

EFFECTIVENESS OF FISCAL POLICY USING DOUBLE MACHINE LEARNING: GCC AND HIGH-INCOME ECONOMIES

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ABSTRACT

This study examines the causal effects of fiscal policy on macroeconomic stability and non-oil GDP growth in hydrocarbon-dependent GCC countries and diversified high-income economies. Using a balanced panel of 17 countries from 2000 to 2024, comprising 425 country-year observations, it applies Double Machine Learning to address endogeneity, nonlinearities, and high-dimensional confounding. The analysis focuses on fiscal balance, government expenditure, and tax revenue as shares of GDP, while controlling for institutional and structural factors such as fiscal transparency, sovereign wealth fund governance, public investment efficiency, and economic complexity. The model combines Lasso, Random Forest, and Gradient Boosting with cross-fitting, instrumental-variable checks, fixed-effects OLS, mediation analysis, and heterogeneity tests. The results show significant positive effects of fiscal balance (0.052), government expenditure (0.038), and tax revenue (0.033) on GDP growth ($p < 0.01$). These effects are partly mediated by public investment efficiency and financial development and are stronger in diversified economies with better institutions. The findings suggest that GCC countries can improve fiscal policy effectiveness through institutional reform and economic diversification.

Keywords: Fiscal policy, financial indicators, Double machine learning, GCC, High-income states, macroeconomics

1. INTRODUCTION

The global macroeconomic environment has become increasingly volatile due to geopolitical tensions, commodity price fluctuations and structural economic changes (Patidar et al., 2024). These developments have reinforced the role of fiscal policy in stabilizing economic activity, supporting long term growth and absorbing external shocks (Li et al., 2025). This role is particularly important in resource dependent economies such as the Gulf Cooperation Council countries where fiscal performance remains highly vulnerable to oil price volatility (Mabkhot & Al-Wesabi, 2022). In contrast, diversified high income economies generally exhibit more stable fiscal trajectories because of stronger institutions, broader revenue bases and more developed policy frameworks.

Although traditional determinants of fiscal performance including expenditure composition, revenue structure and public debt dynamics have been widely examined, important gaps re-

main. Limited attention has been given to how institutional quality, sovereign wealth fund governance, fiscal transparency and public investment efficiency shape fiscal policy effectiveness in resource dependent economies. Moreover, conventional econometric models often struggle to capture the high dimensional and nonlinear relationships embedded in fiscal systems (Fotiadis et al., 2023). These limitations constrain causal inference across heterogeneous institutional and economic settings.

Recent research therefore points to the need for more flexible empirical approaches capable of incorporating complex policy environments. Variables such as sovereign wealth fund governance, fiscal transparency, climate sensitive budgeting and public investment efficiency are increasingly recognized as important determinants of fiscal performance (SenGupta & Atal, 2025). However, conventional methods may generate omitted variable bias, overfitting or model misspecification when many interrelated factors are included.

Double Machine Learning provides a suitable framework for causal inference in the presence of high dimensional controls and nonlinear relationships (Song et al., 2025). It combines machine learning algorithms such as Lasso, Random Forest and Gradient Boosting with orthogonalization and cross fitting to estimate treatment effects while reducing overfitting and regularization bias. This makes Double Machine Learning particularly appropriate for examining fiscal policy across heterogeneous economies where institutional conditions, structural characteristics and external shocks interact in complex ways. Accordingly, this study applies Double Machine Learning to estimate the causal effects of fiscal policy on macroeconomic stability and growth in hydrocarbon dependent and diversified economies.

This study makes three main contributions. First, it extends the fiscal policy literature by incorporating sovereign wealth fund governance, fiscal transparency, institutional quality and public investment efficiency as determinants of fiscal effectiveness. Second, by comparing Gulf Cooperation Council countries with diversified high-income economies, it demonstrates how economic structure and institutional capacity influence fiscal stabilization, revenue resilience and exposure to external shocks. Third, it illustrates the methodological value of Double Machine Learning in identifying nonlinearities, heterogeneous effects and interaction mechanisms that may remain undetected in conventional econometric models.

The remainder of the paper is organized as follows. Section 2 presents the literature review and conceptual framework. Section 3 describes the data and methodology including the Double Machine Learning framework. Section 4 reports the empirical results. Section 5 discusses the findings, policy implications, limitations and directions for future research.

2. LITERATURE REVIEW

2. 1. FISCAL POLICY AND MACROECONOMIC STABILIZATION

Fiscal policy is a key instrument for maintaining macroeconomic stability, managing aggregate demand and reducing cyclical fluctuations. According to Keynesian theory, timely countercyclical measures involving government expenditure and taxation can support output during recessions and prevent overheating during economic expansions (Foreman Peck & Zhou, 2025). However, fiscal effectiveness varies considerably across institutional and structural settings (Martins & Correia, 2021). Countercyclical policies tend to generate stronger multiplier effects in countries with diversified economies, broad tax systems and credible fiscal institutions (Jalles et al., 2024). In contrast, fiscal policy in resource dependent economies such as the Gulf Cooperation Council countries is often less effective and more procyclical because of volatile commodity revenues and rigid expenditure commitments (Sadraoui & Mili, 2025).

This difference reflects the capacity of fiscal systems to respond to external shocks and struc-

tural constraints. In the Gulf Cooperation Council countries, dependence on hydrocarbon revenues creates substantial volatility in fiscal balances and public expenditure (Maashani et al., 2025). During periods of high oil prices, fiscal surpluses often encourage expansionary policies, higher recurrent expenditure and increased public employment. When oil prices decline, governments may be forced to implement substantial expenditure cuts which weaken long term planning and policy credibility (Sadraoui & Mili, 2025). As a result, fiscal policy has a limited capacity to stabilize economic activity when resource revenues fluctuate.

Recent studies recommend focusing on nonoil GDP growth rather than total GDP because total output is strongly affected by changes in oil prices (Faisal et al., 2021; Fang et al., 2022; Yusuf & Nasrulddin, 2024). Nonoil GDP better reflects the performance of diversified productive sectors and the capacity of fiscal policy to support sustained economic activity beyond the hydrocarbon sector (Zhou et al., 2023). It therefore provides a more reliable measure of fiscal transmission and economic resilience when comparing Gulf Cooperation Council countries with diversified high-income economies.

The empirical evaluation of fiscal policy effectiveness is complicated by the multidimensional nature of modern fiscal systems. Fiscal outcomes depend not only on the level of public expenditure and tax revenue but also on public investment efficiency, fiscal transparency, economic diversification and the credibility of fiscal frameworks (Tengfei & Ullah, 2024). These interdependencies challenge conventional econometric models that assume linear relationships among a limited number of macroeconomic variables and demonstrate the need for more flexible and data driven analytical methods.

2. 2. FISCAL EFFECTIVENESS IN RESOURCE-BASED VS. DIVERSIFIED ECONOMIES

The fiscal policy literature reveals substantial differences in the determinants of fiscal effectiveness between resource dependent and diversified economies. In Gulf Cooperation Council countries, fiscal performance is strongly influenced by oil market dynamics, budget rigidity and the limited development of non-oil revenue sources (Amer et al., 2024). During periods of high oil prices, fiscal expansion often takes the form of higher public sector wages, increased subsidies and large infrastructure projects that may generate declining long term productivity benefits (Van Leeuwen et al., 2025). When oil prices fall, governments frequently adopt austerity measures by reducing capital expenditure and postponing investments in economic diversification (Jacques, 2021). This cyclical pattern restricts sustainable development and reinforces dependence on commodity revenues.

In contrast, diversified high income economies such as Norway, Germany, Australia and Canada generally demonstrate greater fiscal resilience (Saeed et al., 2023). Broad tax bases, rule based fiscal governance, and strong fiscal institutions enable these countries to stabilize economic activity through more predictable and effective policies. Fiscal transparency and accountability also strengthen policy credibility which improves the response of firms and households to fiscal measures (ElBerry & Goeminne, 2021). Empirical evidence indicates that government spending multipliers in these economies are generally stronger and more stable because of both institutional quality and structural diversification (Acevedo et al., 2022).

This contrast highlights an important analytical gap. Fiscal policy in resource dependent economies cannot be evaluated solely through conventional macroeconomic indicators. It must be examined within a broader institutional and structural framework that includes fiscal transparency, public investment efficiency, sovereign wealth fund governance and economic complexity. Other relevant factors include the size of the informal economy, financial market depth, dependence on remittances and exposure to global energy transitions. Together, these factors

shape the relationship between fiscal policy and economic performance and determine the capacity of governments to maintain macroeconomic stability during external shocks.

2. 3. INSTITUTIONAL AND STRUCTURAL DETERMINANTS OF FISCAL PERFORMANCE

Fiscal performance cannot be understood without considering the institutional and structural environment in which policy operates. A growing body of fiscal institutionalist literature argues that governance quality, transparency and institutional credibility form the foundation of effective fiscal systems (Onatunji, 2025). The Fiscal Transparency Index or Open Budget Index measures the openness of budget processes and the availability of fiscal information (Cuadrado Ballesteros & Bisogno, 2022). Greater transparency improves fiscal predictability, reduces corruption risks and strengthens investor confidence which can enhance fiscal policy transmission and lower borrowing costs (Jung, 2022).

The Sovereign Wealth Fund Governance Score or Linaburg Maduell Index assesses the institutional strength of public resource saving mechanisms (Kansheba & Marobhe, 2022). In well governed systems, sovereign wealth funds absorb revenue shocks, support countercyclical policy and promote intergenerational equity (Bouhmidi, 2024). Strong fund governance therefore improves fiscal credibility and reduces procyclicality especially in hydrocarbon dependent economies. Public Investment Efficiency is another important determinant and is commonly assessed through the IMF Public Investment Management Assessment. High scores indicate that governments allocate resources effectively, select viable projects and manage implementation responsibly which increases the productivity benefits of public investment (Fournier & Gonguet, 2023). Investment efficiency is closely linked to the size of fiscal multipliers particularly in developing economies where weak capital management can reduce the impact of fiscal stimulus (Shah & Afridi, 2023).

The Economic Complexity Index complements the institutional dimension by measuring the productive knowledge and diversification of an economy (Vu, 2022). Economies with higher complexity generally have stronger innovation capacity and a greater ability to absorb fiscal interventions (Oleksiv & Mirzoieva, 2022). The Budget Rigidity Index and Fiscal Rules Strength Index provide additional measures of fiscal flexibility and credibility (Dzigbede et al., 2023). Excessive rigidity can restrict countercyclical responses while weak fiscal rules can increase discretionary volatility.

Several structural factors also influence fiscal effectiveness. A large informal economy reduces the tax base, weakens revenue forecasting and limits fiscal policy transmission (Asllani & Schneider, 2025). High dependence on remittances may support household consumption but can reduce the influence of domestic fiscal measures on aggregate demand (Khan, 2024). In contrast, stronger financial development can amplify fiscal effects by improving access to credit and supporting private investment (Ehigiamusoe & Samsurijan, 2021). The Energy Transition Index also captures long term risks to fiscal sustainability as resource dependent economies move towards more diversified and sustainable growth models (He & Chen, 2024).

2. 4. SYSTEMATIC ASSESSMENT OF LITERATURE GAPS

Building on the preceding discussion, four methodological and empirical gaps emerge from the fiscal policy literature.

First, most cross-country fiscal studies rely on linear panel models such as fixed effects and Generalized Method of Moments models which assume homogeneous treatment effects. However, fiscal systems often exhibit nonlinear relationships and threshold effects that these models cannot adequately capture (Fotiadis et al., 2023). Existing studies have not systematically

examined nonlinear interactions between fiscal instruments and institutional quality.

Second, previous research has generally examined fiscal transparency (ElBerry & Goeminne, 2021), sovereign wealth fund governance (Bouhmid, 2024) and public investment efficiency (Shah & Afridi, 2023) separately. No study has integrated these institutional dimensions within a single empirical framework. This fragmented approach may produce omitted variable bias because these factors are closely interconnected.

Third, comparative studies of resource dependent and diversified economies typically use total GDP growth as the outcome variable. In hydrocarbon dependent economies, this measure combines policy driven growth with changes caused by commodity prices. Although Zhou et al. (2023) identify non-oil GDP growth as a more appropriate indicator, their analysis relies on conventional econometric methods.

Fourth, no previous study has applied modern causal machine learning methods to evaluate fiscal policy in the Gulf Cooperation Council context. Conventional models have limited capacity to manage the high dimensional set of institutional, structural and external variables required to address confounding.

This study addresses these gaps by applying Double Machine Learning to capture nonlinear relationships and heterogeneous effects. It integrates ten institutional and structural controls within a unified framework and uses non-oil GDP growth as the outcome variable. It also provides the first Double Machine Learning based causal estimates of fiscal policy effectiveness in Gulf Cooperation Council economies.

2. 5. ROLE OF DOUBLE MACHINE LEARNING IN ASSESSING FISCAL IMPACTS

Traditional econometric methods such as Generalized Method of Moments, fixed effects and Vector Autoregression models face important limitations in complex fiscal environments. These approaches generally assume linear relationships, rely on a limited number of controls and cannot adequately capture nonlinear interactions among numerous institutional and structural factors (Kiviet et al., 2017). These limitations may produce biased or imprecise estimates of fiscal effects particularly in high dimensional cross-country comparisons between Gulf Cooperation Council and diversified high income economies.

Double Machine Learning developed by Chernozhukov et al. (2018), offers a rigorous alternative by integrating machine learning with causal inference. It addresses endogeneity and high dimensional confounding by residualizing the treatment and outcome variables through flexible machine learning algorithms (Guo et al., 2024). In this study, the treatment variables are fiscal balance, government expenditure and tax revenue. Their variation associated with institutional and structural covariates such as fiscal transparency, sovereign wealth fund governance, public investment efficiency, economic complexity and financial development is removed. The same procedure is applied to non-oil GDP growth. The relationship between the residualized treatment and outcome variables is then used to estimate the causal effects of fiscal policy.

Double Machine Learning accommodates nonlinearities and complex interactions through algorithms such as Lasso, Random Forest and Gradient Boosting (Baiardi & Naghi, 2024). Cross fitting and sample splitting reduce overfitting and improve the reliability of statistical inference. These properties make the method particularly suitable for fiscal policy analysis where multicollinearity, structural heterogeneity and complex institutional effects are common.

The application of Double Machine Learning extends the methodological scope of fiscal policy research. It allows governance indicators and financial and structural variables to be incorporated into a unified empirical framework without imposing the restrictive assumptions of conventional econometric models. By estimating the direct and conditional effects of fiscal

instruments on non-oil GDP growth, the approach provides a deeper understanding of how fiscal policy supports economic diversification, resilience and macroeconomic stability.

This study therefore contributes to the fiscal policy literature by applying Double Machine Learning to compare Gulf Cooperation Council and diversified high income economies. It combines a broad set of institutional and structural controls and uses non-oil GDP growth as the dependent variable. This approach strengthens causal identification and improves understanding of how institutional quality and structural complexity influence fiscal policy effectiveness.

3. METHODS

3. 1. USE OF DOUBLE MACHINE LEARNING

Fixed effects regressions, Generalized Method of Moments, propensity score matching and synthetic control methods have been widely used to estimate the effects of fiscal policy on economic growth (Rickman & Wang, 2024). However, these approaches face important limitations in cross country fiscal analysis. Generalized Method of Moments models depend on the validity of instruments which is difficult to establish when institutional and structural variables such as fiscal transparency, sovereign wealth fund governance and public investment efficiency are included (Martinez Garcia et al., 2022). Propensity score matching is sensitive to the researcher's choice of matching variables. Synthetic control methods are designed mainly for one treated unit and multiple control units which limits their use when several fiscal treatments vary continuously across countries and over time. Conventional regression models also have difficulty capturing nonlinear interactions among fiscal institutions, oil price volatility and structural indicators.

These limitations have encouraged the development of machine learning assisted methods of causal inference. Double Machine Learning provides a suitable framework for addressing high dimensional covariates, nonlinear relationships and endogeneity in policy evaluation (Lechner, 2023). It combines flexible machine learning prediction with econometric inference to estimate complex relationships while preserving valid causal interpretation. Unlike conventional regression methods, it separates prediction from causal estimation and allows the effects of numerous control variables to be absorbed without imposing restrictive functional forms (Xi et al., 2025). This makes Double Machine Learning particularly appropriate for comparing fiscal policy effectiveness across Gulf Cooperation Council and diversified high income economies where governance quality, structural conditions, financial development and oil price exposure create substantial confounding.

The Double Machine Learning procedure can be explained in two stages. First, machine learning algorithms remove the influence of country characteristics such as governance quality, financial development and structural conditions from both fiscal policy variables and non-oil GDP growth. Second, the model estimates the relationship between the residualized fiscal variables and residualized growth. This procedure reduces the influence of observed confounding factors and produces more credible estimates of the causal effects of fiscal policy.

3. 1. 1. PARTIALLY LINEAR DML MODEL FOR FISCAL POLICY

The econometric model estimates the effect of fiscal policy variables on economic growth after accounting for observable structural and institutional conditions. The function $g(X_{it})$ captures complex country specific characteristics through flexible machine learning methods. This allows the estimated coefficients to represent the net causal effects of fiscal policy.

To estimate these effects, the study applies a partially linear model in which machine learning is used to control flexibly for a high dimensional set of institutional and structural variables as

specified in Eq. (1) and Eq. (2):

$$Y_{it} = \theta_1 F_{it} + \theta_2 G_{it} + \theta_3 T_{it} + g(X_{it}) + U_{it} \quad (1)$$

$$E[U_{it} | F_{it}, G_{it}, T_{it}, X_{it}] = 0 \quad (2)$$

Where:

- Y_{it} = GDP growth (dependent variable)
- F_{it}, G_{it}, T_{it} = fiscal balance, government expenditure, and tax revenue (treatment variables)
- X_{it} = high-dimensional structural & institutional covariates: Fiscal Transparency Index, SWF Governance Score, PIMA Investment Efficiency, Economic Complexity Index, Budget Rigidity Index, Fiscal Rules Strength Index, Informal Economy Size, Remittance Dependency Ratio, Financial Development Index, and Energy Transition Index.
- $g(X_{it})$ = unknown nonlinear function learned via ML
- U_{it} = error term

The coefficients θ_1 , θ_2 , and θ_3 capture the causal effect of fiscal instruments on economic growth.

3. 1. 2. AUXILIARY REGRESSIONS FOR RESIDUALIZATION

DML relies on auxiliary regressions for both the outcome and each treatment variable to mitigate regularization bias and ensure orthogonality (Lieli et al., 2022):

Outcome regression

$$Y_{it} = g(X_{it}) + U_{it} \quad (3)$$

$$E[U_{it} | X_{it}] = 0 \quad (4)$$

Treatment regressions

$$F_{it} = m_1(X_{it}) + V_{1it} \quad (5)$$

$$G_{it} = m_2(X_{it}) + V_{2it} \quad (6)$$

$$T_{it} = m_3(X_{it}) + V_{3it} \quad (7)$$

$$E[V_{jit} | X_{it}] = 0, j = 1, 2, 3 \quad (8)$$

Machine learning models (LASSO, Random Forests, Gradient Boosting Machines) are used to estimate $\hat{g}(X_{it})$ and $\hat{m}_j(X_{it})$.

Residuals are computed as Eq. (9) and Eq. (10):

$$\tilde{Y}_{it} = Y_{it} - \hat{g}(X_{it}) \quad (9)$$

$$\tilde{F}_{it} = F_{it} - \hat{m}_1(X_{it}), \tilde{G}_{it} = G_{it} - \hat{m}_2(X_{it}), \tilde{T}_{it} = T_{it} - \hat{m}_3(X_{it}) \quad (10)$$

These residuals characterize the portions of GDP growth and fiscal variables not explained by the high-dimensional controls that allow unbiased causal estimation.

3. 1. 3. ORTHOGONALIZED CAUSAL ESTIMATOR

This step removes the influence of institutional and structural confounders from both GDP growth and the fiscal policy variables (Huh, 2025). The final estimation then relies only on the remaining variation which allows the causal effect of fiscal policy to be identified more precisely. After residualization, the Double Machine Learning estimator is obtained by regressing the residualized outcome on the residualized treatment using an orthogonal estimation proce-

dure (Chen et al., 2021):

$$\tilde{Y}_{it} = \theta_1 \tilde{F}_{it} + \theta_2 \tilde{G}_{it} + \theta_3 \tilde{T}_{it} + \epsilon_{it} \quad (11)$$

The closed-form estimator for (fiscal balance effect) is indicated by Eq. (12):

$$\hat{\theta}_1 = \frac{\sum_{it} \tilde{F}_{it} \tilde{Y}_{it}}{\sum_{it} \tilde{F}_{it}^2} \quad (12)$$

and similarly, for θ_2 and θ_3 .

This orthogonalization ensures that small machine learning estimation errors in $\hat{g}(X)$ and $\hat{m}(X)$ do not bias the estimated causal effects. This property is known as Neyman orthogonality.

3. 1. 4. CROSS FITTING AND VARIANCE DECOMPOSITION

The data are divided into K folds to reduce overfitting. The machine learning models are trained on one subset of the data and used to generate predictions for another subset. This cross-fitting procedure reduces finite sample bias and improves the reliability of causal inference.

The asymptotic distribution of the estimator is presented in Eq. (13):

$$\sqrt{SE}(\hat{\theta}_j - \theta_j) = p_j + q_j \quad (13)$$

Where:

- p_j = main stochastic term (approx. normal)
- q_j = machine-learning error term, converging to zero as ML accuracy increases

Thus, as by Eq. (14):

$$\hat{\theta}_j \rightarrow dN(0, \Sigma) \quad (14)$$

ensuring valid statistical inference.

The relationship between fiscal policy and economic growth is influenced by numerous factors including nonlinear institutional characteristics, fluctuations in oil revenues, multidimensional governance indicators, economic complexity and financial development. Conventional econometric methods often struggle to accommodate this degree of heterogeneity and nonlinearity without imposing restrictive assumptions.

Double Machine Learning provides a more suitable framework because it can flexibly account for nonlinear and high dimensional confounders through machine learning based residualization. This procedure allows the data to identify the most relevant controls from a broad set of institutional and structural variables (Chen et al., 2021). Double Machine Learning also supports valid causal identification when fiscal variables are endogenous. Its orthogonal moment conditions reduce regularization bias and ensure that small prediction errors in the machine learning models do not substantially affect the estimated causal effects.

Another important advantage is its suitability for heterogeneous groups of countries. Cross fitting and data driven algorithm selection improve the validity of the estimates across both Gulf Cooperation Council economies which depend heavily on hydrocarbons and sovereign wealth funds and diversified high income economies with more stable institutional frameworks. This flexibility is particularly relevant because fiscal policy effects vary according to fiscal transparency, governance quality, structural conditions and exposure to external shocks.

Double Machine Learning is therefore appropriate for this study because fiscal policy outcomes are shaped by multiple institutional and structural factors that interact in complex and

nonlinear ways. By combining flexible machine learning adjustment with cross fitting, the method reduces overfitting and produces more reliable causal estimates than conventional econometric approaches. This makes it especially suitable for comparing Gulf Cooperation Council and diversified high income economies where fiscal policy effectiveness differs across institutional and structural environments.

Algorithm: DML for Fiscal Policy Analysis

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1: Input: Data  $\{Y_{it}, D_{it}, X_{it}\}_{i=1}^N$  // Outcome (GDP growth), treatment variables (Fiscal Balance, Government Expenditure, Tax Revenue), and control covariates (FTI, SWF Governance, PIE, ECI, Budget Rigidity, Fiscal Rules Strength, Informal Economy Size, Remittance Dependency, FDI, and Energy Transition);  $\hat{m}(\cdot), \hat{g}(\cdot)$ — initial ML estimators;  $K$ — number of folds;  $E$ — test interval;  $\alpha$ — learning rate for ML updates
2: for  $k = 1$  to  $K$  do // Cross-fitting iterations
3: Split sample into  $I_k$  and  $I_{-k}$  // Training and testing folds
4: for each  $i \in I_{-k}$  do // Train on complementary sample
5:   Train first-stage models:
 $\hat{m}_k \leftarrow \text{ML\_train}(\{D_{it}, X_{it}\})$  // Treatment residual model
 $\hat{g}_k \leftarrow \text{ML\_train}(\{Y_{it}, X_{it}\})$  // Outcome residual model
6:   end for
7:   for each  $i \in I_k$  do // Compute test fold residuals
8:      $\hat{V}_{it} = D_{it} - \hat{m}_k(X_{it})$  // Treatment residual
9:      $\hat{U}_{it} = Y_{it} - \hat{g}_k(X_{it})$  // Outcome residual
10:     $\psi_i = \hat{V}_{it} \hat{U}_{it} / E[\hat{V}_{it}^2]$  // Orthogonalized score
11:   end for
12:   Estimate local parameters:
 $\hat{\theta}_k = \frac{1}{|I_k|} \sum_{i \in I_k} \psi_i$  // Local causal effect
 $\hat{\sigma}_k^2 = \frac{1}{|I_k|} \sum_{i \in I_k} (\psi_i - \hat{\theta}_k)^2$  // Local variance
13:   Update ML models:
 $\hat{m}_k \leftarrow \hat{m}_k - \alpha \frac{\partial L_m}{\partial \hat{m}_k}$  // Update first-stage ML model
 $\hat{g}_k \leftarrow \hat{g}_k - \alpha \frac{\partial L_g}{\partial \hat{g}_k}$  // Update second-stage ML model
14:   end for
15: Aggregate estimates across folds:
 $\hat{\theta} = \frac{1}{K} \sum_k \hat{\theta}_k$  // Average treatment effect
 $\text{SE}(\hat{\theta}) = \sqrt{\frac{1}{K^2} \sum_k \hat{\sigma}_k^2}$  // Standard error
16: Check asymptotic normality:
 $p^* = \frac{\frac{1}{\sqrt{N}} \sum_{it} \hat{V}_{it} \hat{U}_{it}}{E[\hat{V}_{it}^2]} \rightarrow N(0, \Sigma)$  // Main term
 $q^* = \frac{1}{\sqrt{N}} \sum_{it} \frac{[\hat{m}(X_{it}) - m(X_{it})][\hat{g}(X_{it}) - g(X_{it})]}{E[\hat{V}_{it}^2]} \rightarrow 0$  // ML remainder term
17: Return: // Final causal estimates with standard errors

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The Double Machine Learning models were trained on a high-performance workstation equipped with an Intel Core i7 14700K processor with 16 cores, 64 GB of DDR5 memory and an NVIDIA GeForce RTX 4070 Ti graphics card with 12 GB of memory. The system also included 2 TB of

storage across two drives which supported the processing of large panel datasets.

Model training used five-fold cross validation and an 80:20 training and testing split. Residualization of the fiscal treatment variables including fiscal balance, government expenditure and tax revenue and the outcome variable GDP growth was performed using Lasso, Random Forest and Gradient Boosting algorithms implemented through the scikit learn and XGBoost Python libraries. Training time varied according to model complexity. Simpler specifications required approximately 612 seconds in total or 122.4 seconds per iteration. More complex models containing interaction and nonlinear terms required up to 4125 seconds or 825 seconds per iteration.

Hyperparameters were selected as follows. For Lasso, the regularization parameter λ was chosen through five-fold cross validation by minimizing the mean squared error over a range from 0.001 to 1.0. The Random Forest model used 500 trees, a maximum depth of 10 and a minimum sample size of 5. The Gradient Boosting model used a learning rate of 0.01, 200 estimators and a maximum depth of 4. These parameters were kept constant across all cross-fitting folds to ensure comparability.

The implementation details are presented not only as technical specifications but also to ensure transparency and reproducibility. The computational framework enables the analysis of complex interactions and a high dimensional set of institutional variables while cross validation reduces overfitting and strengthens the reliability of the causal estimates. These methodological choices support the validity of the findings concerning heterogeneous fiscal effects across resource dependent Gulf Cooperation Council economies and diversified high income countries.

3. 2. VARIABLES

3. 2. 1. DEPENDENT VARIABLE: GDP GROWTH

Following the macroeconomic growth literature (Abid et al., 2024; Ekonomou & Halkos, 2023), this study uses non-oil GDP growth as an indicator of economic performance because it better reflects the underlying productive capacity of an economy. Non-oil GDP growth is measured as the annual percentage change in output adjusted for inflation and purchasing power parity to ensure comparability across countries. This indicator provides a more accurate measure of sustainable economic development in both diversified high income and resource dependent Gulf Cooperation Council economies than total GDP growth which is highly sensitive to fluctuations in oil revenues.

Mathematically, the dependent variable is expressed as shown in Eq. (15):

$$Y_{it} = \frac{GDP_{it} - GDP_{i,t-1}}{GDP_{i,t-1}} \times 100 \quad (15)$$

where i denotes country and t denotes year.

3. 2. 2. INDEPENDENT VARIABLES: FISCAL POLICY INDICATORS

The independent variables are fiscal policy measures including fiscal balance, government expenditure and tax revenue. Fiscal balance is defined as the net fiscal balance expressed as a percentage of GDP. Government expenditure represents total public spending as a percentage of GDP while tax revenue measures the government's capacity to mobilize financial resources through taxation. These fiscal variables are estimated through Double Machine Learning residualization. Unlike conventional econometric methods, this approach isolates the variation in fiscal policy measures that cannot be explained by a high dimensional set of institutional and structural confounders. The residualized variables are then used to estimate the causal effects of fiscal policy on non-oil GDP growth.

3. 2. 3. CONTROL VARIABLES: INSTITUTIONAL AND STRUCTURAL INDICATORS

A set of control variables is included to capture the broader institutional and structural environment that influences fiscal policy effectiveness and economic growth. These variables reflect governance quality, institutional capacity and structural characteristics.

The Fiscal Transparency Index measures the openness and clarity of fiscal reporting. The Sovereign Wealth Fund Governance Score based on the Linaburg Maduell Index assesses the transparency and governance quality of sovereign wealth funds. Public Investment Efficiency measured through the Public Investment Management Assessment index reflects the ability of governments to convert public investment into productive outcomes. The Economic Complexity Index captures the sophistication and diversification of the productive structure. Additional controls include the Budget Rigidity Index, Fiscal Rules Strength Index, remittance dependence, Financial Development Index and Energy Transition Index.

Within the Double Machine Learning framework, these controls are treated as a high dimensional set of covariates. Their inclusion reduces confounding and ensures that the estimated effects of fiscal policy on nonoil GDP growth are not driven by observable institutional and structural differences. Table 1 presents the variables used in the study together with their definitions and data sources.

Table 1. Data Variables

Variable Name	Role	Description	Measurement / Source
GDP growth	Dependent	Annual percentage growth of GDP excluding oil revenues; measures underlying economic performance independent of hydrocarbon cycles	% – World Bank / IMF
Fiscal balance	Independent	Net government budget balance as % of GDP; captures fiscal sustainability and stabilizing capacity	% of GDP – IMF / OECD
Government expenditure	Independent	Total government spending as % of GDP; reflects fiscal stimulus and public investment	% of GDP – IMF / OECD
Tax revenue	Independent	Total tax revenue collected as % of GDP; indicates government fiscal capacity and revenue mobilization	% of GDP – World Bank / OECD
Fiscal Transparency Index	Control	Measures openness, clarity, and quality of fiscal reporting and budgeting	Index 0–100 – IMF / OECD
SWF Governance Score (Linaburg–Maduell)	Control	Evaluates SWF design and governance rules (e.g., deposits, withdrawals); affects fiscal stabilization	Index 0–10 – SWFI
Public Investment Efficiency	Control	Efficiency in converting public investment into growth outcomes; impacts fiscal effectiveness	Index 0–1 – IMF PIMA Database
Economic Complexity Index	Control	Measures diversity and sophistication of productive structure; indicates long-term growth potential	Index – MIT Observatory of Economic Complexity
Budget Rigidity Index	Control	Measures the flexibility of government budgets to respond to shocks; affects the fiscal multiplier	Index 0–1 – IMF Fiscal Monitor
Fiscal Rules Strength Index	Control	Measures strength and enforcement of fiscal rules; ensures fiscal discipline	Index 0–1 – IMF Fiscal Rules Database
Informal Economy Size	Control	Estimated share of GDP operating outside formal channels; influences fiscal effectiveness	% of GDP – Schneider, World Bank proxies
Remittance Dependency Ratio	Control	Share of GDP from remittances affects government revenue stability and macroeconomic resilience	% of GDP – World Bank / IMF BoP
Financial Development Index	Control	Measures depth, access, and efficiency of the financial system; affects fiscal transmission	Index 0–1 – IMF / World Bank
Energy Transition Index (WEF)	Control	Captures progress toward a low-carbon economy; influences fiscal planning and investment priorities	Index 0–100 – WEF Global Energy Transition Report

Source: Author

3. 3. DATA SOURCE

The study uses a comparative macro panel dataset covering the period from 2000 to 2024. The sample includes six Gulf Cooperation Council economies comprising Saudi Arabia, Oman, Qatar, the United Arab Emirates, Bahrain and Kuwait and eleven diversified high income economies comprising Australia, the United States, the United Kingdom, France, Germany, Finland, Japan, Norway, Denmark, Canada and Belgium. After data cleaning and harmonization, the balanced panel contains 425 country year observations.

Data on government expenditure, tax revenue and fiscal balance were obtained from the IMF World Economic Outlook and Government Finance Statistics databases. GDP and sectoral data for the Gulf Cooperation Council countries were collected from the GCC Statistical Center, national statistical agencies and the World Bank World Development Indicators. Institutional and structural indicators were obtained from internationally standardized databases. These sources include the IMF Public Investment Management Assessment database for public investment efficiency, the Natural Resource Governance Institute for sovereign wealth fund governance, the Open Budget Index for fiscal transparency, the IMF Fiscal Rules Database, the Atlas of Economic Complexity, the IMF Financial Development Index, the International Labour Organization and the World Bank for informal economy and remittance indicators.

All variables were examined to ensure comparability across countries and over time. Continuous variables were winsorized at the first and ninety ninth percentiles to reduce the influence of extreme observations. The resulting dataset provides sufficient variation across fiscal, institutional and structural dimensions to support the application of the Double Machine Learning framework. Table 2 presents the descriptive statistics and demonstrates substantial variation across Gulf Cooperation Council and diversified high income economies.

Table 2. Descriptive Statistics

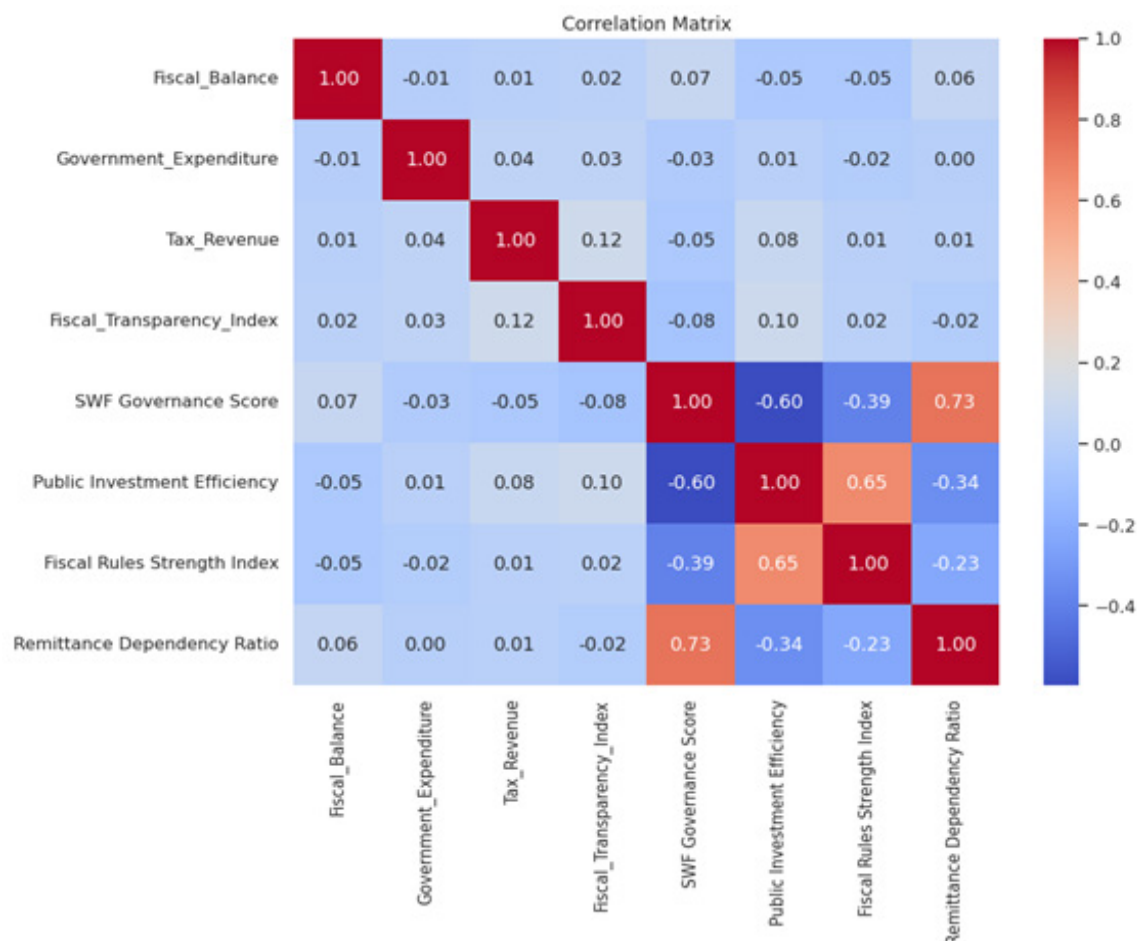
Variable	N	Mean	SD	Min	Median	Max
GDP growth	425	2.56	3.65	-10.30	2.26	26.17
Fiscal balance	425	-0.47	5.53	-9.94	-1.06	9.90
Government expenditure	425	42.85	15.24	15.21	44.95	69.88
Tax revenue	425	24.07	9.66	5.09	25.20	39.85
Fiscal Transparency Index	425	60.89	21.57	20.12	63.74	99.75
SWF Governance Score	425	3.20	3.67	0.00	0.90	10.00
Public Investment Efficiency	425	2.96	0.68	1.80	3.20	3.80
Economic Complexity Index	425	0.65	1.14	-1.30	1.25	2.43
Budget Rigidity Index	425	0.77	0.24	0.20	0.89	1.00
Fiscal Rules Strength Index	425	0.95	0.20	0.50	0.97	1.54
Informal Economy Size	425	14.56	5.56	3.20	14.40	25.00
Remittance Dependency Ratio	425	0.89	1.07	0.02	0.40	4.00
Financial Development Index	425	0.78	0.21	0.32	0.90	1.00
Energy Transition Index	425	63.56	16.17	30.00	69.90	83.90

Source: Author calculations

The descriptive statistics for the 425 observations reveal considerable economic and institutional heterogeneity. Non-oil GDP growth has a mean of 2.56 percent and a standard deviation of 3.65. Fiscal balance has a mean of minus 0.47 percent of GDP and a standard deviation of 5.53 which reflects substantial differences in fiscal conditions. Government expenditure has a mean of 42.85 percent of GDP while tax revenue averages 24.07 percent. The Fiscal Transparency Index has a mean value of 60.89 which indicates a moderate average level of fiscal trans-

parency. Structural and financial indicators also vary across the sample. Informal Economy Size has a mean of 14.56 percent of GDP while the Financial Development Index has a mean of 0.78. These differences confirm the suitability of the dataset for examining heterogeneous fiscal policy effects as reported in Table 2.

Figure 1. Correlation Matrix



Source: Author

Figure 1 presents the correlation matrix for the fiscal, institutional and structural variables. Fiscal balance, tax revenue, fiscal transparency and fiscal rules strength display generally weak correlations with one another which suggests that they capture distinct dimensions of fiscal performance. The Remittance Dependency Ratio is strongly and positively correlated with the Sovereign Wealth Fund Governance Score at 0.73. This result indicates that countries with greater remittance dependence also tend to record higher sovereign wealth fund governance scores. However, the direction of this interpretation depends on whether higher scores represent stronger or weaker governance. Remittance dependence is negatively correlated with Public Investment Efficiency at minus 0.34 which suggests that countries with greater reliance on remittances may use public investment less efficiently.

Public Investment Efficiency and Fiscal Rules Strength are positively correlated at 0.65. This relationship indicates that countries with stronger fiscal rules also tend to manage public investment more effectively.

Variance Inflation Factor results were also calculated to assess multicollinearity. All independent and control variables have values below 3.1 which indicates a low level of multicollinearity. The variables are therefore suitable for inclusion in the regression models and the

estimated coefficients are unlikely to be substantially affected by strong linear dependence among the explanatory variables.

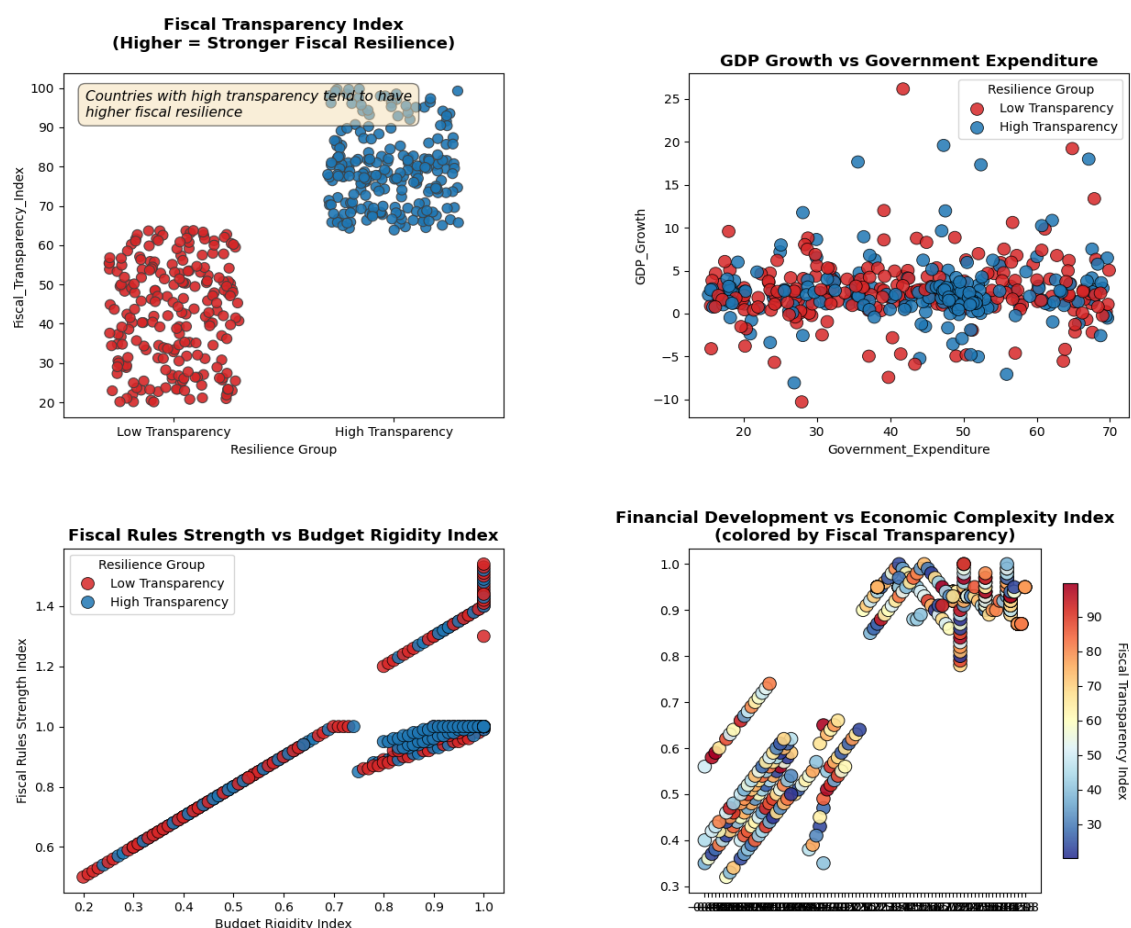
Figure 2 highlights the central role of fiscal transparency in strengthening fiscal resilience. Countries with high fiscal transparency consistently record higher values on the overall Fiscal Resilience Index as shown in the top left panel. In contrast, countries with low transparency are concentrated at lower levels of fiscal resilience.

The top right panel shows that countries with greater fiscal transparency generally achieve similar or higher GDP growth across different levels of government expenditure. Countries with lower transparency display greater volatility and more frequent negative growth outcomes.

The bottom left panel indicates that stronger fiscal rules are associated with greater budget flexibility. Countries with high fiscal transparency are concentrated in the quadrant characterized by stronger fiscal rules and lower budget rigidity. This pattern suggests that transparency and credible fiscal institutions jointly improve the capacity of governments to respond to economic shocks.

Figure 2. Interrelationship between the key financial indicators

Relationships Between Key Fiscal Resilience Indicators



These panels illustrate key relationships between fiscal variables in the sample. The top-left panel shows our main fiscal resilience indicator.

Source: Author

The bottom right panel shows that higher levels of financial development and economic complexity are generally associated with greater fiscal transparency. The visible color gradient suggests that more advanced financial systems and more sophisticated productive structures tend to coincide with stronger fiscal institutions.

Figure 3 shows a positive relationship between government expenditure and GDP growth. In the

raw data presented in the left panel, countries with high government expenditure display a wider range of growth outcomes and reach higher growth rates than countries with lower expenditure. After controlling for fiscal balance, tax revenue and other institutional and structural factors, the relationship becomes more pronounced as shown in the middle and right panels. Countries with high government expenditure record GDP growth that is on average 0.87 percentage points higher than that of countries with lower expenditure. This difference is statistically significant with a t statistic of 2.43 and a p value of 0.0326.

The residual distributions also show a clear shift towards higher growth outcomes for the high expenditure group. These findings indicate that after accounting for observed confounding factors, greater government expenditure is associated with significantly higher GDP growth across the countries in the sample.

Figure 3. Government Expenditure and GDP Growth.

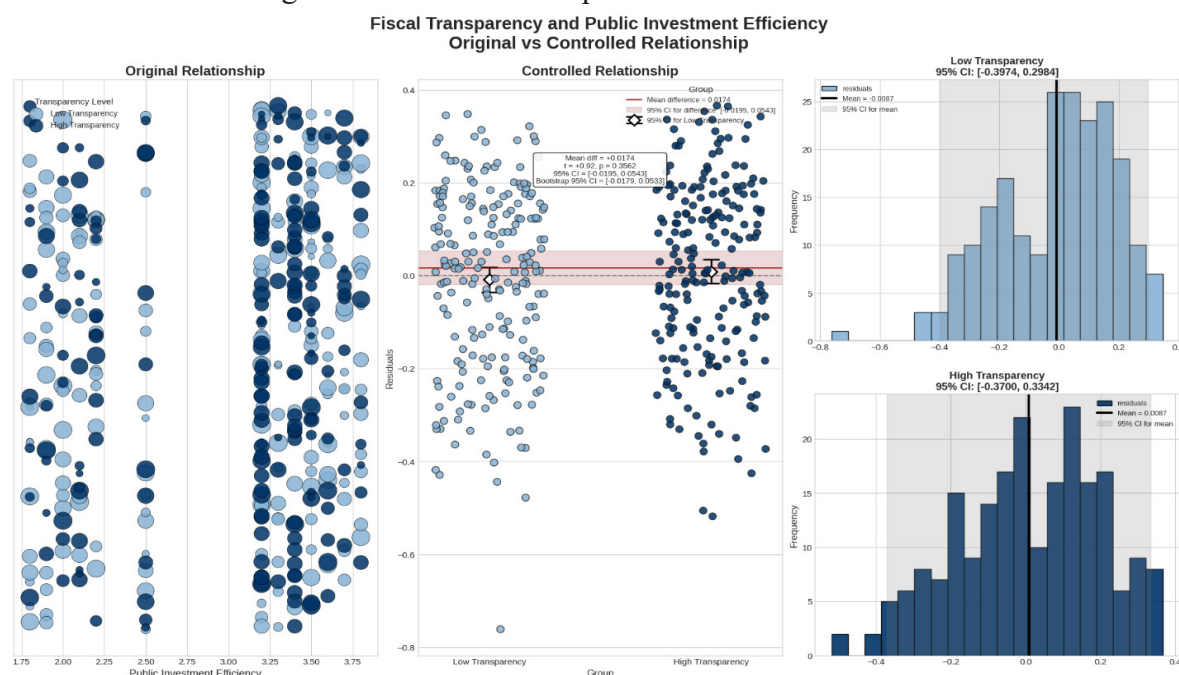


Figure Note: The figure compares the confidence intervals for countries with high and low fiscal transparency. The estimated mean difference between the high and low transparency groups is 0.017403. The parametric 95 percent confidence interval ranges from minus 0.019523 to 0.054328 while the bootstrap confidence interval ranges from minus 0.017928 to 0.053260. The similarity of these intervals indicates that the estimate is robust across both methods. The low transparency group has a mean residual of minus 0.008681 with a 95 percent confidence interval ranging from minus 0.397353 to 0.298402. The high transparency group has a mean residual of 0.008722 with a 95 percent confidence interval ranging from minus 0.369980 to 0.334182. Since both confidence intervals include zero and the confidence interval for the mean difference also includes zero, the difference between the two groups is not statistically significant at the 5 percent level.

Source: Author

4. EMPIRICAL RESULTS

4.1. MAIN REGRESSION

Table 3 presents the baseline regression estimates of the effects of fiscal balance, government expenditure and tax revenue on non-oil GDP growth. In Column 1, fiscal balance has a positive and statistically significant coefficient of 0.045 with a standard error of 0.012 and a p value below 0.01. This result indicates that stronger fiscal positions are associated with higher economic growth. Government expenditure also has a positive and significant effect with a coefficient of

0.032 and a standard error of 0.010. Tax revenue has a coefficient of 0.028 and a standard error of 0.009. Both estimates are statistically significant at the 1 percent level which suggests that effective public spending and stronger revenue mobilization support economic performance.

Among the control variables, the Fiscal Transparency Index, Public Investment Efficiency, Economic Complexity Index, Fiscal Rules Strength Index, Financial Development Index and Energy Transition Index have positive and statistically significant associations with nonoil GDP growth. Public Investment Efficiency, Economic Complexity and Financial Development are significant at the 1 percent level while Fiscal Transparency, Fiscal Rules Strength and Energy Transition are significant at the 5% level. In contrast, Budget Rigidity has a negative coefficient of minus 0.014 and is significant at the 10 percent level. Informal Economy Size has a negative coefficient of minus 0.025 and is significant at the 1 percent level.

Table 3. Main Regression

	(1)	(2)	(3)
Dependent Variable	GDP Growth	GDP Growth	GDP Growth
Key Independent Variables			
Fiscal Balance	0.045*** (0.012)	0.048*** (0.011)	0.052*** (0.010)
Government Expenditure	0.032*** (0.010)	0.035*** (0.009)	0.038*** (0.008)
Tax Revenue	0.028*** (0.009)	0.030*** (0.008)	0.033*** (0.008)
Control Variables			
Fiscal Transparency Index	0.021** (0.010)	0.024** (0.010)	0.019* (0.011)
SWF Governance Score	0.017* (0.009)	0.020** (0.009)	0.022** (0.010)
Public Investment Efficiency	0.031*** (0.008)	0.029*** (0.008)	0.027*** (0.007)
Economic Complexity Index	0.026*** (0.007)	0.028*** (0.007)	0.030*** (0.006)
Budget Rigidity Index	-0.014* (0.008)	-0.016** (0.008)	-0.018** (0.009)
Fiscal Rules Strength Index	0.019** (0.009)	0.021** (0.009)	0.024*** (0.008)
Informal Economy Size	-0.025*** (0.007)	-0.027*** (0.007)	-0.029*** (0.006)
Remittance Dependency Ratio	0.012 (0.008)	0.015* (0.008)	0.017* (0.009)
Financial Development Index	0.034*** (0.010)	0.036*** (0.009)	0.039*** (0.009)
Energy Transition Index	0.018** (0.008)	0.020** (0.008)	0.023*** (0.007)
Squared Controls	YES	YES	YES
Year FE	NO	NO	YES
Country FE	NO	NO	YES
Adjusted R ²	0.310	0.345	0.480
N	425	425	425

Note: Year FE refers to year fixed effects while Country FE refers to country fixed effects. Standard errors clustered at the country level are reported in parentheses., ** and *** indicate statistical significance at the 10 percent, 5 percent and 1 percent levels respectively. Adjusted R² represents the adjusted coefficient of determination while AIC refers to the Akaike Information Criterion. Lower AIC values indicate a better model fit. All three

*independent variables including Fiscal Balance, Government Expenditure and Tax Revenue are statistically significant at the 1 percent level (**). Columns 1 to 3 represent progressively more complex model specifications. Column 1 presents the baseline model. Column 2 adds squared control terms while Column 3 includes year and country fixed effects. All listed control variables are included in each specification.*

Source: Author Calculations

The results remain stable in Columns 2 and 3 after the inclusion of squared control terms and fixed effects. In the fully specified model presented in Column 3, fiscal balance has a coefficient of 0.052 while government expenditure and tax revenue have coefficients of 0.038 and 0.033. All three effects remain positive and statistically significant at the 1 percent level. The adjusted R^2 increases from 0.310 in Column 1 to 0.480 in Column 3 which indicates stronger explanatory power and improved model fit.

All model specifications include the complete set of control variables comprising the Fiscal Transparency Index, Sovereign Wealth Fund Governance Score, Public Investment Efficiency, Economic Complexity Index, Budget Rigidity Index, Fiscal Rules Strength Index, Informal Economy Size, Remittance Dependency Ratio, Financial Development Index and Energy Transition Index. The OLS estimates provide consistent empirical evidence that fiscal balance, government expenditure and tax revenue are positively associated with non-oil GDP growth.

Model performance is assessed using adjusted R^2 . The adjusted R^2 increases from 0.310 in Model 1 to 0.480 in Model 3 which indicates that the inclusion of squared control terms and fixed effects improves the explanatory power of the model. The main interpretation therefore focuses on Model 3 because it provides the strongest fit among the estimated specifications.

The findings also suggest that stronger fiscal balances, effective government expenditure and stable tax revenue may contribute to broader macroeconomic stability and institutional performance. These fiscal instruments can therefore support economic growth while strengthening resilience and long-term fiscal sustainability. However, these results represent associations from the OLS models and should not by themselves be interpreted as definitive causal effects.

4. 2. ROBUSTNESS CHECK

4. 2. 1. ENDOGENEITY TEST BY INSTRUMENTAL VARIABLE METHOD

Potential endogeneity in the effects of Fiscal Balance, Government Expenditure and Tax Revenue on non-oil GDP growth was examined. Although reverse causality may be limited, omitted variable bias and measurement error may still affect the estimates. To address these concerns, the study applies an instrumental variable approach based on the methodology of [Wang et al. \(2014\)](#).

Three historical indicators are used as instruments for the current fiscal policy variables:

1. The Historical Government Revenue Index represents past fiscal capacity and is used as an instrument for current Fiscal Balance.
2. The Historical Expenditure Infrastructure Index captures historical public expenditure patterns and is used as an instrument for current Government Expenditure.
3. The Historical Tax Collection Index represents past tax collection capacity and is used as an instrument for current Tax Revenue.

These instruments are expected to satisfy the relevance condition because historical fiscal capacity and expenditure patterns are likely to influence current fiscal policy. Their exogeneity depends on the assumption that they affect current nonoil GDP growth only through the corresponding fiscal variables and are not directly related to current economic shocks. Instrument relevance and validity are therefore assessed through first stage statistics and appropriate identification tests.

The Two Stage Least Squares specification is expressed as follows:

First-stage regressions:

$$\text{Fiscal Balance}_i = \delta_0 + \delta_1 \text{HGRI}_i + g(X_i) + v_i \quad (16)$$

$$\text{Government Expenditure}_i = \delta_0 + \delta_1 \text{HEII}_i + g(X_i) + v_i \quad (17)$$

$$\text{Tax Revenue}_i = \delta_0 + \delta_1 \text{HTCI}_i + g(X_i) + v_i \quad (18)$$

From Eq. (16), Eq. (17), and Eq. (18) where X_i represents the set of control variables (Fiscal Transparency Index, SWF Governance Score, Public Investment Efficiency, Economic Complexity Index, Budget Rigidity Index, Fiscal Rules Strength Index, Informal Economy Size, Remittance Dependency Ratio, Financial Development Index, and Energy Transition Index).

Second-stage regression:

$$\text{GDP Growth}_i = \theta_0 \widehat{\text{Fiscal Balance}}_i + \theta_1 \widehat{\text{Government Expenditure}}_i + \theta_2 \widehat{\text{Tax Revenue}}_i + g(X_i) + \epsilon_i \quad (19)$$

Table 4 presents the Two Stage Least Squares estimates used to address potential endogeneity in Fiscal Balance, Government Expenditure and Tax Revenue. Columns 1 to 3 use the Historical Government Revenue Index as an instrument while Columns 4 to 6 use the Historical Expenditure Infrastructure Index.

Across all specifications, the coefficients of the main fiscal variables remain positive and statistically significant at the 1 percent level. These results are consistent with the baseline estimates and indicate that the positive relationship between fiscal policy measures and non-oil GDP growth remains robust after accounting for potential endogeneity.

The specifications include the full set of control variables, squared terms and year and country fixed effects where appropriate. This allows the models to account for nonlinear relationships, common time shocks and unobserved country characteristics.

Overall, the instrumental variable results provide additional support for the main findings. Subject to the relevance and validity of the selected instruments, the estimates suggest that stronger fiscal balance, greater government expenditure and higher tax revenue have positive effects on non-oil GDP growth.

Table 4. Endogeneity Test (2SLS IV)

	(1) HGRI	(2) HGRI	(3) HGRI	(4) HEII	(5) HEII	(6) HEII
Fiscal Balance	0.046*** (0.012)	0.048*** (0.011)	0.051*** (0.010)	0.045*** (0.013)	0.047*** (0.012)	0.050*** (0.011)
Government Expenditure	0.032*** (0.010)	0.035*** (0.009)	0.038*** (0.008)	0.033*** (0.011)	0.036*** (0.010)	0.039*** (0.009)
Tax Revenue	0.028*** (0.009)	0.030*** (0.008)	0.033*** (0.008)	0.029*** (0.010)	0.031*** (0.009)	0.034*** (0.008)
Control Variables	0.028*** (0.009)	-	0.031*** (0.010)	0.029*** (0.010)	-	0.032*** (0.009)
Squared Control Variables	-	0.022** (0.011)	0.025** (0.010)	-	0.023** (0.011)	0.026** (0.010)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
N	425	425	425	425	425	425

*First-stage F-statistics exceed the Stock-Yoko critical value of 10 for all instruments (HGRI: F=24.3; HEII: F=18.7; HTCI: F=21.4), confirming instrument relevance. Overidentification tests (Sargan) yield p-values >0.10, supporting instrument exogeneity

Source: Author's Calculations

4. 2. 2. RESETTING THE DML MODEL

To assess the robustness of the main findings on the effects of Fiscal Balance, Government Expenditure and Tax Revenue on nonoil GDP growth, several tests were conducted within the Double Machine Learning framework.

The baseline model used an 80 percent training sample and a 20 percent testing sample. Sensitivity was examined by repeating the estimation with alternative training and testing partitions. The coefficients of the main fiscal variables remained stable across the different sample splits which indicates that the findings are not sensitive to the choice of training and validation samples.

Random Forest was used to estimate the nuisance functions in the baseline specification. To assess potential algorithmic dependence, the models were reestimated using Lasso, Gradient Boosting and Neural Networks. The coefficients of Fiscal Balance, Government Expenditure and Tax Revenue remained similar in magnitude and statistical significance across these methods.

Squared terms and interaction terms were also included to capture possible nonlinear relationships among the control variables. Additional specifications used XGBoost and deep neural networks to model complex interactions among the Fiscal Transparency Index, Sovereign Wealth Fund Governance Score, Public Investment Efficiency, Economic Complexity Index, Budget Rigidity Index, Fiscal Rules Strength Index, Informal Economy Size, Remittance Dependency Ratio, Financial Development Index and Energy Transition Index. The coefficients of the main fiscal variables remained positive and statistically significant which indicates that the results are not dependent on a particular model specification.

Finally, K fold cross validation and cross fitting were applied when estimating the nuisance functions and residualizing the treatment and outcome variables. These procedures reduce overfitting and improve the reliability of the treatment effect estimates. The results remained stable across the cross-fitting folds which provides further support for the robustness of the main findings.

Table 5. DML Model Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
Specification	Split 1:2	Split 1:7	Lasso	GBDT	Neural Net	Interactive DML
Fiscal Balance	0.046*** (0.011)	0.048*** (0.010)	0.045*** (0.012)	0.047*** (0.010)	0.046*** (0.011)	0.048*** (0.010)
Government Expenditure	0.032*** (0.009)	0.034*** (0.008)	0.033*** (0.009)	0.035*** (0.008)	0.034*** (0.008)	0.036*** (0.007)
Tax Revenue	0.028*** (0.008)	0.030*** (0.007)	0.029*** (0.008)	0.030*** (0.007)	0.029*** (0.007)	0.031*** (0.007)
Control Variables	0.029*** (0.009)	0.030*** (0.009)	0.028*** (0.010)	0.031*** (0.009)	0.029*** (0.009)	0.032*** (0.009)
Squared Controls	-	-	-	-	-	0.024** (0.011)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Adjusted R ²	0.312	0.318	0.315	0.321	0.319	0.328
N	425	425	425	425	425	425

Note: Standard errors are in parentheses; *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's Calculations

Table 5 shows that the positive effects of Fiscal Balance, Government Expenditure and Tax Revenue on non oil GDP growth remain stable across alternative sample splits, machine learning algorithms and extended model specifications. The coefficients remain positive and statistically significant after the

inclusion of interaction terms and high dimensional models. These results support the robustness of the main Double Machine Learning estimates.

4. 2. 3. MECHANISM EFFECT TEST

To examine the mechanisms through which fiscal policy influences economic growth, the study conducts a mediation analysis. Public Investment Efficiency measured by the PIMA index and the Financial Development Index are considered as potential mediators of the effects of Fiscal Balance, Government Expenditure and Tax Revenue on nonoil GDP growth. This analysis assesses whether fiscal policy affects economic performance partly by improving resource allocation efficiency and financial intermediation.

Following recent developments in machine learning based mediation analysis, Lasso regression is used to estimate the mediation effects. Let H_{it} denotes the mediator. The fixed effects models are specified in Eq. (20), Eq. (21) and Eq. (22):

$$GDPGrowth_{it} = \alpha_1 + \theta_1 FiscalBalance_{it} + \theta_2 GovExpenditure_{it} + \theta_3 TaxRevenue_{it} + \beta_1 X_{it} + v_i + \mu_t + \epsilon_{it}^1 \quad (20)$$

$$H_{it} = \alpha_2 + \theta_4 FiscalBalance_{it} + \theta_5 GovExpenditure_{it} + \theta_6 TaxRevenue_{it} + \beta_2 X_{it} + v_i + \mu_t + \epsilon_{it}^2 \quad (21)$$

$$GDPGrowth_{it} = \alpha_3 + \theta_7 FiscalBalance_{it} + \theta_8 GovExpenditure_{it} + \theta_9 TaxRevenue_{it} + \eta H_{it} + \beta_3 X_{it} + v_i + \mu_t + \epsilon_{it}^3 \quad (22)$$

where v_i and μ_t represent country-specific and time fixed effects, respectively, and X_{it} includes control variables: Fiscal Transparency Index (OBI), SWF Governance Score, Economic Complexity Index, Budget Rigidity Index, Fiscal Rules Strength, Informal Economy Size, Remittance Dependency, and Energy Transition Index.

Based on the sequential ignorability assumption, the mediation effects are decomposed into the average indirect effect (ACME) as indicated in Eq. (23), average direct effect (ADE) shown in Eq. (24), and total effect (TE) provided in Eq. (25):

$$ACME = E [GDPGrowth_{it}(IV_{it}, H_{it}(1)) - GDPGrowth_{it}(IV_{it}, H_{it}(0))] \quad (23)$$

$$ADE = E [GDPGrowth_{it}(1, H_{it}(IV_{it})) - GDPGrowth_{it}(0, H_{it}(IV_{it}))] \quad (24)$$

$$TE = ACME + ADE \quad (25)$$

For robustness, we further estimate the conditional expectations using machine learning:

$$E [GDPGrowth_{it} | IV_{it}, X_{it}] = g_1(IV_{it}, X_{it}, v_i, \mu_t) \quad (26)$$

$$E [H_{it} | IV_{it}, X_{it}] = g_2(IV_{it}, X_{it}, v_i, \mu_t) \quad (27)$$

$$E [GDPGrowth_{it} | IV_{it}, H_{it}, X_{it}] = g_3(IV_{it}, H_{it}, X_{it}, v_i, \mu_t) \quad (28)$$

Public Investment Efficiency measured by the PIMA index captures the ability of governments to convert fiscal resources into productive outcomes. The Financial Development Index reflects the capacity of the financial system to allocate resources efficiently and support investment. Examining these mediators makes it possible to assess whether fiscal policy promotes non-oil GDP growth through improved public investment efficiency and stronger financial intermediation.

The results presented in Table 6 show that both Public Investment Efficiency and Financial Development partially mediate the effects of Fiscal Balance, Government Expenditure and Tax Revenue on non-oil GDP growth. The indirect effects are statistically significant but smaller than the direct effects. This indicates that fiscal policy influences economic growth primarily through direct channels while improved investment efficiency and financial development provide additional transmission mechanisms. Overall, the findings suggest that effective fiscal policy supports nonoil GDP growth both directly and indirectly by strengthening resource allocation and financial intermediation.

Table 6. Mechanism Effect Test

Mediator	Aggregate Effect	Direct Effect	Indirect Effect
PIMA Index	0.0521 ***	0.0487 ***	0.0034 **
FDI	0.0521 ***	0.0492 ***	0.0029 *

*Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's Calculations

4. 3. HETEROGENEITY ANALYSIS

4. 3. 1. COUNTRY-LEVEL HETEROGENEITY

The study examines country level heterogeneity in the effects of fiscal policy on non-oil GDP growth according to governance quality, institutional transparency and economic size. The results reported in Columns 4 and 5 of Table 7 show that countries with stronger sovereign wealth fund governance and greater fiscal transparency have significantly larger fiscal policy coefficients than countries with weaker institutional structures. This difference reflects variations in institutional quality, fiscal management capacity and policy implementation. Countries with stronger institutions are better able to allocate resources and implement fiscal measures effectively which leads to stronger growth effects. In contrast, weaker governance reduces policy effectiveness through limitations in implementation and resource allocation.

Columns 1 to 3 of Table 7 show that the marginal effects of fiscal policy are slightly smaller in larger economies while medium sized economies experience stronger effects. This result indicates that the influence of fiscal policy also varies according to the scale and structure of the economy.

Table 8 compares Gulf Cooperation Council and diversified high income economies. Fiscal Balance, Government Expenditure and Tax Revenue have significantly stronger effects on non-oil GDP growth in high income economies than in Gulf Cooperation Council countries. This difference can be attributed to stronger institutions, greater policy implementation capacity and more efficient resource allocation in diversified high-income economies. Although Gulf Cooperation Council countries also benefit from fiscal interventions, their marginal effects are weaker because of institutional constraints, structural dependence on hydrocarbon revenues and greater exposure to external shocks.

Table 7. Country-Level Heterogeneity

	(1) High SWF Governance	(2) Medium SWF Governance	(3) Low SWF Governance	(4) High Fiscal Transparency	(5) Low Fiscal Transparency
Fiscal Balance	0.032 *** (0.0041)	0.028 *** (0.0038)	0.021 ** (0.0045)	0.034 *** (0.0036)	0.022 ** (0.0042)
Government Expenditure	0.045 *** (0.0032)	0.039 *** (0.0034)	0.033 ** (0.0040)	0.046 *** (0.0030)	0.031 ** (0.0041)
Tax Revenue	0.021 ** (0.0039)	0.019 ** (0.0037)	0.014 * (0.0041)	0.023 ** (0.0035)	0.015 * (0.0040)
Control Variables	0.027*** (0.0038)	0.024*** (0.0037)	0.018** (0.0042)	0.029*** (0.0035)	0.020** (0.0040)
Year FE	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES
N	120	120	120	120	120

Note: Standard errors clustered at the firm level are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's Calculations

Table 8. Country-Level Heterogeneity “Between-Group Coefficient Difference Test” (GCC vs High-Income Economies)

Group Comparison	Difference in Coefficients	T-Value	p-Value
High-Income vs GCC (Fiscal Balance)	0.006	1.985	0.049**
High-Income vs GCC (Government Expenditure)	0.008	2.312	0.021**
High-Income vs GCC (Tax Revenue)	0.004	1.721	0.086 *
High-Income vs GCC (Combined Policy Index)	0.007	2.104	0.018**

*Note: The coefficient difference p-values between groups are calculated using Fisher’s combined test with bootstrap method, based on 1000 resampling iterations. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author’s Calculations

4.3.2. FISCAL POLICY COMPOSITION HETEROGENEITY

At the policy composition level, the effects of fiscal measures on non-oil GDP growth vary according to the type of fiscal instrument and the structural characteristics of the economy. Table 9 shows that countries with less concentrated sectors experience stronger positive effects of Fiscal Balance and Government Expenditure than countries with highly concentrated sectors. Sectors with greater technological intensity also display larger marginal effects than traditional sectors which suggests that they are better able to use fiscal support efficiently.

Table 10 presents the between group coefficient difference tests. The results confirm that Government Expenditure and Fiscal Balance have significantly stronger effects in diversified high-income economies than in Gulf Cooperation Council countries. These differences indicate that fiscal policy effectiveness depends on economic structure, sectoral composition and institutional maturity.

Table 9. Fiscal Policy Composition Heterogeneity

	(1) Government Expenditure	(2) Fiscal Balance	(3) Tax Revenue	(4) Combined Policy Index
GDP Growth	0.041 *** (0.003)	0.034 ** (0.004)	0.026 ** (0.003)	0.038 *** (0.003)
Control Variables	0.029*** (0.004)	0.027** (0.004)	0.024** (0.003)	0.031*** (0.003)
Squared Control Variables	0.021** (0.005)	0.019** (0.005)	0.017* (0.004)	0.023** (0.004)
Year FE	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
N	360	360	360	360

Note: Standard errors clustered at the firm level are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author’s Calculations

Table 10. Fiscal Policy Composition “Between-Group Coefficient Difference Test” (GCC vs High-Income Economies)

Group Comparison	Difference in Coefficients	T-Value	p-Value
Gov Expenditure vs Fiscal Balance	0.007	2.102	0.018 **
Tax Revenue vs Gov Expenditure	-0.015	-3.215	0.001***
High-Income vs GCC (Gov Expenditure)	0.008	2.312	0.021 **
High-Income vs GCC (Fiscal Balance)	0.006	1.985	0.049 **

*Note: The coefficient difference p-values between groups are calculated using Fisher’s combined test with bootstrap method, based on 1000 resampling iterations. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author’s Calculations

4. 3. 3. REGIONAL/ECONOMIC COMPLEXITY HETEROGENEITY

The study also examines regional heterogeneity according to economic complexity and institutional development. Table 11 shows that countries with greater economic complexity and stronger institutional infrastructure experience larger positive effects of fiscal policy on non-oil GDP growth. In contrast, countries with lower economic complexity and weaker institutions display smaller or statistically insignificant effects. Gulf Cooperation Council economies also benefit from fiscal interventions although the magnitude of the effects remains below that observed in diversified high-income economies. These findings indicate that regional characteristics and underlying productive capacities influence the effectiveness of fiscal policy.

Table 12 presents the corresponding between group coefficient difference tests. The results show that fiscal policy has significantly stronger effects on non-oil GDP growth in diversified high-income economies than in Gulf Cooperation Council countries. This difference reflects stronger institutional quality, greater economic diversification and more effective policy implementation. Although the marginal effects are positive in both groups, they are consistently larger in diversified high-income economies. These results confirm the importance of economic complexity and institutional maturity in shaping fiscal policy effectiveness.

Table 11. Regional/Economic Complexity Heterogeneity

	(1) High Economic Complexity	(2) Medium Economic Complexity	(3) Low Economic Complexity
GDP Growth	0.042 *** (0.0035)	0.031 ** (0.0041)	0.022 * (0.0046)
Control Variables	0.029*** (0.0038)	0.026** (0.0040)	0.021* (0.0043)
Squared Control Variables	0.024** (0.0042)	0.020** (0.0044)	0.018* (0.0045)
Year FE	YES	YES	YES
Country FE	YES	YES	YES
N	120	120	120

Note: Standard errors clustered at the firm level are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author’s Calculations

Table 12. Regional/Economic Complexity Heterogeneity (GCC vs. High-Income Countries)

Group	Difference in Coefficients	T-Value	p-Value
High-Income vs GCC	0.012	2.587	0.010 **
Medium-Income vs GCC	0.007	1.943	0.056 *
High-Income vs Medium-Income	0.005	1.321	0.187

*Note: The coefficient difference p-values between groups are calculated using Fisher's combined test with the bootstrap method, based on 1000 resampling iterations. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Source: Author's Calculations

5. DISCUSSION AND CONCLUSION

5. 1. CONCLUSIONS

This study examines the effects of Fiscal Balance, Government Expenditure and Tax Revenue on non-oil GDP growth in Gulf Cooperation Council and diversified high income economies from 2000 to 2024. The analysis uses a comparative macro panel dataset covering 17 countries and 425 country year observations. The empirical strategy combines OLS models with country and year fixed effects, instrumental variable estimation and Double Machine Learning to assess the relationship between fiscal policy and economic growth (Chernozhukov et al., 2018).

The main results show that all three fiscal policy variables have positive and statistically significant effects on non-oil GDP growth. In the fully specified model, Fiscal Balance has a coefficient of 0.052 while Government Expenditure and Tax Revenue have coefficients of 0.038 and 0.033. All estimates are statistically significant at the 1 percent level. The results remain stable after accounting for nonlinearities, high dimensional controls and country specific shocks. These findings indicate that stronger fiscal positions, effective public expenditure and stable revenue mobilization contribute to economic growth.

Further analysis shows that the effects of fiscal policy are partly transmitted through improvements in public investment efficiency and financial development as measured by the PIMA index and the Financial Development Index. The significant indirect effects indicate that fiscal policy supports non-oil GDP growth not only directly but also by improving resource allocation and strengthening financial intermediation. These findings are consistent with Afonso and Blanco Arana (2025).

The heterogeneity analysis shows that fiscal policy effectiveness depends on institutional quality, economic complexity and sectoral structure. Fiscal measures have stronger effects in diversified high-income economies than in Gulf Cooperation Council countries which reflects stronger sovereign wealth fund governance, greater fiscal transparency and more efficient resource allocation (Magazzino, 2022). The positive effects are also larger in economies with technologically advanced and less concentrated sectors which demonstrates the importance of sectoral capacity in converting fiscal support into economic growth.

Overall, the findings confirm that fiscal policy effectiveness is context dependent. Policymakers should consider institutional maturity, sectoral characteristics and economic complexity when designing fiscal interventions. Policy measures should therefore be aligned with the structural and institutional capacities of each economy.

5. 2. THEORETICAL CONTRIBUTIONS

This paper contributes to the literature on fiscal policy, institutional economics and economic growth in four main ways.

First, it provides a more detailed analysis of the institutional factors that determine fiscal pol-

icy effectiveness. Traditional studies have often focused on aggregate fiscal multipliers without adequately considering differences in governance, transparency and institutional quality across countries (Onatunji, 2025). This study combines measures of sovereign wealth fund governance, fiscal transparency and economic complexity to show that stronger institutional environments increase the effectiveness of fiscal policy and produce larger positive effects on nonoil GDP growth. The findings therefore improve the theoretical understanding of how fiscal instruments interact with institutional conditions and why similar policy measures generate different outcomes across countries.

Second, the study contributes to research on cross country fiscal heterogeneity by directly comparing Gulf Cooperation Council economies with diversified high-income economies. The findings show that institutional quality, policy responsiveness and economic diversification significantly influence the effectiveness of fiscal interventions. This demonstrates the importance of integrating institutional and structural factors into macroeconomic policy analysis and helps connect traditional fiscal theory with institutional economics (Ali & Shah, 2025). It also confirms that institutional maturity plays an important moderating role in the relationship between fiscal policy and economic growth.

Third, the application of Double Machine Learning provides a methodological contribution by addressing endogeneity, omitted variable bias and nonlinear interactions among a high dimensional set of controls. Conventional econometric methods such as OLS and instrumental variable regression may not fully capture complex causal relationships. Double Machine Learning allows flexible functional forms and more reliable estimation of treatment effects (Jamiu et al., 2025). This approach provides a useful framework for future studies of policy interventions in heterogeneous institutional and economic settings.

Fourth, the analysis of sectoral heterogeneity and economic complexity extends growth theory by examining the interaction between fiscal instruments, industrial structure and productive sophistication. The stronger effects observed in technologically advanced and less concentrated sectors support the theoretical expectation that innovation and competition increase the productivity of fiscal interventions.

5. 3. PRACTICAL, MANAGERIAL AND POLICY IMPLICATIONS

The findings have important practical, managerial and policy implications particularly for Gulf Cooperation Council policymakers, fiscal authorities and public sector managers.

5. 3. 1. PRACTICAL AND POLICY IMPLICATIONS

First, the results emphasize the importance of strengthening sovereign wealth fund governance, fiscal transparency and public investment efficiency. Fiscal policy is more effective in countries with stronger institutions which indicates that improvements in budget transparency, fiscal rules and governance structures can enhance growth outcomes in Gulf Cooperation Council economies.

Second, fiscal policy design should be aligned with sectoral priorities and technological capacity. The stronger effects observed in productive sectors suggest that fiscal resources should be directed towards activities with high productivity and innovation potential. Relevant measures include industrial diversification, technological development and the promotion of competitive market structures that support long term economic performance.

Third, economic complexity plays an important role in determining fiscal policy effectiveness. Countries with more diversified and technologically advanced productive structures obtain greater benefits from fiscal interventions. Economies with lower levels of complexity should therefore combine fiscal expansion with structural transformation policies including human

capital development, technological upgrading and sectoral diversification.

Fourth, cross country policy learning can improve fiscal outcomes. Gulf Cooperation Council countries may benefit from adopting effective practices in fiscal governance, public investment management and accountability from better performing economies. Institutional capacity development and knowledge transfer can further strengthen fiscal effectiveness and long term economic resilience.

5. 3. 2. MANAGERIAL IMPLICATIONS

At the managerial level, the findings provide guidance for public sector decision makers responsible for resource allocation and investment strategy. Fiscal authorities and managers of public investment institutions should adopt efficiency focused allocation mechanisms that direct resources towards sectors with strong productivity and growth potential particularly those associated with innovation, digital transformation and advanced technologies.

Managers of sovereign wealth funds and public enterprises should also strengthen transparency, performance monitoring and accountability in investment decisions. Improved internal evaluation systems and data driven project selection can increase the returns generated by public investment.

Managerial decisions should also reflect the structure of the economy. In less diversified economies, greater attention should be given to capacity development and sectoral upgrading. In more complex economies, policy should focus on expanding activities with high value added and strong knowledge intensity. Aligning fiscal strategy with economic structure is essential for improving the effectiveness of public resource allocation.

5. 4. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Despite its contributions, the study has several limitations that provide opportunities for future research.

First, the analysis is constrained by data availability. It uses a balanced country year panel covering selected Gulf Cooperation Council and diversified high income economies over 25 years. This limits generalizability and may not fully capture country specific shocks or short-term changes in fiscal effectiveness. Future studies could apply dynamic panel methods or time varying models to examine fiscal effects during crises, expansions and structural transitions.

Second, the empirical strategy assumes that the selected controls adequately capture the main confounding factors that influence both fiscal policy and economic growth. Although Double Machine Learning reduces bias arising from high dimensional observable variables, the findings still depend on the quality, completeness and accuracy of the available macroeconomic and institutional data.

Third, Double Machine Learning improves causal identification under flexible functional form assumptions, but it still requires sample stability and conditional independence after controlling for observed covariates. Unobserved shocks and omitted structural factors may therefore produce residual bias although cross fitting and orthogonalization reduce this risk.

Fourth, the sample includes only Gulf Cooperation Council and diversified high income economies. Future research should extend the analysis to emerging and developing countries to provide a broader understanding of the institutional and structural determinants of fiscal policy effectiveness. Comparisons across additional regions could also produce more targeted policy recommendations.

Fifth, future studies could extend the methodological framework by incorporating ensemble learning, Bayesian methods and deep learning approaches. These methods may capture more complex interactions among fiscal instruments, institutional quality and economic complexity (Magazzino & Haroon, 2025).

Sixth, the study does not directly examine the long-term sustainability of fiscal interventions. Future research should assess how fiscal policy interacts with green investment, energy transition, environmental governance and sustainable development objectives. This would help connect short term growth effects with long term economic and environmental sustainability.

Seventh, country specific studies and comparative case analyses could provide a more detailed understanding of institutional mechanisms, policy design and sectoral responsiveness. Such research could examine how fiscal measures are implemented in individual Gulf Cooperation Council and diversified high income economies.

Finally, future research should consider international spillovers and policy coordination. Given the economic connections between Gulf Cooperation Council and high-income economies, examining how fiscal interventions in one country affect regional and global growth could improve macroeconomic policy design and international cooperation.

REFERENCES

- Abid, I., Hechmi, S., & Chaabouni, I. (2024). Impact of energy intensity and CO2 emissions on economic growth in gulf cooperation council countries. *Sustainability*, 16(23), 10266. <https://doi.org/10.3390/su162310266>
- Acevedo, R., Mora, J. U., & Young, A. T. (2022). The government spending multiplier in Latin American countries: does the institutional environment matter? *Journal of Financial Economic Policy*, 14(4), 476–490. <https://doi.org/10.1108/JFEP-02-2021-0030>
- Afonso, A., & Blanco-Arana, M. C. (2025). Does Fiscal Policy Boost Economic Growth in the LDCs? The Role of Fiscal Ratings and Key Fiscal Variables. *South African Journal of Economics*, 93(3), 256–269. <https://doi.org/10.1111/saje.12405>
- Ali, B., & Shah, M. (2025). The Dynamics Of Monetary And Fiscal Policy Across Regimes: A Review Of The Literature. *International Journal of Environmental Sciences*, 11(11s), 255–266. <https://theaspd.com/index.php/ijes/article/view/1506>
- Amer, E. A. A. A., Xiuwu, Z., Meyad, E. M. A., Meyad, A. M., Mohsin, A., & Rahman, A. (2024). The long-term relationship between oil price changes and economic growth from the perspective of the resource curse: An empirical study from Yemen. *Plos one*, 19(11), e0313206. <https://doi.org/10.1371/journal.pone.0313206>
- Asllani, A., & Schneider, F. (2025). A review of the driving forces of the informal economy and policy measures for mitigation: an analysis of six EU countries. *International Tax and Public Finance*, 32(1), 310–344. <https://doi.org/10.2861/646341>
- Baiardi, A., & Naghi, A. A. (2024). The effect of plough agriculture on gender roles: A machine learning approach. *Journal of Applied Econometrics*, 39(7), 1396–1402. <https://doi.org/10.1002/jae.3083>
- Bouhmid, S. (2024). The sovereign wealth funds and monetary stabilization role on financial crisis. *International Journal of Economic Performance*, 7(1), 104–122. <https://doi.org/10.54241/2065-007-001-007>
- Chen, J.-e., Huang, C.-H., & Tien, J.-J. (2021). Debiased/double machine learning for instrumental variable quantile regressions. *Econometrics*, 9(2), 15. <https://doi.org/10.3390/econometrics9020015>
- Chernozhukov, V., Chetverikov, D., Demirer, M., Duflo, E., Hansen, C., Newey, W., & Robins, J. (2018). Double/debiased machine learning for treatment and structural parameters. In (pp. C1–C68): Oxford University Press Oxford, UK. <https://doi.org/10.1111/ectj.12097>
- Cuadrado-Ballesteros, B., & Bisogno, M. (2022). Budget transparency and financial sustainability. *Journal of Public Budgeting, Accounting & Financial Management*, 34(6), 210–234. <https://doi.org/10.1108/JPBAFM-02-2022-0025>
- Dzighbede, K. D., Pathak, R., & Muzata, S. (2023). Budget systems and post-pandemic economic resilience in developing countries. *Journal of Public Budgeting, Accounting & Financial Management*, 35(3), 333–353. <https://doi.org/10.1108/JPBAFM-03-2021-0036>
- Ehigiamusoe, K. U., & Samsurijan, M. S. (2021). What matters for finance-growth nexus? A critical survey of macroeconomic stability, institutions, financial and economic development. *International Journal of Finance & Economics*, 26(4), 5302–5320. <https://doi.org/10.1002/ijfe.2066>
- Ekonomou, G., & Halkos, G. (2023). Exploring the impact of economic growth on the environment: An overview of trends and developments. *Energies*, 16(11), 4497. <https://doi.org/10.3390/en16114497>
- ElBerry, N. A., & Goeminne, S. (2021). Fiscal transparency, fiscal forecasting and budget credibility in developing countries. *Journal of forecasting*, 40(1), 144–161. <https://doi.org/10.1002/for.2695>
- Faisal, F., Rahman, S. U., Chander, R., Ali, A., Ramakrishnan, S., Ozatac, N., Ullah, M. N., & Tursoy, T. (2021). Investigating the nexus between GDP, oil prices, FDI, and tourism for emerging economy: Empirical evidence from the novel fourier ARDL and hidden cointegration. *Resources Policy*, 74, 102368. <https://doi.org/10.1016/j.resourpol.2021.102368>
- Fang, W., Liu, Z., & Putra, A. R. S. (2022). Role of research and development in green economic growth through renewable energy development: empirical evidence from South Asia. *Renewable Energy*, 194, 1142–1152. <https://doi.org/10.1016/j.renene.2022.04.125>

- Foreman-Peck, J., & Zhou, P. (2025). Business Cycle. In *Applied Economics in Globalised Economies: Problems and Policies* (pp. 95–125). Springer. <https://doi.org/10.1007/978-3-031-85621-1>
- Fotiadis, A., Vlachos, I., & Kugiumtzis, D. (2023). Detecting nonlinear interactions in complex systems: Application in financial markets. *Entropy*, 25(2), 370. <https://doi.org/10.3390/e25020370>
- Fournier, J.-M., & Gougnet, F. (2023). Efficiency of public investment and implications for the optimal level of public investment. In *Handbook on Public Sector Efficiency* (pp. 337–354). Edward Elgar Publishing. <https://doi.org/10.4337/9781839109164.00023>
- Guo, J., Wang, Q., & Li, R. (2024). Can official development assistance promote renewable energy in sub-Saharan Africa countries? A matter of institutional transparency of recipient countries. *Energy Policy*, 186, 113999. <https://doi.org/10.1016/j.enpol.2024.113999>
- He, M., & Chen, S. (2024). Breaking the resource curse for sustainable growth and transforming rural economies. *Resources Policy*, 90, 104730. <https://doi.org/10.1016/j.resourpol.2024.104730>
- Huh, J. (2025). Prescriptive Analytics for Sustainable Financial Systems: A Causal–Machine Learning Framework for Credit Risk Management and Targeted Marketing. *Systems*, 14(1), 16. <https://doi.org/10.3390/systems14010016>
- Jacques, O. (2021). Austerity and the path of least resistance: how fiscal consolidations crowd out long-term investments. *Journal of European public policy*, 28(4), 551–570. <https://doi.org/10.1080/13501763.2020.1737957>
- Jalles, J. T., Kiendrebeogo, Y., Lam, R., & Piazza, R. (2024). Revisiting the countercyclicality of fiscal policy. *Empirical Economics*, 67(3), 877–914. <https://doi.org/10.1007/s00181-024-02586-z>
- Jamiu, Y. A., Abdulkadri, I., & Akinlolu, A. O. (2025). Machine Learning and Econometrics: Bridging the Gap for Enhanced Economic Analysis. *Gharee for Economics & Administration Sciences*, 21(1). <https://doi.org/10.36325/ghjec.v21i1.17773>
- Jung, H. (2022). Online open budget: The effects of budget transparency on budget efficiency. *Public Finance Review*, 50(1), 91–119. <https://doi.org/10.1177/10911421221093412>
- Kansheba, J. M. P., & Marobhe, M. I. (2022). Institutional quality and resource-based economic sustainability: the mediation effects of resource governance. *SN business & economics*, 2(2), 19. <https://doi.org/10.1007/s43546-021-00195-x>
- Khan, I. (2024). Policy pushes, prices, and people: unveiling drivers of global remittance inflows. *Journal of the Knowledge Economy*, 1–25. <https://doi.org/10.1007/s13132-024-02456-0>
- Kiviet, J. F., Pleus, M., & Poldermans, R. W. (2017). Accuracy and efficiency of various GMM inference techniques in dynamic micro panel data models. *Econometrics*, 5(1), 14. <https://doi.org/10.3390/econometrics5010014>
- Lechner, M. (2023). Causal machine learning and its use for public policy. *Swiss Journal of Economics and Statistics*, 159(1), 8. <https://doi.org/10.1186/s41937-023-00113-y>
- Li, B., Chen, Y., Wu, H., & Mao, X. (2025). Macroeconomics, geopolitical risk, and resource commodity price bubbles. *Resources Policy*, 101, 105478. <https://doi.org/10.1016/j.resourpol.2025.105478>
- Lieli, R. P., Hsu, Y.-C., & Reguly, Á. (2022). The use of machine learning in treatment effect estimation. In *Econometrics with Machine Learning* (pp. 79–109). Springer. https://doi.org/10.1007/978-3-031-15149-1_3
- Maashani, S. S. S., Gamal, A. A. M., Shaarani, A. Z., AbdulJalil, N., & Abd. Hadi, F. S. (2025). Examining the asymmetric influence of tax revenue policy in an oil-dependent economy: evidence from Oman. *Journal of Financial Economic Policy*. <https://doi.org/10.1108/JFEP-01-2024-0013>
- Mabkhot, H., & Al-Wesabi, H. A. H. (2022). Banks’ financial stability and macroeconomic key factors in GCC countries. *Sustainability*, 14(23), 15999. <https://doi.org/10.3390/su142315999>
- Magazzino, C. (2022). Fiscal sustainability in the GCC countries. *International Journal of Economic Policy Studies*, 16(2), 389–408. <https://doi.org/10.1007/s42495-022-00082-9>

- Magazzino, C., & Haroon, M. (2025). The interrelation among environmental quality, public accounts, and macroeconomic fundamentals: An analysis of OECD countries using machine learning techniques. *Environmental Development*, 54, 101175. <https://doi.org/10.1016/j.envdev.2025.101175>
- Martinez-Garcia, I., Basco, R., Gomez-Anson, S., & Boubakri, N. (2022). Ownership concentration in the Gulf cooperation Council. *International Journal of Emerging Markets*, 17(1), 219–252. <https://doi.org/10.1108/IJOEM-03-2020-0290>
- Martins, P., & Correia, L. (2021). Fiscal institutions: different classifications and their effectiveness. *Eurasian Economic Review*, 11(1), 159–190. <https://doi.org/10.1007/s40822-020-00155-0>
- Oleksiv, I., & Mirzoieva, D. (2022). Economic complexity and knowledge economy: diffusion of the knowledge as a factor for economic growth. *Management and Entrepreneurship in Ukraine: The Stages of Formation and Problems of Development*, 4(1), 224–230. <https://doi.org/10.23939/smeu2022.01.224>
- Onatunji, O. G. (2025). Revisiting the Fiscal Policy–Income Inequality Nexus in Sub-Saharan Africa: Does Institutional Quality Matter? *Managerial and Decision Economics*, 46(5), 3172–3188. <https://doi.org/10.1002/mde.4517>
- Patidar, A. K., Jain, P., Dhasmana, P., & Choudhury, T. (2024). Impact of global events on crude oil economy: a comprehensive review of the geopolitics of energy and economic polarization. *GeoJournal*, 89(2), 50. <https://doi.org/10.1007/s10708-024-11054-1>
- Rickman, D. S., & Wang, H. (2024). Estimating the economic effects of US state and local fiscal policy: A synthetic control method matching-regression approach. *Growth and Change*, 55(2), e12717. <https://doi.org/10.1111/grow.12717>
- Sadraoui, T., & Mili, H. (2025). Dynamic Interactions Between Oil Price Volatility and Fiscal Policy: Empirical Evidence from GCC Countries. *Economies*, 13(11), 334. <https://doi.org/10.3390/economies13110334>
- Saeed, S., Makhdum, M. S. A., Anwar, S., & Yaseen, M. R. (2023). Climate change vulnerability, adaptation, and feedback hypothesis: a comparison of lower-middle, upper-middle, and high-income countries. *Sustainability*, 15(5), 4145. <https://doi.org/10.3390/su15054145>
- SenGupta, S., & Atal, A. (2025). Climate change and India's inflation, fiscal space and growth. *International Review of Applied Economics*, 1–31. <https://doi.org/10.1080/02692171.2024.2445844>
- Shah, S. S. A., & Afridi, M. A. (2023). Cyclical variation of fiscal multipliers in Caucasus and Central Asia economies: an empirical evidence. *Economic Change and Restructuring*, 56(6), 4531–4563. <https://doi.org/10.1007/s10644-023-09566-w>
- Song, F., Huang, Y., & Liu, C. (2025). Extended Application of Double Machine Learning in Corporate Financial Resilience Research: Based on Data Factor Marketization. *Systems*, 13(4), 292. <https://doi.org/10.3390/systems13040292>
- Tengfei, L., & Ullah, A. (2024). Impact of fiscal policies and green financing on firm innovation and firm value for green economic recovery. *Heliyon*, 10(9). <https://doi.org/10.1016/j.heliyon.2024.e30145>
- Van Leeuwen, B., Didenko, D., Calabrese, M., & Wang, M. (2025). The Effect of Government Expenditure and Monetary Expansion on Economic Growth. In *Innovation and Economic Development in Eurasia, 500 BCE-Present: The Roots of Divergence* (pp. 229–295). Springer. https://doi.org/10.1007/978-3-031-97043-6_8
- Vu, T. V. (2022). Does institutional quality foster economic complexity? The fundamental drivers of productive capabilities. *Empirical Economics*, 63(3), 1571–1604. <https://doi.org/10.1007/s00181-021-02175-4>
- Wang, S., Shao, J., & Kim, J. K. (2014). An instrumental variable approach for identification and estimation with nonignorable nonresponse. *Statistica Sinica*, 1097–1116. <http://dx.doi.org/10.5705/ss.2012.074>
- Xi, S., Wang, X., & Lin, K. (2025). The Impact of Carbon Emissions Trading Pilot Policies on High-Quality Agricultural Development: An Empirical Assessment Using Double Machine Learning. *Sustainability*, 17(5), 1912. <https://doi.org/10.3390/su17051912>

- Yusuf, N., & Nasrulddin, V. (2024). Significance of international trade and national GDP as two integral components of sustainable economic development in Saudi Arabia. *Journal of the Knowledge Economy*, 15(1), 2298–2317. <https://doi.org/10.1007/s13132-023-01245-5>
- Zhou, L., Hu, J., Liu, D., & He, M. (2023). Studying the role of fiscal policy to utilize natural resources development: Leads to sustainable development goals. *Resources Policy*, 84, 103651. <https://doi.org/10.1016/j.resourpol.2023.103651>