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Does economic diversification affect GDP growth asymmetrically in GCC countries? Panel PMG–NARDL evidence

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ABSTRACT

This paper investigates whether economic diversification affects GDP growth symmetrically or asymmetrically in GCC countries over the period 2000–2022. Economic diversification is measured using a Composite Economic Diversification Index (CEDIX) based on export, revenue, and sectoral concentration measures. The study uses a pooled mean group nonlinear autoregressive distributed lag (PMG–NARDL) model following tests for cross-sectional dependence, mixed orders of integration, and panel cointegration. The results show a stable long-run relationship between GDP growth, economic diversification, investment, labor force participation, and oil prices. More importantly, the results show a strong long-run asymmetry: diversification gains have a positive effect on long-run GDP growth, while diversification setbacks have a greater negative effect, thereby suggesting a reversal penalty. With respect to the control variables, oil prices are significant in the long run, while investment and labor force participation are more relevant to short-run dynamics. Short-run diversification effects are weaker and provide little evidence of asymmetric adjustment. Overall, the results suggest that the growth advantages of diversification take time to materialize through cumulative structural change rather than immediate short-run responses. The findings stress the importance of continuing diversification efforts to enhance long-run growth performance in GCC economies.

Contribution/Originality: This study adds to the diversification-growth literature by combining a multidimensional diversification index with a panel PMG–NARDL framework to test whether diversification gains and setbacks affect GDP growth asymmetrically in GCC economies.

1. INTRODUCTION

GCC countries have historically relied on hydrocarbons to a significant degree as a source of exports, domestic production, and government revenues. This growth model underpinned rapid development during periods of high oil prices, but it also increased exposure to oil-market volatility and raised concerns about the sustainability of growth when oil prices weakened. This has led to economic diversification being a key objective of GCC development strategies, particularly through reforms to develop non-oil production, promote non-oil exports, and reduce fiscal reliance on oil revenues (Callen, Cherif, Hasanov, Hegazy, & Khandelwal, 2014; Hvidt, 2013; International Monetary Fund, 2017).

Economic diversification is also important, as it can broaden the productive base, reduce dependence on a narrow range of activities, and support more sustainable growth. But diversification is not necessarily a simple or linear process. At some stages of development, countries may diversify and, at others, they may re-specialize. Diversification gains may require long periods of structural transformation, investment, and capability accumulation (Cadot, Carrère, & Strauss-Kahn, 2011; Imbs & Wacziarg, 2003; Lashitew, Ross, & Werker, 2021). In hydrocarbon-dependent economies, this process is more complex because dependence may appear not only in exports but also in domestic production and public revenues.

This raises an important question for the economies of the GCC: do diversification improvements and diversification setbacks affect GDP growth in the same way? Diversification gains can be accumulated gradually as the non-oil sector, institutions, and private sector develop, but can be lost quickly in oil booms as exports, output, or fiscal revenues become more concentrated. If these gains and setbacks have differential effects, a symmetric model may conceal an important part of the diversification-growth relationship.

This paper investigates the asymmetric effect of economic diversification on real GDP growth in Gulf Cooperation Council countries from 2000 to 2022. Economic diversification is measured by a Composite Economic Diversification Index (CEDIX) based on export, revenue, and sectoral diversification pillars, capturing the multidimensionality of diversification in resource-dependent economies. In addition, CEDIX decomposes into negative and positive partial sums to test for asymmetry in a pooled mean group nonlinear autoregressive distributed lag (PMG–NARDL) framework. Standard growth controls are investment, labour force participation, and real oil prices.

The study addresses three research questions. First, is there a significant long-run effect of economic diversification on GDP growth in GCC countries? Second, do the improvements in diversification and the setbacks in diversification have asymmetric effects on GDP growth? Third, are the asymmetric effects larger in the long run than in the short run?

The paper makes three contributions. First, it uses a multidimensional diversification measure that is suitable for hydrocarbon economies by combining export, revenue, and sectoral diversification into a single composite index. Second, it offers new GCC panel evidence on whether the growth response to diversification gains and setbacks differs. Third, it combines second-generation pretests for cross-sectional dependence and mixed integration orders with a PMG–NARDL error-correction model that allows for heterogeneous short-run dynamics but a common long-run relationship across the GCC countries.

The paper is organized as follows. Section 2 surveys the literature. Section 3 describes the data and methodology. Section 4 provides the empirical results. The paper ends with Section 5, which draws conclusions and discusses policy implications.

2. LITERATURE REVIEW

Economic diversification is generally seen as a process of moving the productive base of an economy further away from a narrow range of activities. In the development literature, diversification is closely associated with structural transformation, learning, and resilience to shocks, but its relationship with growth is not the same across countries or across time periods.

Imbs and Wacziarg (2003) show that diversification tends to increase at low levels of development and then decline at high levels of income, while the pattern of export diversification identified by Cadot et al. (2011) is comparable: there is no monotonic relationship between diversification and growth, and the extent to which sectors are diversified very much depends on where a country finds itself within its trajectory.

There is a large literature that relates diversification to better economic performance, especially in the context of resource-dependent and developing economies. Hesse (2008) finds that diversification in exports has been positively associated with growth in developing economies. Aditya and Acharyya (2013) and Munir and Javed (2018) similarly find a growth payoff of diversification, but one that depends, in addition to diversification itself, on the composition and quality of the production and export basket. More recent literature tends, however, to put more emphasis on capabilities, productivity, and technological upgrading. Canh and Thanh (2022) suggest that diversification has stronger growth-enhancing effects when coupled with greater economic complexity. Parteka, Zarach, and Kordalska (2025) also argue that the long-run benefits of diversification depend on its technological content. At the same time, the evidence suggests that diversification does not pay off equally everywhere. The level of income, the size of the country, and structural conditions are important, and the relation between diversity and growth is probably context-dependent (Ali, Murshed, & Papyrakis, 2023; Lee & Zhang, 2022). Related studies also indicate that the effects of diversification may be non-linear across stages of development or levels of concentration (Cadot et al., 2011; Imbs & Wacziarg, 2003; Trinh & Thuy, 2021).

These issues are especially prominent in resource-rich economies, where diversification is often constrained by natural resources, commodity-price cycles, and persistence of state-owned structures. Internationally, natural-resource dependence is associated with relatively underdeveloped diversification into more value-added activities, typically in the context of weak governance and institutions (Matallah, 2022; Zarach & Parteka, 2023). But at the same time, the resource-rich country literature highlights that successful diversification is contingent on broader capability building in the non-resource economy: human capital, quality of institutions, investment, and private-sector dynamism (International Monetary Fund, 2017; Jolo, Ari, & Koç, 2022; Lashitew et al., 2021). This suggests that diversification is not limited strictly to oil-exporting economies as an export issue, but more globally as a material change in the structure of production, in the composition of trade, and in the dependence of public revenue.

The GCC literature complements this view, with studies showing that the results of diversification are heterogeneous in their dimensions and by country. Alkhathlan, Alkhateeb, Mahmood, and Bindabel (2020) show for Saudi Arabia that diversification measured through production, exports, and government revenues does not evolve the same way, nor respond the same way to macroeconomic conditions. Houfi (2021) shows that diversification can be examined within a nonlinear framework in the Saudi case.

Al-Kathiri and Dhaoui (2023) report positive growth effects of output- and revenue-based diversification and their interactions in Oman. Shadab (2023) describes the case of the UAE as relatively successful, but the broader GCC literature underlines that diversification is incomplete, generally slow, and highly contingent on oil-financed demand, state control, and limited transformation of the private sector (Callen et al., 2014; Cherif & Hasanov, 2014; Hvidt, 2013). Related work also indicates that export, sectoral, and revenue diversification need not proceed in parallel, further underscoring the conclusion that diversification in hydrocarbon-dependent economies is inherently multi-faceted (Prasad et al., 2025; Usman & Landry, 2021).

Table 1 summarizes selected studies on economic diversification, growth, and resource-dependent economies. The table presents a summary of the diversification measures used, the empirical approaches, and the main findings of prior work. The studies reviewed together lead to three conclusions relevant for this paper. First, although diversification is generally linked to improved long-run economic performance, its impacts differ across countries, income levels, and structural conditions. Second, diversification in oil-dependent economies is a multi-dimensional transition involving exports, domestic production, and public revenues, rather than a mere change in export concentration.

Third, nonlinear and asymmetric effects are still under-explored, especially in the GCC panel settings. The existing evidence is based on single-country studies, one-dimensional proxies, or symmetric models. Thus, this research contributes to the literature by using a multidimensional Composite Economic Diversification Index (CEDIX) and a panel PMG–NARDL framework to investigate whether improvements in diversification and setbacks in diversification have differential impacts on the GDP growth of GCC countries during the period 2000–2022.

Table 1. Summary of Selected Studies on Economic Diversification and Growth.

Study	Context	Diversification measure	Method	Main finding
Imbs and Wacziarg (2003)	Cross-country sectoral evidence	Sectoral concentration measures, including Gini and HHI	Nonparametric and panel regressions	Countries diversify in the early phases of development before re-specializing at greater economic levels.
Cadot et al. (2011)	156 countries, export data	Theil index, HHI, Gini, and active export lines	Panel estimation and Theil decomposition	Export diversification is U-shaped. This is largely driven by changes in the extensive margin.
Aditya and Acharyya (2013)	65 countries	Export concentration and export composition	Dynamic panel system GMM	Export diversification and export composition matter for growth, but the relationship is nonlinear.
Trinh and Thuy (2021)	44 emerging and developing countries	HHI for export markets and the Theil index for products	Panel threshold regression	Diversification matters for growth only under some regimes. The relationship is not linear.
Hesse (2008)	Broad cross-country sample	Export concentration using HHI	Dynamic panel system GMM	Export diversification supports growth, particularly in developing countries, with evidence of non-linearity.
Canh and Thanh (2022)	70 economies	Export diversification indices and economic complexity	Panel Granger causality, 3SLS, 2SLS, and GMM	Export diversification and economic complexity are mutually reinforcing forces. Complexity smooths growth cycles.
Ali et al. (2023)	Sudan	Export HHI and oil rents	VAR and impulse-response analysis	Oil rents increase the concentration of exports, and the growth effect of diversification is not statistically clear.
Lee and Zhang (2022)	Low-income countries and small states	HHI, Theil, and Gini for goods and services exports	System GMM	Diversification of exports is good for growth and reduces volatility, especially for smaller and poorer economies.
Zarach and Parteka (2023)	160 countries, resource-dependent focus	The relative Theil index is decomposed into resource and non-resource exports	Theil decomposition and econometric analysis	Dependence on natural resources constrains the diversification of exports other than resource- and technology-based exports.
Houfi (2021)	Saudi Arabia	Normalized HHI based on sectoral value added	ARDL and NARDL	Diversification supports Saudi growth in the long run, but symmetry is not rejected.
Alkhathlan et al. (2020)	Saudi Arabia	Production, revenue, export, investment, and employment diversification indices	ARDL bounds testing	Diversification is multi-dimensional, and each dimension responds differently to policy variables.
Shadab (2023)	UAE	Export HHI, manufacturing value added, and private-sector credit	Cointegration, VECM, and Granger causality	Export diversification drives growth in the UAE in both the long and short term.

Study	Context	Diversification measure	Method	Main finding
Prasad et al. (2025)	Global Economic Diversification Index	Output, trade, and government revenue diversification	PCA-based composite index	Diversification of economies is multi-dimensional, and countries that depend on commodities continue to be less diversified.
Al-Kathiri and Dhaoui (2023)	Oman	HHI for GDP/output and government revenue diversification	Descriptive and regression analysis	Oman's GDP growth was underpinned by better diversification of output and revenues.
Callen et al. (2014)	GCC countries	Non-oil output, non-oil exports, export quality, fiscal and financial diversification	IMF policy and descriptive analysis	The GCC's non-oil activity improved, but real diversification is still limited and heavily reliant on oil-financed spending.
Jolo et al. (2022)	14 resource-rich countries	Non-resource GDP-based diversification proxy	FGLS panel estimation	Diversification is supported by capital formation, finance, labor participation, education and rule of law.

Figure 1 presents the study's conceptual framework. The Composite Economic Diversification Index (CEDIX) is constructed by combining export, sectoral, and revenue diversification. The index is then decomposed into its positive and negative partial sums, $CEDIX^{+}$ and $CEDIX^{-}$, to reflect the potential asymmetric effects of improvements and setbacks in diversification on GDP growth. As control variables that may also influence growth, we include investment, labor-force participation, and real Brent oil prices.

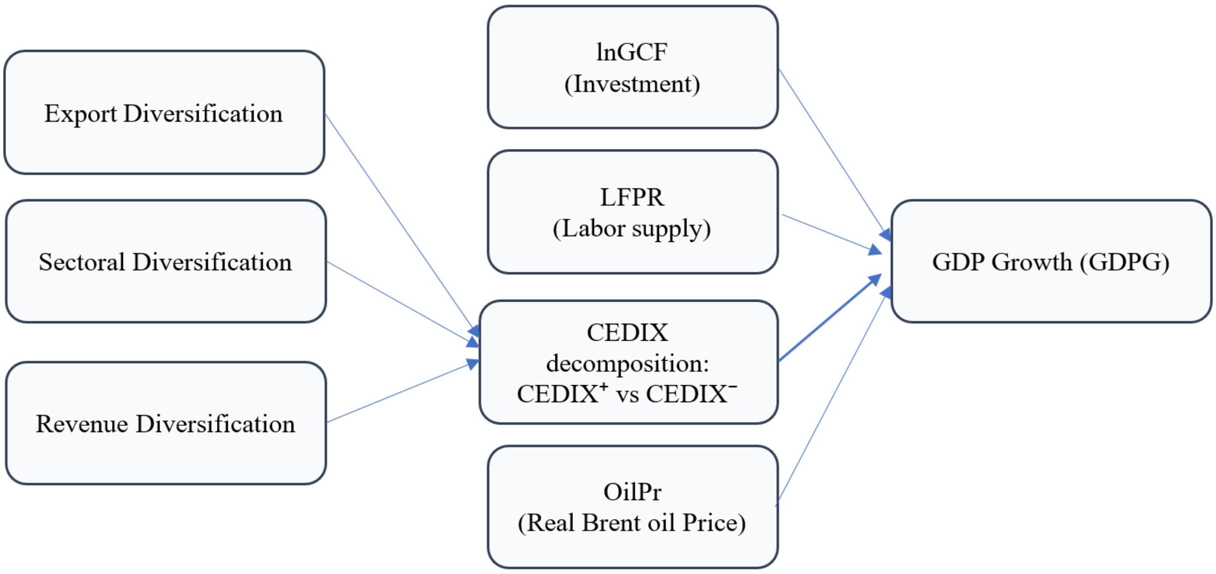

Figure 1. Conceptual Framework of the Asymmetric Diversification–Growth Relationship.

3. DATA AND METHODOLOGY

3.1. Data

This study employs a yearly balanced panel for the six Gulf Cooperation Council countries (Bahrain, Saudi Arabia, Qatar, Kuwait, the United Arab Emirates, and Oman) from 2000 to 2022. The period 2000–2022 is selected due to the longest annual balanced coverage of the three pillars of diversification among the six GCC countries. It also contains significant macroeconomic phenomena that are relevant for hydrocarbon-dependent countries: the oil-price boom of the 2000s, the global financial crisis, the oil-price fall of 2014–2016, the COVID-19 shock, and the post-pandemic recovery. The period also coincides with the intensification of GCC national diversification strategies and Vision-led reform initiatives.

The dependent variable is real GDP growth (GDPG), which is the yearly percentage growth rate of GDP at constant 2015 US dollars from the World Development Indicators. The main explanatory variable is the Composite Economic Diversification Index (CEDIX), built on three standardized diversification pillars: export concentration, sectoral concentration, and revenue concentration. Each pillar is built on an HHI-type measure of concentration, with a higher number indicating higher concentration and less diversification. Then, the methods of principal component analysis (PCA) are used on the three standardized pillars to combine them into a single composite index. The sign of the retained component is reversed, so that higher values of CEDIX indicate better diversification. CEDIX is then rescaled to the [0,1] range for interpretability and cross-country comparability.

To allow for potential asymmetric effects, CEDIX is divided into $CEDIX^{+}$ and $CEDIX^{-}$, the former capturing cumulative diversification benefits and the latter capturing cumulative diversification deteriorations. The control variables are investment, measured by the natural logarithm of real gross capital formation (lnGCF); labour market conditions, measured by the participation rate of the labour force (LFPR); and oil price, measured by the real Brent oil price (OilPr), where the nominal Brent price is deflated using the GDP deflator. Table 2 shows a summary of the definitions, transformations, and sources of all variables.

The balanced panel comprises 138 country-year observations, but the estimation sample size is reduced by including lagged dependent and explanatory variables in the PMG-NARDL specification. This limitation is inherent in GCC panel research as the region only has six member countries and reliable data on revenue diversification is available for a relatively limited yearly span. Thus, the empirical results are more relevant for medium- to long-run relationships, while short-run coefficients have to be seen in the light of the limited time dimension and lag structure.

Table 2. Variables, Definitions, Transformations, and Data Sources.

Variables	Definition	Transformation/Units	Data source
GDPG	Real GDP growth rate	Annual % change in real GDP (Constant prices)	World Development Indicators (WDI)
CEDIX	Composite Economic Diversification Index (Export, sectoral, revenue pillars via PCA)	Rescaled to [0,1]; higher values = More diversification	Authors' calculations (See diversification pillars); PCA
$CEDIX^{+}$	Positive partial sum of CEDIX (Cumulative diversification improvements)	NARDL decomposition of CEDIX; cumulative positive changes	Authors' calculations from CEDIX
$CEDIX^{-}$	Negative partial sum of CEDIX (Cumulative diversification deteriorations)	NARDL decomposition of CEDIX; cumulative negative changes	Authors' calculations from CEDIX
lnGCF	Real gross capital formation (Investment proxy)	Natural log; nominal GCF deflated using GDP deflator	World Bank, WDI
LFPR	Labor force participation rate (Labor market conditions)	Percent of working-age population	ILO
OilPr	Real Brent crude oil price	Nominal Brent price deflated using a GDP deflator	U.S. EIA; World Bank (GDP deflator)
EXDIV	Export concentration (HHI) used to construct CEDIX	Higher values = higher export concentration (lower diversification)	UNCTADstat
SECDIV	Sectoral concentration (HHI) used to construct CEDIX	HHI from sectoral value-added shares; higher values = higher concentration	UNData (National accounts)
REVDIV	Revenue (Fiscal) concentration (HHI) used to construct CEDIX	HHI from oil vs non-oil revenue shares; higher values = higher concentration	Arab Monetary Fund / Ministries of Finance

3.2. Economic Diversification Measure and Index Specification

Economic diversification is measured by a Composite Economic Diversification Index (CEDIX) using three concentration-based pillars (revenue concentration (REVDIV), export concentration (EXDIV), and sectoral concentration (SECDIV)). The design reflects the multidimensionality of diversification in hydrocarbon-dependent countries, where dependence could be extended to not only exports but also to domestic output and government revenues. Each pillar is measured by a Herfindahl–Hirschman-type concentration index, where a higher value indicates higher concentration and, therefore, less diversification.

The export concentration (EXDIV) is measured by the normalized export concentration index provided by UNCTADstat.

$$EXDIV_{jt} = \frac{\sum_{i=1}^{n}(\frac{x_{ijt}}{X_{jt}})^2 - 1/n}{1-1/n} \quad (1)$$

Where x_{ijt} is the exports of product *i* from nation *j* in year *t*, X_{jt} is the overall *j* country exports in year *t*, and *n* is the number of product categories exported. Higher EXDIV values indicate higher export concentration.

Sectoral concentration (SECDIV) is calculated as the Herfindahl–Hirschman Index of sectoral value-added shares.

$$SECDIV_{jt} = \sum_{i=1}^{N}(\frac{VA_{ijt}}{\sum_{i=1}^{N} VA_{ijt}})^2 \quad (2)$$

Where VA_{ijt} represents the value added in sector *i* for nation *j* in year *t*, and N represents the number of sectors covered in the calculation. The larger the value, the more concentrated the domestic output among sectors.

Revenue concentration (REVDIV) is measured as the HHI of oil and non-oil revenue shares.

$$REVDIV_{jt} = (S_{jt}^{oil})^2 + (S_{jt}^{nonoil})^2 \quad (3)$$

Where S_{jt}^{oil} and S_{jt}^{nonoil} are the proportions of revenues that are oil and non-oil in overall government revenues for country *j* in year t. The higher the REVDIV, the more concentrated is the fiscal revenue and the more dependent on oil-related revenues.

In order to ensure comparability across the three pillars, each is first standardized using z-scores before aggregating them using principal components analysis (PCA). PCA is used to derive what common, dominant factor underlies the three concentration-based pillars, as well as to avoid some ad hoc weighting scheme (Jolliffe & Cadima, 2016). The retained principal component is the first, which accounts for the most common variance across the three pillars. Since signs of PCA components are indeterminate, and every input is a concentration measure, this retained component is oriented such that greater values of CEDIX indicate greater diversification, i.e., lower concentration. Finally, and to make it more interpretable and comparable between countries, the index is rescaled to the [0,1] unit interval by min-max normalization (Joint Research Centre, 2008).

3.3. Econometric Methodology

3.3.1. Model Specification

To test for the impact of economic diversification on economic growth in the GCC economies, the following baseline growth specification, in which GDP growth is a function of diversification and the usual determinants of growth, is used.

$$GDPG_{it} = \beta_0 + \beta_1 lnGCF_{it} + \beta_2 LFPR_{it} + \beta_3 OilPr_{it} + \beta_4 CEDIX_{it} + \epsilon_{it} \quad (4)$$

Where *i* is for country and *t* is for time, GDPG is the annual real GDP growth rate, lnGCF is the log of real gross capital formation and acts as a proxy for investment, LFPR is the labour force participation rate and captures labour market conditions, CEDIX is the Composite Economic Diversification Index, whereas OilPr is the real oil price. Investment and labour market conditions are part and parcel of empirical growth models, determinants of growth (Barro, 1991; Mankiw, Romer, & Weil, 1992). The coefficient on diversification, which is β4, is expected to be positive if more diversification aids growth through structural upgrading, capability expansion, and reducing dependence on a narrow range of activities (Hesse, 2008; Imbs & Wacziarg, 2003). Oil prices are included because hydrocarbon prices remain an important condition for GCC economies in determining macroeconomic performance (Kilian, 2009).

3.3.2. Pre-Estimation Tests

Given the regional integration of the GCC economies and their common susceptibility to oil-market shocks, the analysis starts with a test of cross-sectional dependence (Pesaran, 2004). The null hypothesis of this test is cross-sectional independence; the null is rejected when there is cross-sectional dependence, resulting in the justification for second-generation panel procedures.

Next, the variables' time-series properties are evaluated using the IPS test (Im, Pesaran, & Shin, 2003) and the cross-sectionally augmented IPS test (Pesaran, 2007). It is a broadening exercise to report on which tests are used to assess the level of stationarity. The CIPS test is especially relevant when there is cross-sectional dependence since the test augments the country-specific ADF regressions with cross-sectional averages to account for common factors. Both tests have a unit root as the null hypothesis.

3.3.3. Panel Cointegration and Long-Run Estimation Strategy (PMG)

As the NARDL estimation methodology requires a long-run relationship among variables, panel cointegration is carried out before NARDL estimation. The error-correction-based panel cointegration test of Westerlund (2007) is used in the analysis because evidence of cross-sectional dependence in the GCC macroeconomic series is presented. The methodology assesses whether an error-correction mechanism exists in the panel by implementing the method using bootstrap p-values, thereby allowing inference in the presence of cross-sectional dependence and common shocks. Rejection of the null hypothesis of no cointegration is evidence of the long-run equilibrium relationship among the GDP growth, economic diversification, and control variables.

Conditional on cointegration, short-run and long-run dynamics using the Pooled Mean Group (PMG) estimator within an error-correction framework are estimated (Pesaran, Shin, & Smith, 1999). The PMG estimator allows short-run coefficients, adjustment speeds, and error variances to be different across countries, but restricts the long-run coefficients to be homogeneous. This structure is appealing in the GCC context, where the countries have important common features, such as oil dependence, common reform priorities, and exposure to common external shocks, but differ in their short-run responses because of country-specific institutions, the timing of policy initiatives, and cyclical features.

The error-correction term (ECT) is a critical parameter of the error-correction format. In the case of cointegration, the coefficient is anticipated to be significant and negative, meaning that short-run deviations will lead to long-run equilibrium convergence.

3.3.4. Panel NARDL Specification and Asymmetry Tests

To control for the possibility that GDP growth may react differently to gains and losses in diversification, the baseline specification is extended to an NARDL framework (Nonlinear Autoregressive Distributed Lag) by decomposing the diversification index into negative and positive partial sums (Shin, Yu, & Greenwood-Nimmo, 2014). Let

$$\Delta CEDIX_{it} = CEDIX_{it} - CEDIX_{it-1} \qquad (5)$$

The partial-sum processes are defined as:

$$CEDIX_{it}^{+} = \sum_{s=1}^{t} \max\left(\Delta CEDIX_{is}, 0\right) \qquad (6)$$

$$CEDIX_{it}^{-} = \sum_{s=1}^{t} \min\left(\Delta CEDIX_{is}, 0\right) \qquad (7)$$

Where s indexes time. CEDIX⁺ captures cumulative diversification improvement, while CEDIX⁻ captures cumulative diversification setbacks. By construction, CEDIX⁻ is nonpositive, so its effect must be interpreted jointly with the sign of both the regressor and its estimated coefficient.

The Pooled Mean Group (PMG) approach (Pesaran et al., 1999) is used to estimate the panel NARDL model in an error-corrected representation.

$$\begin{aligned}\Delta GDPG_{it} = {} & \lambda_i\big(GDPG_{i,t-1} - \beta_1 CEDIX^{+}_{i,t-1} - \beta_2 CEDIX^{-}_{i,t-1} - \beta_3 \ln\mathrm{GCF}_{i,t-1} - \beta_4 \mathrm{LFPR}_{i,t-1} \\ & - \beta_5 OilPr_{i,t-1} - \eta_i\big) + \sum_{k=1}^{p-1} \psi_{1,i,k}\, \Delta GDPG_{i,t-k} + \sum_{k=0}^{q_1-1} \psi^{+}_{2,i,k}\, \Delta CEDIX^{+}_{i,t-k} \\ & + \sum_{k=0}^{q_1-1} \psi^{-}_{2,i,k}\, \Delta CEDIX^{-}_{i,t-k} + \sum_{k=0}^{q_2-1} \psi_{3,i,k}\, \Delta ln\mathrm{GCF}_{i,t-k} + \sum_{k=0}^{q_3-1} \psi_{4,i,k}\, \Delta\mathrm{LFPR}_{i,t-k} \\ & + \sum_{k=0}^{q_4-1} \psi_{5,i,k} \Delta OilPr_{i,t-k} + \tau_t + \varepsilon_{it}\end{aligned} \tag{8}$$

Where λ_i is the adjustment parameter speed is anticipated to be negative. The coefficients β1 and β2 capture the long-run effects of diversification improvements and diversification setbacks, respectively, while the short-run responses are captured by the coefficients on ΔCEDIX⁺ and ΔCEDIX⁻. The term η_i denotes country-specific effects and captures common time effects.

To test for asymmetry formally, Wald tests are conducted for both short-run and long-run effects (Shin et al., 2014). The null hypothesis for long-run symmetry is:

$$H_0^{LR}: \beta_1 = \beta_2$$

Short-run symmetry is examined by determining whether the cumulative short-run effects of ΔCEDIX⁺ and ΔCEDIX⁻ are equal across the included lags:

H_0^{SR}: $\sum_{k=0}^{q_1-1} \psi^{+}_{2,i,k} = \sum_{k=0}^{q_1-1} \psi^{-}_{2,i,k}$

Rejection of H_0^{LR} indicates that diversification improvements and diversification setbacks exert different long-run effects on growth, while rejection of H_0^{SR} indicates asymmetric short-run responses. If the adverse effect associated with diversification setbacks exceeds the positive effect associated with diversification improvements, the results are interpreted as evidence of a reversal penalty.

3.3.5. Lag Selection and Diagnostic Checks

The choice of lag is very important in the NARDL estimation because it not only determines the dynamic structure of the model but also the distinction between long-run and short-run effects. First, country-specific ARDL lag trials were conducted for each GCC country according to the lag-selection logic used in panel ARDL applications like Kim, Lin, and Suen (2016). The selected country lag orders were compared to find a common feasible dynamic structure of the panel model.

The final lag structure was chosen to balance the recurring country-level lag patterns against the need to avoid over-parameterization in a short annual panel, since the PMG estimator imposes the same lag specification on all countries.

Diagnostic tests are used to evaluate residual properties for their possible influence on statistical inference. The Wooldridge test for autocorrelation in panel data is used to test for serial correlation. The null hypothesis is no first-order serial correlation (Drukker, 2003). The modified Wald test (Greene, 2012) is used to assess groupwise heteroskedasticity. The normality of residuals was assessed using the Shapiro-Wilk test (Shapiro & Wilk, 1965).

4. RESULTS

4.1. Descriptive Statistics

Table 3 displays the descriptive statistics for the GCC panel for the years 2000–2022. Average GDP growth is 4.41%, with considerable dispersion across country-year observations (standard deviation = 5.00), ranging from -7.08% to 26.17%, reflecting considerable heterogeneity across the sample in growth performance. The CEDIX has a mean of 0.558 and a standard deviation of 0.247 and spans the full [0,1] interval. This indicates meaningful variation in the depth of diversification across GCC countries and years. Consistent with the NARDL decomposition, CEDIX+ is non-negative and CEDIX− is non-positive (by construction), indicating that the sample reflects both instances of diversification improvements and diversification setbacks.

Of the controls, only lnGCF varies moderately across the panel, while LFPR varies widely across GCC. OilPr also varies appreciably over the sample, underscoring the importance of the hydrocarbon external.

Table 3. Descriptive Overview of the Empirical Variables.

Variables	N	Mean	Std. Dev.	Minimum	Maximum
CEDIX	138	0.558	0.247	0	1
$CEDIX^{+}$	138	0.506	0.359	0	1.200
$CEDIX^{-}$	138	-0.364	0.285	-1.048	0
lnGCF	138	24.237	1.096	21.664	26.333
OilPr	138	71.469	17.28	39.917	111.888
LFPR	138	69.892	10.631	47.891	87.575
GDPG	138	4.409	4.999	-7.076	26.17

Figure 2 plots GCC panel averages of GDP growth (left axis) and CEDIX (right axis) for 2000-2022. CEDIX series tend to increase in the early 2000s, declining in 2011-2014, and improving sharply from 2015 onwards, hitting their peak level in 2020-2021 before decreasing slightly in 2022. Real GDP growth, in contrast, shows prominent boom-bust patterns, notably including a sudden contraction in 2020. Together, this suggests that diversification evolves gradually over longer horizons, whereas growth is much "noisier" in the short run, motivating an econometric framework that permits the imposition of long-run versus short-run effects, while allowing for possible asymmetry.

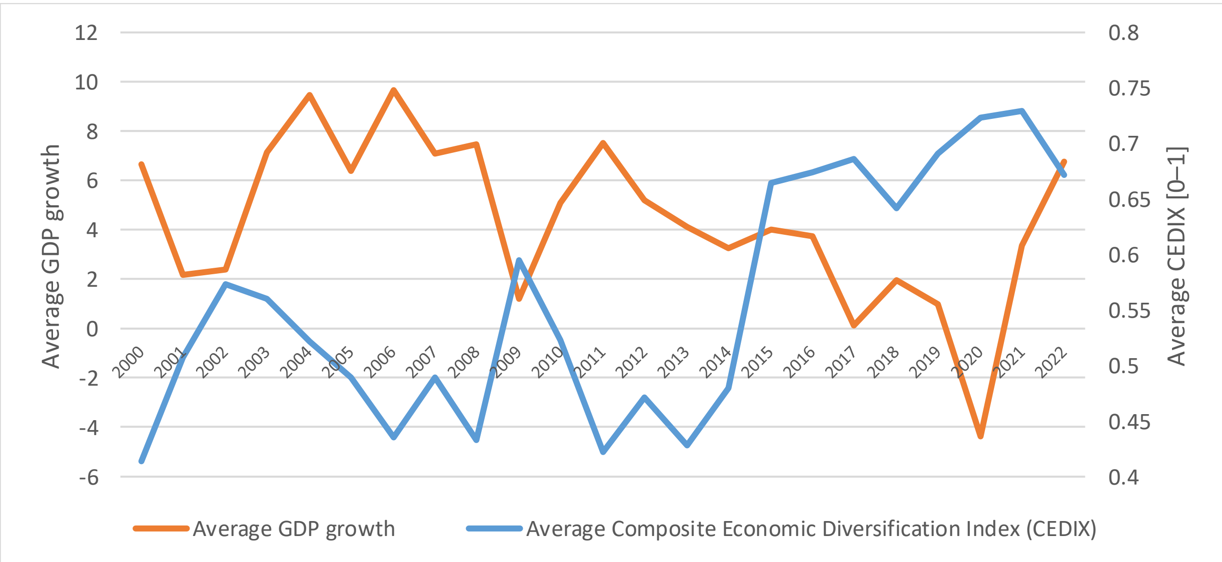

Figure 2. GCC Panel Averages of Real GDP Growth and CEDIX, 2000–2022.

4.2. Composite Economic Diversification Index: PCA Results and Index Properties

Table 4 shows the PCA results used to construct CEDIX based on three concentration-based pillars: revenue concentration, export concentration, and sectoral concentration (REVDIV, EXDIV, SECDIV). The first principal component (PC1) has an eigenvalue of 1.929 and accounts for 64.3% of the total variance. This implies that a single common factor explains a large part of the co-movement across the three dimensions and justifies the inclusion of PC1 as a parsimonious summary measure of multidimensional diversification.

All the PC1 loadings are positive and fairly similar in size (0.543 for EXDIV, 0.604 for SECDIV, and 0.583 for REVDIV). This indicates that the composite index is not being dominated by any one pillar; rather, the loading suggests the composite index contains the common variance across these three pillars of export, sectoral, and revenue concentration. The factorability diagnostics support these findings; sampling adequacy is acceptable according to the Kaiser–Meyer–Olkin (KMO) statistic (0.664). Bartlett's test of sphericity was statistically significant ($\chi2(3)$ =83.89, $p<0.001$), showing there is enough correlation across the three pillars to justify factor extraction.

Because the underlying inputs are concentration measures, the retained component is oriented so that higher values imply more diversification (that is, higher CEDIX = more diversified). The index is then simply rescaled to the unit interval [0,1].

Table 4. Principal Component Analysis Diagnostics for the Composite Economic Diversification Index.

Panel A. Variance captured by the retained component:			
Component	**Eigenvalue**	**Share of variance**	**Total variance retained**
PC1	1.93	0.64	0.64
Panel B. PC1 loadings			
Indicator	Loading PC1		
EXDIV	0.543		
REVDIV	0.583		
SECDIV	0.604		
Panel C. Factorability diagnostics			
Test	Statistic		
KMO (Overall)	0.664		
Bartlett's test $\chi^2(3)$	83.9		
Bartlett p-value	0.000		

4.3. Preliminary Panel Diagnostics

Table 5 presents Pesaran (2004) CD statistics for the variables in levels. At 1%, the null hypothesis of cross-sectional independence is rejected for all series. Thus, indicating that there is strong contemporary dependence among GCC economies. The estimated average pairwise correlations are sizeable, especially between prices of oil and the diversification components, which is consistent with the idea of common regional and global shocks affecting GCC macroeconomic outcomes. These results justify the use of second-generation panel procedures that remain valid in the presence of cross-sectional dependence.

Table 5. Pesaran CD Diagnostics for the Study Variables.

Variables	**Pesaran CD statistic**	**p-value**	**Mean pairwise correlation**	**Mean absolute correlation**
$CEDIX^+$	17.7	(0.000)	0.96	0.96
$CEDIX^-$	17.8	(0.000)	0.97	0.97
lnGCF	16.4	(0.000)	0.89	0.89
OilPr	17.9	(0.000)	0.97	0.97
LFPR	14.9	(0.000)	0.81	0.81
GDPG	8.15	(0.000)	0.44	0.44

Panel unit-root test results using both the CIPS test (Pesaran, 2007) and IPS test (Im et al., 2003) are presented in Table 6. Given the existence of cross-sectional dependence, greater weight is placed on the CIPS results. The results thus provide mixed orders of integration: $CEDIX^+$, $CEDIX^-$, lnGCF, LFPR, and OilPr are non-stationary in levels but become stationary at first difference, I(1), while GDPG is stationary in levels, that is, I(0). None of the variables is of order two. This confirms that the panel meets integration requirements for the ensuing NARDL error-correction framework.

Table 6. Panel Unit-Root Test Results (IPS and CIPS), GCC Panel, 2000–2022.

Variables	IPS level	IPS Δ	CIPS level	CIPS Δ	Order of Integration
$CEDIX^{+}$	1.587 (0.944)	-6.222 (0.000)	2.466 (0.993)	-3.226 (0.001)	I(1)
$CEDIX^{-}$	2.167 (0.985)	-5.968 (0.000)	0.283 (0.611)	-4.222 (0.000)	I(1)
lnGCF	0.143 (0.557)	-4.842 (0.000)	-0.495 (0.310)	-3.271 (0.001)	I(1)
OilPr	-1.104 (0.135)	-4.841 (0.000)	0.139 (0.555)	-3.224 (0.001)	I(1)
LFPR	1.418 (0.922)	-2.993 (0.001)	0.809 (0.791)	-2.327 (0.010)	I(1)
GDPG	-3.726 (0.000)	—	-2.474 (0.007)	-4.196 (0.000)	I(0)

Note: p-values are reported in parentheses. Δ denotes first difference.

4.4. Panel Cointegration Evidence

Table 7 displays the findings of the (Westerlund, 2007) panel cointegration test utilizing the error-correction methodology. To control for cross-sectional dependence, bootstrap p-values are employed. The four statistics give mixed evidence on cointegration. This is not surprising, as the Westerlund ECM test gives group-mean statistics, Gt and Ga, and panel statistics, Pt and Pa, with different alternative hypotheses and degree of pooling across cross-sectional units (Persyn & Westerlund, 2008; Westerlund, 2007).

The Pt statistic is given more weight since it is a panel-wide test of error correction and is thus more in line with the PMG–NARDL framework that estimates a common long-run relationship while allowing for heterogeneous short-run dynamics. Since cross-sectional dependence is present, inference is based mainly on bootstrap p-values, which are more appropriate when cross-sectional dependence may affect asymptotic inference (Westerlund, 2007; Westerlund & Edgerton, 2007).

The Pt statistic gives strong evidence against the null hypothesis of no cointegration at the 1% level using the bootstrap p-value (p=0.003), while Gt gives weaker evidence at the 10% level. The test results are therefore interpreted to be consistent with a panel-level long-run relationship, even if the evidence is not unanimous for all statistics. This interpretation is also supported by the negative and statistically significant error-correction coefficient from the PMG–NARDL model.

Table 7. Bootstrap Westerlund Error-Correction Cointegration Results.

Test	Statistic	Z-value	p-value	Bootstrap p-value
Ga	-2.076	3.833	(1.000)	(0.560)
Gt	-3.131	-1.246	(0.107)	(0.095)
Pa	-1.681	2.832	(0.998)	(0.640)
Pt	-8.034	-2.055	(0.020)	(0.003)

4.5. PMG–NARDL Estimation Results

Before estimating the PMG–NARDL model, country-specific lag trials were conducted to inform the selection of a common panel lag structure. Due to the limited time dimension of the annual GCC panel, the maximum lag length was truncated at two annual lags for each variable. This restriction preserves degrees of freedom while allowing the model to capture short-run adjustment over a reasonable annual time horizon. The lag orders selected, as shown in Table 8, vary across countries but are generally within one- or two-year lags. Thus, the final baseline specification is fixed at NARDL (2,2,2,1,2,1) for the variables used, which are GDPG, $CEDIX^{+}$, $CEDIX^{-}$, lnGCF, LFPR, OilPr, respectively, as the PMG estimator imposes the same lag structure for all countries. This structure balances the observed dynamics at the country level with the need to avoid over-parameterization in the short annual panel.

Table 8. Country-Specific Lag Selection Trials for the PMG–NARDL Specification.

Country	GDPG	CEDIX+	CEDIX-	lnGCF	LFPR	OilPr
UAE	1	2	2	1	2	0
Oman	1	2	2	2	1	1
Bahrain	2	1	2	1	2	2
Saudi Arabia	2	2	1	2	0	1
Kuwait	2	1	2	1	2	2
Qatar	2	2	2	0	2	1
Selected common PMG–NARDL structure	2	2	2	1	2	1

Note: Numbers denote lag lengths obtained from country-specific ARDL lag trials with a maximum of two annual lags for each variable.

4.5.1. Long-Run Effects

Table 9 shows the short-run and long-run estimates of PMG-NARDL. The error-correction coefficient is statistically significant and negative (λ = -0.883, $p < 0.01$), indicating a long-run relation between GDP growth, economic diversity, and control variables. The coefficient's magnitude suggests that around 88% of any divergence from long-run equilibrium is restored within a year.

The key finding is that the diversification-growth relationship has long-run asymmetry. The long-run coefficient on diversity improvements is positive and statistically significant ($CEDIX^+$ = 10.151, p = 0.013), indicating that sustained increases in diversification are associated with higher long-run GDP growth. The coefficient on the negative partial sum is also positive and statistically significant ($CEDIX^-$ = 15.474, $p < 0.01$). A negative cumulative measure of diversification setbacks is $CEDIX^-$. Thus, a positive coefficient indicates that diversification reversals are associated with worse long-run growth. Furthermore, the estimated effect associated with diversification setbacks is larger in magnitude than the growth benefit associated with similar diversification improvements, indicating a reversal penalty.

In magnitude, since CEDIX is scaled to the [0,1] range, an increase in diversification of 0.10 is associated with about 1.02 percentage points higher long-run GDP growth ($0.10\times10.151=1.02$), and a decrease in diversification of 0.10 is associated with about 1.55 percentage points lower long-run growth ($15.474\times-0.10=-1.55$). This pattern is in line with the assumption that long-run performance is more sensitive to persistent structural transformation than to transient or partial shifts in economic structure (Cadot et al., 2011; Houfi, 2021; Imbs & Wacziarg, 2003).

For the control variables, oil prices in the long run are significant and positive (0.066, p = 0.016), similar to external factors related to hydrocarbons that continue to be important for GCC growth in the longer periods. However, under this specification, lGCF and LFPR are not significant in the long run.

4.5.2. Short-Run Dynamics and Adjustment Speed (ECM)

Short-run results diverged from the long-run estimates. Diversification improvements do not have a statistically significant effect in the short run ($\Delta CEDIX^+$, p = 0.655), which implies that diversification gains do not have a direct impact on output growth. This result is consistent with the view that diversification affects growth through gradual processes of reallocation, learning, investment, and capability accumulation that are usually realized in longer horizons rather than in a single year. Similar evidence is reported by Houfi (2021), who finds that diversification matters mainly in the long run in the case of Saudi Arabia.

In contrast, the coefficient of the negative-change component is negative and statistically significant ($\Delta CEDIX-$ = −21.858, p = 0.016). Because by construction $\Delta CEDIX^- \leq 0$, the coefficient has to be interpreted together with the sign of the regressor. This does not imply that diversification setbacks are structurally growth-enhancing. In GCC economies, it may be a composition effect of an oil boom in the short run. In a period of rising hydrocarbon activity or oil-related revenues, measured GDP growth may increase temporarily, as the concentration of exports, output, or government revenues increases. In this case, renewed concentration may be associated with stronger short-run growth, not because lower diversification is desirable, but because oil-sector expansion dominates growth outcomes in the short run. This view is consistent with the structure of GCC economies, where non-oil diversification has often been tied to oil-financed demand and hydrocarbon cycles (Callen et al., 2014; Cherif & Hasanov, 2014; Hvidt, 2013).

Investment and labour-market movements (ΔlnGCF = 9.415, $p < 0.01$; ΔLFPR = 1.433, p = 0.002) are positively related to short-run growth among the control variables. In the short run, oil-price changes are not statistically significant (p = 0.128). This suggests that oil-market conditions operate more strongly through the long-run equilibrium relationship than through immediate year-to-year changes once the other short-run dynamics are taken into account. The lagged change in GDP growth is also insignificant ($\Delta GDPG_{t-1}$, p=0.392).

Table 9. PMG–NARDL Estimates for GDP Growth (PMG NARDL (2,2,2,1,2,1)).

Variables	Coef.	p-value
Long-run estimates		
$CEDIX^{+}$	10.1506**	(0.013)
$CEDIX^{-}$	15.4738***	(0.000)
lnGCF	−1.1842	(0.372)
LFPR	0.0157	(0.911)
OilPr	0.0664**	(0.016)
Error-correction coefficient, λ	−0.8830***	(0.000)
Short-run dynamics		
$\Delta\ GDPG_{t-1}$	0.11897	(0.392)
$\Delta\ CEDIX^{+}$	5.5448	(0.655)
$\Delta\ CEDIX^{+}_{t-1}$	−4.3766	(0.421)
$\Delta\ CEDIX^{-}$	−21.8576**	(0.016)
$\Delta\ CEDIX^{-}_{t-1}$	3.6661	(0.621)
Δ lnGCF	9.4154***	(0.000)
Δ LFPR	1.4329***	(0.002)
$\Delta\ LFPR_{t-1}$	0.1009	(0.904)
Δ OilPr	0.122	(0.128)
Constant	22.5657***	(0.000)

Note: **, and *** indicate statistical significance at the 5% and 1% levels, respectively. p-values are reported in parentheses.

4.6. Asymmetry Tests Results

Table 10 provides the Wald test results for the long-run and short-run asymmetry under the PMG–NARDL specification. The null of long-run symmetry is rejected at the 5% level, $\chi^2(1) = 5.63$, p = 0.0176. This is formal evidence of the differential long-run impact of diversification improvements and diversification setbacks on GDP growth. This result is in line with the unequal long-run coefficients on $CEDIX^{+}$ and $CEDIX^{-}$ reported in Table 9, and it confirms the existence of long-run asymmetry in the diversification–growth relationship.

The short-run symmetry null hypothesis is not rejected at the 5% level ($\chi^2(1) = 3.45$, p = 0.0631), but is marginally rejected at the 10% level. This indicates that the short-run asymmetry is less than the long-run asymmetry and should therefore be interpreted with caution. The overall Wald test results indicate that the main source of asymmetry in the GCC panel is attributed to the long-run adjustment process. Hence, diversity seems to affect growth mainly through longer-term structural change rather than short annual responses.

Table 10. Wald Test Results for Asymmetric Effects of CEDIX.

Test (H_0)	$\chi^2(1)$	p-value	Decision (5%)
LR-ASYM: $H_0^{LR}: \beta_1 = \beta_2$	5.63	(0.0176)	Reject H_0 (at 5%)
SR-ASYM: $H_0^{SR}: \sum_{k=0}^{q_1-1} \psi_{2,i,k}^{+} = \sum_{k=0}^{q_1-1} \psi_{2,i,k}^{-}$	3.45	(0.0631)	Fail to reject H_0 (at 5%); Reject H_0 (at 10%)

Note: LR-ASYM compares long-run coefficients on $CEDIX^{+}$ and $CEDIX^{-}$ in the error-correction relation; SR-ASYM compares the short-run (first-difference) effects. χ^2 tests have 1 d.f.

4.7. Diagnostic Tests and Robustness Analysis

Table 11 reports the residual diagnostic tests for the PMG–NARDL model. The results show no evidence of first-order serial correlation (Wooldridge test, p=0.210) or groupwise heteroskedasticity (modified Wald test, p=0.186). Residual normality cannot be rejected based on either the skewness/kurtosis test (p=0.204) or the Shapiro–Wilk test (p=0.108). Overall, these diagnostics do not indicate serious specification problems and support the reliability of the estimated model.

Table 11. Residual Diagnostic Test Results for the PMG–NARDL Model.

Diagnostic check	Test statistic	Probability value
Wooldridge panel autocorrelation check	$F(1, 5) = 2.065$	(0.2102)
Shapiro–Wilk normality test	$W = 0.98340$	(0.1081)
Skewness–Kurtosis normality test	$\chi^2(2) = 3.18$	(0.2039)
Modified Wald check for cross-sectional heteroskedasticity	$\chi^2(6) = 1.75$	(0.1864)

To test robustness, a more parsimonious PMG–NARDL (1,1,1,1,1,1) specification is estimated to show that the main conclusions are not affected by the chosen lag length. The results are qualitatively similar to the baseline definition and are reported in Table 12. The coefficient of the error-correction term is negative and significant, implying that the variables converge to the long-run equilibrium. The long-run coefficients on $CEDIX^{+}$ and $CEDIX^{-}$ are positive and statistically significant. The estimated effect associated with diversification setbacks is still larger than the effect associated with diversification improvements. In the short run, $\Delta CEDIX^{-}$ remains statistically significant, while $\Delta CEDIX^{+}$ remains negligible. The main results do not change for the baseline lag specification.

Table 12. Robustness Results Using the Parsimonious PMG–NARDL(1,1,1,1,1,1) Specification.

Variable	Coef.	Probability Value
Long-run estimates		
$CEDIX^{+}$	14.2704***	(0.002)
$CEDIX^{-}$	19.5247***	(0.000)
lnGCF	−0.2717	(0.806)
LFPR	−0.0918	(0.524)
OilPr	0.0721***	(0.004)
Error-correction coefficient, λ	−0.8169***	(0.000)
Short-run dynamics		
Δ $CEDIX^{+}$	6.9228	(0.564)
Δ $CEDIX^{-}$	−17.9309***	(0.000)
Δ lnGCF	7.8005***	(0.000)
Δ LFPR	1.7206***	(0.000)
Δ OilPr	0.1439**	(0.032)
Constant	7.7164***	(0.000)

Note: **, and *** indicate statistical significance at the 5% and 1% levels, respectively. p-values are reported in parentheses.

5. CONCLUSION

This paper investigated the asymmetric impact of economic diversification on real GDP growth in Gulf Cooperation Council economies during 2000-2022. Economic diversification was measured by a Composite Economic Diversification Index (CEDIX) using export diversification, revenue diversification, and sectoral diversification. The empirical investigation was carried out by employing a panel PMG-NARDL model, allowing for asymmetric effects of increases and decreases in diversity on GDP growth in the long run and in the short run.

The results indicate the existence of a long-run stable relationship among GDP growth, economic diversification, investment, labor-force participation, and oil prices. The main result is that the relation between growth and diversification is asymmetric in the long term. The long-run coefficient on improvements in diversification is significant and positive, while the coefficient on setbacks in diversification points to a larger negative effect on growth. The magnitude of the coefficient on $CEDIX^{+}$ is 10.151, and the magnitude of the coefficient on $CEDIX^{-}$ is 15.474. Because CEDIX is bounded between 0 and 1, a 0.10 increase in diversification is associated with roughly 1.02 percentage points higher long-run GDP growth, whereas a 0.10 deterioration in diversification is associated with roughly 1.55 percentage points lower long-run GDP growth. This supports the notion of a reversal penalty, where the costs of diversification setbacks are greater than the gains from equivalent diversification improvements.

The short-run results are less strong. The results suggest that gains in diversification do not have an immediate large impact on GDP growth, indicating that the benefits of diversification unfold gradually through structural transformation, investment, capability accumulation, and sectoral reallocation. The negative coefficient on $\Delta CEDIX^{-}$ should not be interpreted as implying that diversification setbacks are growth-enhancing. It is more consistent with a short-run oil-boom composition effect where hydrocarbon-led expansion may temporarily boost measured GDP growth, but also increase concentration in exports, output, or fiscal revenues. To conclude, the results indicate that diversification is mainly relevant for long-term growth rather than short-term yearly changes.

This indicates that GCC countries should view diversification as a structural priority in the long run rather than a policy goal that may be loosened during periods of oil booms. Given that the long-run growth costs of diversification setbacks appear to be bigger than the gains from corresponding improvements, it is important to keep the reform momentum going. This closely relates to the GCC national Vision plans such as Saudi Vision 2030, Oman Vision 2040, Qatar National Vision 2030, Bahrain Economic Vision 2030, Kuwait Vision 2035, and the long-term diversification initiatives of the UAE. These initiatives should not only create new non-oil sectors but also protect existing diversification advantages during periods of high oil earnings. Policy priorities should include strengthening non-oil revenue mobilization, promoting productivity-enhancing tradable industries, improving private sector competitiveness, upgrading human capital, and using oil windfalls to finance structural change rather than deferring reform.

There are some limitations to this study. First, the sample is limited to six GCC nations for the period 2000–2022, which limits the number of observations available for dynamic panel estimates. Second, although the PMG–NARDL approach accounts for the dynamic adjustment and long-run relationship, the possibility of endogeneity between growth and diversification cannot be eliminated. Third, the research is based on macro-level data and does not reflect the sector-level heterogeneity in the effect of diversification on development across industries such as manufacturing, services, logistics, finance, tourism, or other non-oil activities. Fourth, the composite index reflects export, sectoral, and revenue diversification but does not directly assess the quality, technological sophistication, productivity, or employment intensity of diversification.

Future work can use the analysis to investigate country-specific asymmetries in the GCC, try out different measures of diversification, include sectoral data, and apply techniques that better address endogeneity and cross-sectional dependence. Further work could also distinguish between diversification into low-productivity non-oil activities and diversification into knowledge-intensive, export-oriented, and high-productivity sectors. But the results indicate that diversification is relevant for long-run growth in GCC economies, not simply because progress is good but also because reversals are very costly.

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