoretical framework of the study and its objectives, and what was presented from previous studies, the EViews software (version 13) and the R-Programming Language were used to conduct the statistical analysis to achieve the study objectives, which are to measure the role of diversification and development as tools for structural transformation in Saudi Arabia, during the period from 1991 to 2022. This was done by studying the impact of the independent variables, Economic Diversification Index (NHHI), Economic Complexity Index (ECI), Gross Fixed Capital Formation (GFCF), GDP Growth Rate (GDPG), and Oil Prices (OILP), on the dependent variable, Structural Transformation Index (MLI), during the study period from 1991 to 2022.

### 3.2. Descriptive Statistics and Correlation Matrix

A gradual but evident transition away from oil dependence toward a more diversified, non-oil economy has been evident in Saudi Arabia's economic statistics, which have been recording significant economic developments as part of its structural transformation under Vision 2030. According to a recent GASTAT revision of GDP figures, non-oil activities now account for 53.2% of GDP, an increase of almost 5.7% from previous estimates. In 2024, non-oil GDP growth is robust, increasing by roughly 4.3% to 4.6%, while oil GDP decreased. In the upcoming years, real GDP is expected to expand by approximately 4–5%, with non-oil sectors playing a significant role. Despite the comparatively low unemployment rate (3.2–3.5%), Saudi women still experience significantly higher unemployment rates. In the first quarter of 2025, notable structural changes occurred in specific sectors, with building increasing by almost 61%, wholesale and retail, restaurants, and hotels by about 30%, and transportation and communications by around 25.6%. According to these numbers, Saudi Arabia's economic data support its objectives of increasing private-sector involvement, bolstering non-oil income, and laying a broader foundation for inclusive and sustainable growth.

Before estimating the study model, we must first review descriptive statistics for the explanatory variables and test their hypotheses. Descriptive statistics are used to describe the basic features of the study variables. The following table illustrates the descriptive statistics for the study variables.

**Table 1.** Descriptive statistics For the variables

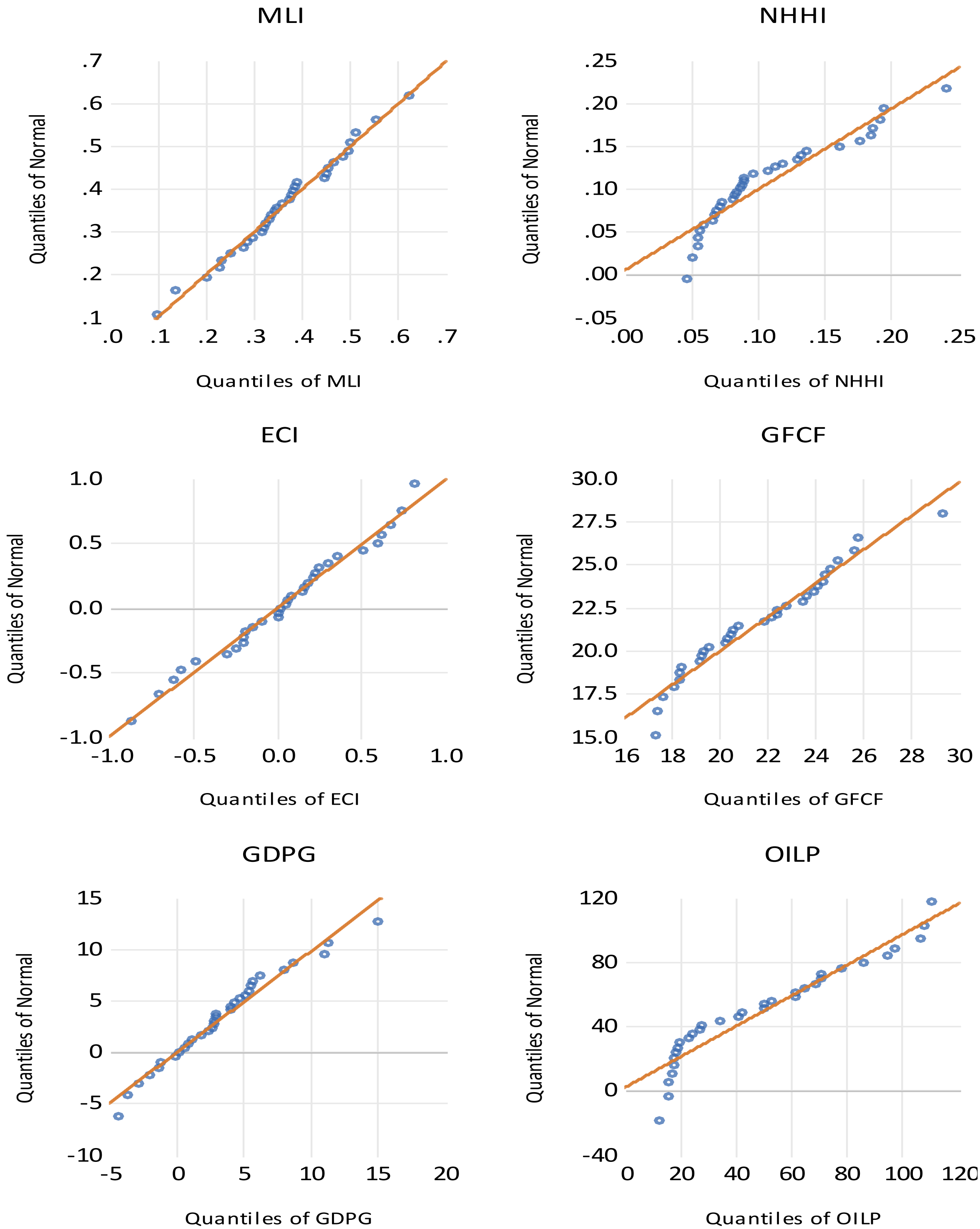
| Statistics | MLI | NHHI | ECI | GFCF | GDPG | OILP |
|---|---|---|---|---|---|---|
| Mean | 0.362853 | 0.107239 | 0.043434 | 21.57429 | 3.251619 | 50.00313 |
| Median | 0.354834 | 0.088278 | 0.052856 | 21.28739 | 2.819373 | 45.8465 |
| Maximum | 0.626568 | 0.240556 | 0.820323 | 29.35602 | 15.00788 | 110.272 |
| Minimum | 0.097288 | 0.045889 | -0.86852 | 17.30892 | -4.34139 | 12.244 |
| Std. Dev. | 0.118678 | 0.05163 | 0.425262 | 2.992183 | 4.402893 | 31.55923 |
| Skewness | -0.06066 | 0.909829 | -0.15533 | 0.424552 | 0.568803 | 0.507561 |
| Kurtosis | 2.856154 | 2.795639 | 2.541994 | 2.577358 | 3.312258 | 1.983413 |
| Jarque-Bera | 0.047213 | 4.470556 | 0.408376 | 1.19947 | 1.855537 | 2.751896 |
| Probability | 0.97667 | 0.106962 | 0.815309 | 0.548957 | 0.395435 | 0.2526 |
| Sum | 11.61129 | 3.43166 | 1.3899 | 690.3774 | 104.0518 | 1600.1 |
| Sum Sq. Dev. | 0.436622 | 0.082637 | 5.60628 | 277.548 | 600.9493 | 30875.54 |
| Observations | 32 | 32 | 32 | 32 | 32 | 32 |

Source: by author

Table 1 presents descriptive statistics for the six key economic variables — MLI, NHII, ECI, GFCF, GDPG, and OILP — that provide a clear overview of their central tendencies and dispersion across 32 observations. The mean and median values are generally close for most variables, suggesting approximate symmetry in their distributions, although GDPG and OILP exhibit somewhat wider ranges, reflecting their inherent volatility. The results show that OILP has the highest mean (50.00313) and standard deviation (31.55923), indicating substantial variability and greater magnitude than other variables. In contrast, ECI records the lowest mean (0.043434) and a relatively small standard deviation (0.425262), suggesting limited fluctuation around its average value. The measures of skewness and kurtosis indicate that most variables are approximately normally distributed, with skewness values close to zero and kurtosis within moderate bounds, as shown in Figure 1. Importantly, the Jarque-Bera test results support the assumption of normality, as the p-values for all variables exceed the 5% significance threshold. Consequently, the data appear suitable for conventional econometric modeling without requiring transformations or robust alternatives solely on the grounds of non-normality. Nonetheless, given the economic nature of variables like OILP and GDPG, which are prone to structural shocks, researchers should remain vigilant for potential outliers or time-series properties, such as stationarity and autocorrelation.

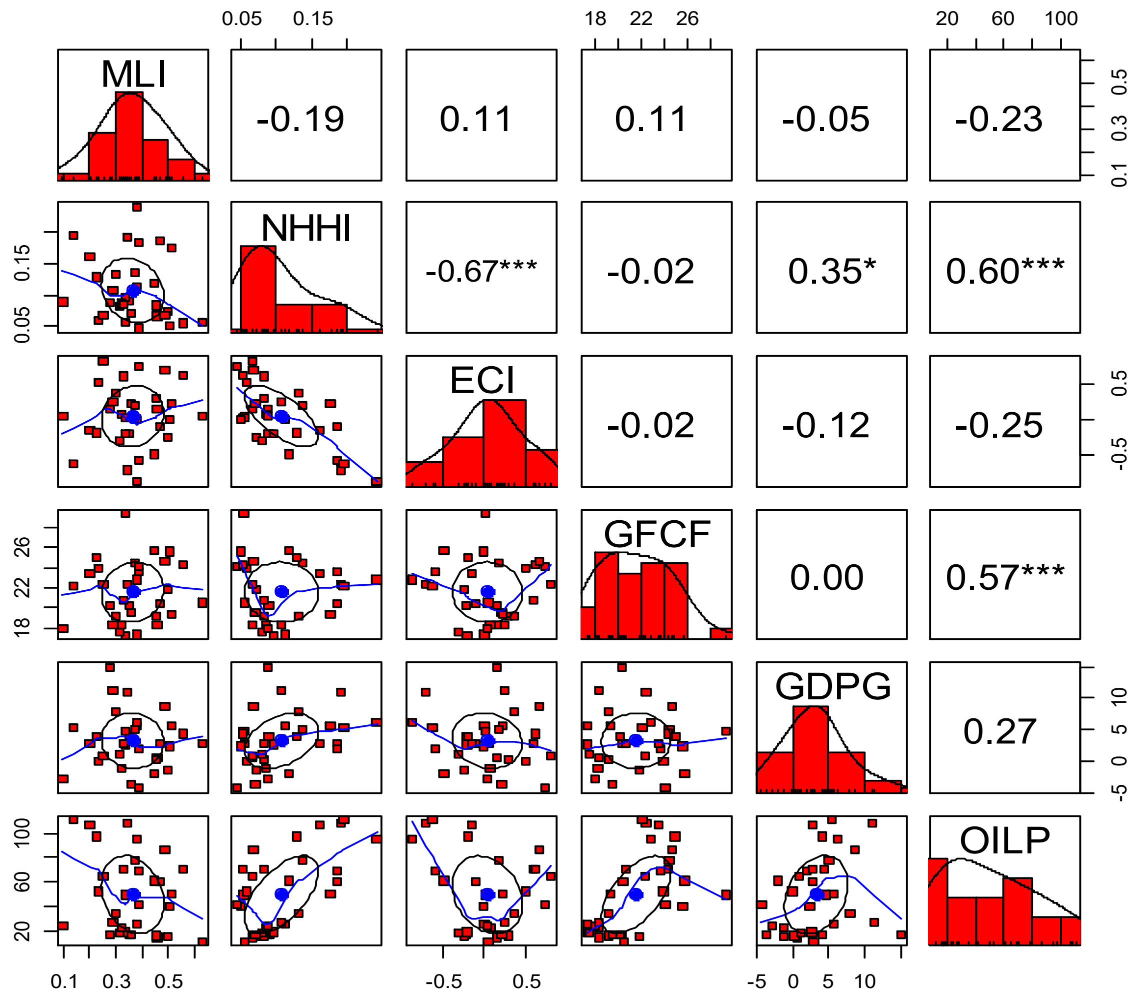
Figure 1 presents the Q–Q plots for all the variables MLI, NHHI, ECI, GFCF, GDPG, and OILP, indicating that the data are approximately normally distributed. In all plots, the majority of data points closely follow the 45-degree line, indicating a good fit between the empirical and theoretical quantiles of a normal distribution. Minor deviations are observed at the tails, particularly for GFCF and OILP, suggesting slight skewness or outliers. Still, these deviations are not substantial enough to indicate serious non-normality. Overall, the Q–Q plots visually confirm the results from the Jarque–Bera test in the descriptive statistics table, supporting the assumption of normality across the variables and justifying their suitability for further econometric analysis.

Figure 1. Description of the variables from 1991 to 2022.




Source: by author

Figure 2. Correlation matrix of the variables from 1991 to 2022.




Source: by author

Figure 2 displays the findings of the correlation matrix, which show significant relationships among the dynamics of oil prices, investment, growth, economic diversification, economic complexity, and structural transformation in the study setting. The NHHI has a strong negative correlation (−0.67***) with the MLI. This suggests that economies undergoing more profound structural changes, such as a shift from agriculture to industry/services, may currently have lower levels of diversification, possibly due to a transitional concentration in specific sectors. The ECI and NHHI exhibit a weak correlation (−0.02), indicating that diversification, as defined here, is not strongly linked to the range or sophistication of productive capacities measured by the ECI.

Regarding growth and investment, the NHHI has a strong correlation with OILP (0.60***) and a positive correlation with GFCF (0.35*). Although the exact causal relationship remains unknown, this suggests that higher oil prices may be supporting or corresponding with greater economic diversification, possibly through increased government investment financed by oil profits. A slight positive correlation between GDPG and OILP (0.27) indicates, on the other hand, that growth remains macroeconomically sensitive to changes in the oil market. Interestingly, there is almost no association between GDPG and GFCF (0.00), raising the question of how effectively capital investment spurs short-term growth in this situation. All things considered, these connections demonstrate the close relationship between structural change, diversification initiatives, and oil dependence. The substantial correlation between oil prices and the diversification index is fascinating, suggesting a "resource-enabled" diversification strategy rather than one driven by endogenous productive transformation. These factors should be taken into account by policymakers when formulating plans to promote objective economic complexity and sustained, non-oil-driven growth (Kamel and Abonazel, 2021). Moreover, all correlation coefficients below 0.8 indicate that there is no multicollinearity among the independent variables in Figure 2.

### 3.3. Stationarity: Unit Root Test

Time series data are often characterized by non-stationarity in the mean and variance due to growth and change over time. The stationarity test examines the characteristics of time series, confirms their stability, and determines their degree of integration before using them to estimate the study model. This is to avoid false or misleading results that do not reflect the actual relationship under investigation. Stationarity testing is performed in several ways. The current study used two unit root tests: the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests. The results of the unit root tests were as follows:

**Table 2**: Results of Unit Root Test.

| **Augmented Dickey and Fuller Test** | | | | | | |
|---|---|---|---|---|---|---|
| **Variable** | **At Level** | | | **First Difference** | | |
| | **None** | **Intercept** | **Intercept and Trend** | **None** | **Intercept** | **Intercept and Trend** |
| MLI | -0.735 | -3.855** | -3.825*** | -5.568*** | -5.443*** | -5.464*** |
| NHHI | -0.877 | -1.894 | -1.842 | -5.775*** | -5.677*** | -5.633*** |
| ECI | -1.999** | -1.991 | -2.299 | -5.704*** | -5.568*** | -5.646*** |
| GFCF | 0.159 | -1.754 | -2.883 | -6.056*** | -6.056*** | -5.896*** |
| GDPG | -4.127*** | -5.49*** | -5.393*** | -6.956*** | -6.781*** | -6.673*** |
| OILP | -0.109 | -1.405 | -2.078 | -4.966*** | -4.971*** | -4.876*** |
| **Phillips and Perron Test** | | | | | | |
| MLI | -0.245 | -3.853*** | -3.807** | -12.063*** | -11.664*** | -11.532*** |
| NHHI | -0.753 | -1.894 | -1.869 | -5.923*** | -5.923*** | -5.988*** |
| ECI | -2.101** | -2.091 | -2.267 | -6.447*** | -6.966*** | -9.544*** |
| GFCF | 0.757 | -1.574 | -2.653 | -7.272*** | -8.432*** | -8.631*** |
| GDPG | -4.172*** | -5.491*** | -5.393*** | -10.331*** | -8.961*** | -10.609*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| OILP | 0.066 | -1.358 | -2.207 | -4.961*** | -4.843*** | -4.942*** |

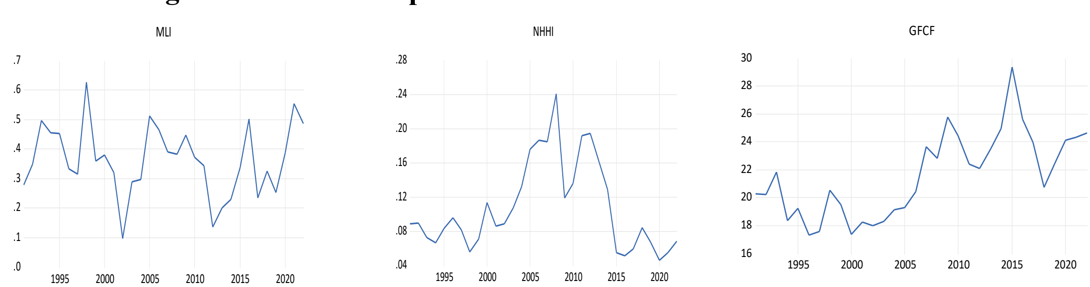
Source: by author Note: ***, **, and *, respectively, denote the 1%, 5%, and 10% significance levels.

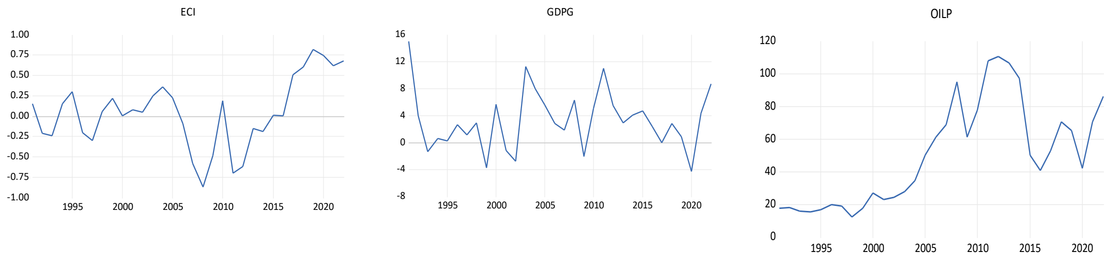
Using both the ADF and PP tests, the unit root test results shown in Table 2 provide important information on the stationarity of the six main economic variables under study: OILP, GFCF, NHHI, ECI, MLI, and GDPG. Test statistics that fail to reject the null hypothesis of a unit root at standard significance levels I(0) show that most variables behave non-stationarily, except for MLI, ECI, and GDPG, which, under specified conditions, show statistically significant rejections. Indicating that growth rates are intrinsically more stable than their level counterparts, MLI, for example, becomes stationary at the 5% level when an intercept is included (ADF: -3.855; PP:-3.853), whereas GDPG achieves stationarity even at the 1% level across multiple specifications (ADF: -4.127; PP: -4.172). On the other hand, even with trend and intercept controls, NHHI and OILP remain nonstationary, suggesting that some long-term structural changes or patterns may require careful modeling.

Crucially, first differencing I (1) makes all variables substantially stationary, which is a prerequisite for reliable cointegration and time-series regression analysis. Across all specifications for the first-differenced I(1) series, the ADF and PP tests consistently reject the unit root hypothesis at the 1% significance level. Robust stationarity is shown by test statistics like -5.568 for MLI, -5.775 for NHHI, and -9.956 for GDPG. Interestingly, GFCF exhibits a very high rejection in first differences (I(1)) (ADF: -6.056; PP: -7.272), suggesting that investment dynamics, notwithstanding level volatility, follow a mean-reverting pattern after differencing.

Lastly, the MLI and GDPG series are confirmed to be stable at the level, with no differences in I(0), as indicated by the ADF and PP tests. The NHHI, ECI, GFCF, and OILP variables were included in the I(1) stationarity test. The time series plots of the variables from 1991 to 2022 are shown in Figure 1. Figure 2 displays the same plots after accounting for differences. The results collectively justify proceeding with additional econometric modeling (e.g., VAR, ARDL, or NARDL) using first-differenced data or accounting for cointegration when long-run relationships exist. Crucially, the non-stationarity of NHHI and OILP at levels suggests that policy interventions targeting diversification or oil-dependent economies must account for structural breaks or time trends to avoid spurious inference. Additionally, the consistent performance of both ADF and PP tests, despite their differing treatments of serial correlation and heteroskedasticity, lends further confidence to these findings.

**Figure 3. Time series plots of the variables from 1991 to 2022.**






Source: by author

**Figure 4. Time series plots of the variables from 1990 to 2022 after taking differences.**


Source: by author

### 3.4. Methodology

The classic Autoregressive Distributed Lag (ARDL) model, introduced by Pesaran, Shin, and Smith (2001), was expanded by Shin et al. (2014) into the Nonlinear Autoregressive Distributed Lag (NARDL) model, an econometric technique. By permitting asymmetric effects, the NARDL model relaxes the standard ARDL model's assumption that the relationship between variables is linear and symmetric. This allows the model to differentiate between the effects of positive and negative changes in an explanatory variable on the dependent variable. Economic linkages are frequently asymmetrical and nonlinear, which is the main driving force behind the NARDL paradigm. For example, a rise in oil prices can have a different impact on economic growth than a fall of the same size. Such asymmetry is not captured by conventional linear models, which can lead to skewed or insufficient interpretations of the underlying dynamics. To evaluate both short- and long-term asymmetries simultaneously within a single equation framework, the NARDL model decomposes the explanatory variable into partial-sum processes of positive and negative changes.

The main benefits of the linear ARDL model remain in the NARDL method. As long as no series are integrated of order two [I(2)], it can be used with variables that are integrated of either order zero [I(0)] or order one [I(1)]. Not all series require the same integration order. Because of this, the NARDL model is very adaptable for empirical research, particularly when working with small samples. Additionally, it enables testing the boundaries of cointegration relationships, allowing investigation of whether a long-term equilibrium exists despite possible nonlinearities.

The NARDL model is frequently used in empirical applications across various disciplines, including macroeconomics, finance, and energy economics, to examine asymmetric responses. These reactions encompass how changes in exchange rates, oil price shocks, or policy adjustments impact macroeconomic variables. Both short-run asymmetric dynamics, which capture instantaneous reactions to positive or negative shocks, and long-run asymmetric relationships, which capture enduring equilibrium effects, are commonly included in the outcomes of NARDL estimation. In conclusion, by incorporating nonlinearity and asymmetry into the classic ARDL framework, the NARDL model emerges as a robust and adaptable econometric tool, offering a more comprehensive and realistic understanding of dynamic economic relationships. The first step in applying the NARDL method is to test for a long-run cointegrating relation among the variables. This is done through a bounds-testing procedure conducted within the framework of the unrestricted NARDL equation.

$$\Delta MLI_t = \alpha_0 + \sum_{i=1}^{p}\beta_{1i}\Delta MLI_{t-i} + \sum_{i=0}^{q1}\beta_{2i}\Delta NHHL_{t-i} + \sum_{i=0}^{q2}\beta_{3i}\Delta ECI_{t-i} + \sum_{i=0}^{q_3}\beta_{4i}\,\Delta GFCF_{t-i} + \sum_{i=0}^{q_4}\beta_{5i}\,\Delta GDPG_{t-i} + \sum_{i=0}^{q_5}\beta_{6i}\,\Delta OILP_{t-i} + \lambda_1 MLI_{t-1} + \lambda_2 NHHL_{t-1} + \lambda_3 ECI_{t-1} + \lambda_4 GFCF_{t-1} + \lambda_5 GDPG_{t-1} + \lambda_6 OILP_{t-1} + \varepsilon_t \qquad (1)$$

Where $\Delta$ denotes the first difference operator, $\beta's$ are the short-run coefficients, and $\lambda's$ capture the long-run estimates. The $p$ and $q$ represent the optimal lag selection for each variable, which can be determined using one of the information criteria, such as the Akaike information criterion (AIC).

Based on the F-statistics, work by [Pesaran, Shin, and Smith (2001)] developed bound tests to determine the existence of long-term associations. The rejection of the null hypothesis, as stated below, verifies cointegration among the variables under investigation, whereas the null hypothesis states that there is none.

$$H_0:\ \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6$$

$$H_1:\ \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6$$

The critical parameters for asymptotically estimating the existence of cointegration were also derived in the study [Pesaran, Shin, and Smith (2001)]. The number of variables included, the integration order of the regressors, and whether the equation has an intercept, a trend, or both determine the computed lower and upper bounds. A value above the threshold indicates that the variables under investigation are cointegrated, whereas a value below the lower bound indicates that there is no cointegration. If the result falls between the lower and upper bounds, the test is considered inconclusive. Following confirmation of cointegration, estimates of the short- and long-term effects of the independent variables on the variables under investigation are obtained.

- **L**

**ong-run coefficients are calculated from**

$$MLI_t = \alpha_0 + \sum_{i=1}^{p}\beta_{1i}MLI_{t-i} + \sum_{i=0}^{q1}\beta_{2i}NHHL_{t-i} + \sum_{i=0}^{q2}\beta_{3i}ECI_{t-i} + \sum_{i=0}^{q_3}\beta_{4i}\,GFCF_{t-i} + \sum_{i=0}^{q_4}\beta_{5i}\,GDPG_{t-i} + \sum_{i=0}^{q_5}\beta_{6i}\,OILP_{t-i} + \varepsilon_t \qquad (2)$$

- **A**

**nd the short-term is estimated from the conditional error correction model (ECM):**

$$\Delta MLI_t = \alpha_0 + \sum_{i=1}^{p} \beta_{1i} \Delta MLI_{t-i} + \sum_{i=0}^{q1} \beta_{2i} \Delta NHHL_{t-i} + \sum_{i=0}^{q2} \beta_{3i} \Delta ECI_{t-i} + \sum_{i=0}^{q_3} \beta_{4i}\, \Delta GFCF_{t-i} + \sum_{i=0}^{q_4} \beta_{5i}\, \Delta GDPG_{t-i} + \sum_{i=0}^{q_5} \beta_{6i}\, \Delta OILP_{t-i} + \varphi ECM_t + \varepsilon_t \quad (3)$$

**Table 3**: Bounds test for NARDL Cointegration result

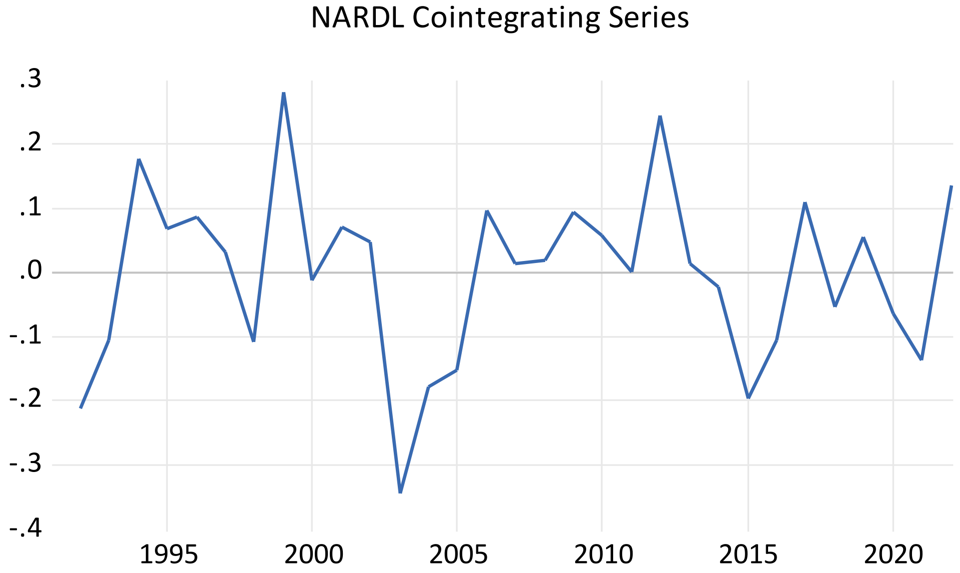
| **Model** | **Optimal Lag** | **F-Statistics** | **Critical Values (1%)** | | **Critical Values (5%)** | |
|---|---|---|---|---|---|---|
| | | | Lower Bound I(0) | Upper Bound I(1) | Lower Bound I(0) | Upper Bound I(1) |
| NARDL Model | (3,0,2,3,3,3) | 16.877*** | 3.41 | 4.68 | 2.62 | 3.79 |

Source: by author Note: ***, **, and *, respectively, denote the 1%, 5%, and 10% significance levels.

The cointegration across the studied series was reassessed following the completion of unit root testing and confirmation that the NARDL model is the best for answering the research question. The cointegration test results for the symmetric NARDL model are displayed in Table 3. The AIC served as the foundation for the chosen models and ideal lag selection. For the presence of cointegration in the model to be confirmed, the F-statistic value must be greater than the upper-bound I(1) value. Using the traditional NARDL model, the results demonstrate long-term correlations among the variables under investigation, with the F-statistic exceeding the asymptotic critical values at the 1% confidence level.

Based on the NARDL model, Figure 5 shows the long-term equilibrium relationship between the variables under study from the early 1990s to about 2022. Significant swings between positive and negative values are seen in the series, suggesting dynamic adjustments around the long-term equilibrium. Negative deviations indicate times of disequilibrium beneath the long-term Trend, whereas positive deviations indicate times when the dependent variable is above its long-term equilibrium path. With peaks around 1998, 2010, and 2021 and troughs around 2004 and 2016, the pattern indicates alternating cycles of adjustment, suggesting that the system often returns to equilibrium following shocks. Overall, the series exhibits mean-reverting behavior, confirming that the variables in the NARDL framework have a stable long-term cointegrating connection.

Figure 5. NARDL Cointegrating Series



Source: by the author

Once cointegration has been established, the NARDL models provide important insights into the short-term dynamics and long-term relationships among the variables. Based on the NARDL model results, MLI is estimated and analyzed. The MLI of variables related to structural transformation movements in Saudi Arabia can be evaluated more precisely using quarterly data, which captures both short-term and long-term fluctuations. Based on the NARDL estimations, the modeling results are shown in Table 4.

**Table 4**: NARDL Model Estimation Results

| Variables | Coefficient | Std. Error | *t*-Statistic | *p*-value |
|---|---|---|---|---|
| | | **Short-Run Results** | | |
| MLI(-1) | 0.184*** | 0.020 | 9.200 | 0.000 |
| MLI(-2) | -1.255*** | 0.279 | -4.498 | 0.000 |
| MLI(-3) | 3.341** | 1.287 | 2.596 | 0.052 |
| NHHI | 0.209*** | 0.079 | 2.646 | 0.008 |
| ECI | 0.078 | 0.073 | 1.068 | 0.294 |
| ECI(-1) | 0.034*** | 0.005 | 6.800 | 0.000 |
| ECI(-2) | 0.094*** | 0.016 | 5.875 | 0.000 |
| GFCF | 0.004* | 0.002 | 2.000 | 0.072 |
| GFCF(-1) | -0.006** | 0.003 | -2.000 | 0.038 |
| GFCF(-2) | 0.017*** | 0.004 | 4.564 | 0.002 |
| GFCF(-3) | -0.035 | 0.018 | -1.938 | 0.845 |
| GDPG | 0.022*** | 0.004 | 4.933 | 0.006 |
| GDPG(-1) | 0.026** | 0.012 | 2.127 | 0.064 |
| GDPG(-2) | 0.030** | 0.012 | 2.462 | 0.036 |
| GDPG(-3) | 0.019*** | 0.006 | 3.240 | 0.009 |

| | | | | |
|---|---|---|---|---|
| OILP | 0.037*** | 0.003 | 11.705 | 0.000 |
| OILP(-1) | -0.041*** | 0.003 | -12.988 | 0.000 |
| OILP(-2) | -0.025*** | 0.003 | -7.566 | 0.000 |
| OILP(-3) | -0.041*** | 0.004 | -11.736 | 0.000 |
| Constant | -2.349*** | 0.236 | -9.954 | 0.000 |
| **Long-Run Results** | | | | |
| NHHI | -3.398*** | 1.005 | -3.382 | 0.001 |
| ECI | -0.167*** | 0.070 | -2.394 | 0.007 |
| GFCF | 0.071*** | 0.022 | 3.305 | 0.009 |
| GDPG | 0.022** | 0.009 | 2.316 | 0.046 |
| OILP | 0.028*** | 0.003 | 8.975 | 0.000 |
| Constant | -1.192** | 0.530 | -2.246 | 0.051 |

Source: by author Note: ***, **, and *, respectively, denote the 1%, 5%, and 10% significance levels.

The variables exhibit both short-term and long-term dynamics, as indicated by the NARDL estimation results shown in Table 4. Firstly, the lagged MLI terms in the short-run estimates indicate high short-term persistence in the dependent variable, with statistical significance at different levels. In particular, MLI(-1) and MLI(-2) contain positive and negative coefficients, respectively, indicating a process for short-term adjustment in which equilibrium deviations are gradually corrected. According to the positive, statistically significant coefficients for NHHI and ECI, MLI is positively affected in the short term by increases in market concentration and economic complexity. Because investment and economic dynamics respond slowly, GFCF and GDPG exhibit mixed short-term effects, with some lags showing negative indicators and others showing positive ones. The OILP variable also exhibits extremely significant negative coefficients for its lagged terms, indicating that changes in oil prices have a substantial short-term negative impact on MLI, possibly due to adjustment costs or unstable economic conditions. Secondly, according to long-term estimates, NHHI and MLI continue to exhibit a negative and significant association, suggesting that greater market concentration eventually leads to a decline in the manufacturing or market liberalization index. On the other hand, ECI and OILP have favorable and statistically significant impacts, indicating that long-term structural enhancements are supported by economic diversification and steady oil earnings. Both GDPG and GFCF have positive coefficients, suggesting that long-term industrial or structural expansion is facilitated by both economic growth and capital formation. The negative value of the long-run constant term indicates a possible equilibrium correction or adjustment back toward the long-run path. Overall, the model's validity and the presence of a stable cointegrating relationship are supported by the NARDL results, which confirm both the short-run dynamics and the long-run equilibrium relationships among the variables.

**Table 5.** Wald test for short-run and long-run asymmetry.

| Test | Short-Run Asymmetry | Long-Run Asymmetry |
|---|---|---|

| | | |
|---|---|---|
| F-statistic | 9.643 *** | 5.836 *** |
| Chi-square | 11.792 *** | 17.294 *** |

Source: by author Note: ***, **, and *, respectively, denote the 1%, 5%, and 10% significance levels.

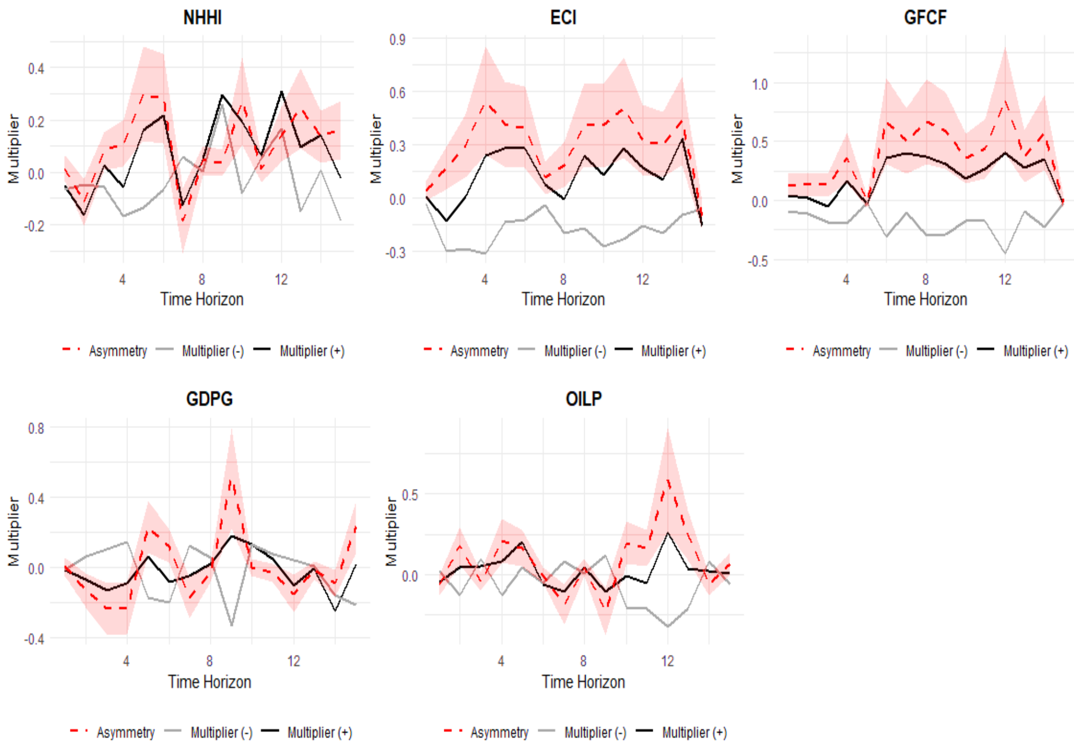
According to the Wald test statistics, the data in Table 6 provide compelling support for the model's short- and long-term asymmetry. With an F-statistic of 9.643 and a Chi-square statistic of 11.792 for short-run asymmetry, the null hypothesis of symmetric short-run adjustment may be safely disproved. The F-statistic of 5.836 and the Chi-square of 17.294 for long-run asymmetry, both significant at the 1% level, imply that the long-run equilibrium relationship is asymmetric. These results suggest that both in the short-term adjustment phase and in the long-term equilibrium, changes in the explanatory variables, whether positive or negative, have statistically distinct effects on the dependent variable (MLI). The resilience of the asymmetry is highlighted by the high significance levels across all test statistics, suggesting that models that assume symmetry may not accurately capture the system's dynamics. This has significant ramifications for forecasting and policymaking, as ignoring such asymmetries may lead to biased estimates and suboptimal decisions.

Figure 6 presents the dynamic multipliers that illustrate the asymmetric adjustment path of the Structural Transformation Index in response to a one-percent shock in the positive and negative partial sums of the independent variables: Oil Prices (OILP), GDP Growth Rate (GDPG), Gross Fixed Capital Formation (GFCF), the Economic Diversification Index (NHHI), and the Economic Complexity Index (ECI).

The asymmetric cumulative adjustment curve, along with its 95% confidence interval (depicted by the lower and upper bands), is derived from the combined impact of the dynamic multipliers for negative and positive shocks. The results of the Economic Complexity Index multiplier indicate that a drop in the ECI has a negative, long-lasting impact on the Structural Transformation Index.

Figure 6 illustrates how a positive shock to oil prices causes the structural transformation index to climb immediately and peak in the fourth quarter. In contrast, a decrease in oil prices has only a slight effect on the structural transformation index. Asymmetry is implied by these variations in the structural transformation index's response to shifts in oil prices. Following the tenth quarter, a long-term adjustment was seen. The responses of the structural transformation index are comparable for both rising and falling oil prices. A decline in the economic complexity index hurts the structural transformation index, according to the multiplier result. These effects, however, are too minor to have a substantial impact on the structural transformation index. Figure 6 shows that shocks to the GDP growth rate increase the structural transformation index, whereas a negative shock to gross fixed capital formation decreases it.

Figure 6: Asymmetric Multiplier of all variables to the MLI.




Source: by author

### 3.5. Post-estimation diagnostic tests

**Table 6:** Post-estimation diagnostic test results.

| Diagnostic test | Test Statistic |
|---|---|
| R-squared | 0.929 |
| F-test | 21.026*** |
| ECT | -0.874*** |
| Heteroskedasticity Test | 22.653 |
| Jarque-Bera Normality test statistics | 3.087 |
| Breusch-Godfrey Serial Correlation LM Test | 4.839 |
| Ramsey RESET Test | 1.428 |

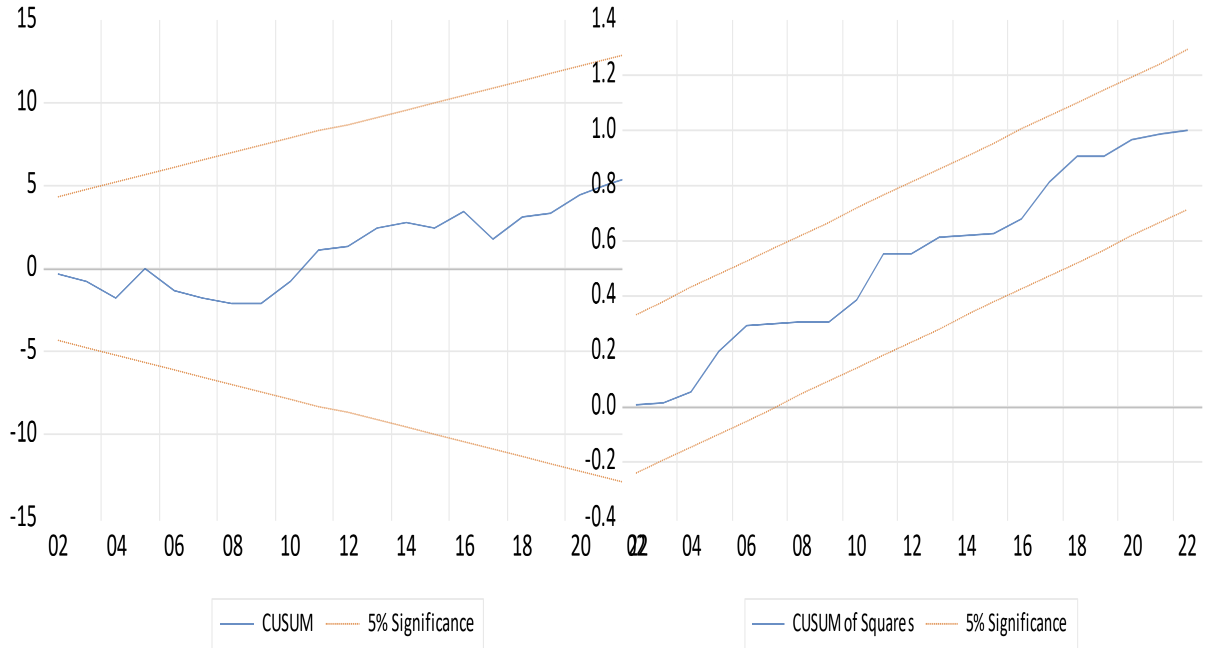
Source: by author Note: ***, **, and *, respectively, denote the 1%, 5%, and 10% significance levels.

The estimated equation was checked for spuriousness using post-estimation diagnostic tests. Table 6 summarizes the findings. The coefficient of determination (R ($^{2}$indicates that the derived equation provides a satisfactory fit to the data, suggesting that the explanatory variables may account for approximately 93% of the variation in the structural transformation index. Because the ECT is negative and statistically significant at the 1% level, the NARDL model appears to be stable. All coefficients are nonzero, as indicated by the F-statistic's significance at the 1% level. It was clear that the error term met the NARDL assumptions. Normal distribution, homoscedasticity, and serial independence characterize the error terms. There are no specification problems in the model, according to the Ramsey RESET test result. Overall, the diagnostic test demonstrated the validity and dependability of the estimations produced by the study.

**3.6. Stability test**

The CUSUM and CUSUM squares examine the stability of the model. The findings showed that across the sample period from 1991 to 2022, the coefficients of the NARDL structural transformation index model are constant at the 5% level of significance (Figure 7). At the 5% level of significance, the expected line (blue line) is well inside the critical bounds. These findings suggest that the inflation NARDL model's coefficients are stable.

Figure 7: CUSUM and CUSUMSQ of the structural transformation index NARDL model.




Source: by author

**4. Conclusion and recommendations**

In the quest for sustainable economic development, structural transformation is a vital process that shifts an economy's composition from reliance on conventional industries to a more diversified, value-added structure. It is essential as a strategic path to increasing economic resilience, creating new job opportunities, boosting productivity, and reducing vulnerability to global market shocks. Here, diversification and economic growth play leading roles in facilitating this change by serving as tools for reallocation and by triggering the transition towards more developed, diversified economic activity.

From this perspective, the research has analyzed the role of economic diversification and development towards structural transformation in the Kingdom of Saudi Arabia. This was done under the theory, with emphasis on the interconnectedness of the concepts, and in line with the vision of "Saudi Vision 2030." The study has utilized the developed NARDL technique to determine the nonlinear and asymmetric relationships, utilizing time series data for the period .(2022-1991)

The econometric exercise yielded cointegrating results confirming the existence of a long-run cointegrating relationship among the model variables. It also revealed an efficient built-in mechanism for correcting imbalances, in which approximately 87.4% of any deviation from the long-run equilibrium path is eliminated in each period. The long-term consequences also indicated that economic diversification is an intrinsic driver of economic restructuring, as evidenced by a strong negative correlation between the market concentration index and the structural transformation index. On the other hand, economic complexity was negatively impacted by the transition costs associated with building a more diversified productive base.

The research also showed a significant positive contribution of both economic growth and investment in enabling the structural transformation process. The study provided substantial econometric evidence that oil wealth can enable structural transformation, showing a strong, positive, and asymmetric long-run relationship between oil prices and structural transformation. The study found asymmetric dynamics in the short term: higher prices strongly confirm structural change, but a fall has a limited impact. The model demonstrated very high explanatory power (92.9%), stability in the estimated coefficients, and no econometric problems, thereby increasing the validity of the findings. This study contributes methodologically to insights on the dynamics of structural transformation in natural resource-based economies. It confirms the viability of Vision 2030's strategic vision in turning challenges into opportunities for structural economic transformation and sustainable diversification.

From the findings of this study, it can be recommended to policymakers in the Kingdom of Saudi Arabia:

There should be enhanced economic diversification policies aimed at building productive and diversified real capabilities and further reducing reliance on the oil sector. Adequate machinery must also be established to translate oil revenues into productive investments in non-oil sectors and to create financial buffers that cushion transformation programs during periods of price declines.

It is necessary to guide industrial and trade policies to promote high-value-added industries and services that leverage advanced knowledge and skill networks, thereby building a flexible economic base to compete internationally. There should be a favorable investment climate and a policy promoting private and foreign direct investment in non-oil sectors to ensure that the climate remains favorable.

Given the asymmetric shocks revealed in this study, there is a recommendation for an adaptable policy framework capable of responding effectively to periods of rising and falling oil prices, as well as to different phases of economic complexity development. Investments must also flow to high-income projects that finance the ambitious structural change process being championed by Vision 2030.

**Funding:** This work was supported by the Deanship of Scientific Research at Imam Mohammad

Ibn Saud Islamic University (IMSIU) (grant number IMSIU-DDRSP2504).
**Acknowledgments:** The authors extend their appreciation to the Deanship of Scientific Research at Imam Mohammad Ibn Saud Islamic University (IMSIU), Saudi Arabia, for its support of this study. The researcher also appreciates the considerable time and effort of the reviewers and the editor in expediting the process. Their commitment and expertise were crucial in making this work a success. I appreciate your unwavering help.
**Data availability**: The authors do not have permission to share data.
**Conflict of interest**: No potential conflict of interest was reported by the authors.

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