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External Debt, Institutional Quality, Smart Governance, and Digital Transformation: Implications for Sustainable Economic Growth in Middle Eastern Oil Countries and Iran

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ABSTRACT

This study examines the relationship between external debt and sustainable economic growth, considering institutional quality, smart governance, and digital transformation in Iran and selected Middle East oil countries. Using annual data for Middle East oil countries (2000–2023) and Iran (1991–2024), the study applies a Panel Smooth Transition Regression (PSTR) model for the panel analysis and a Logistic Smooth Transition Regression (LSTR) model for the country-specific time-series analysis to capture nonlinear relationships. The research is descriptive-correlational and applied. In the panel analysis, LLC and IPS unit root tests confirmed stationarity, and the Kao test established a long-term cointegrating relationship. Linearity tests supported the use of the PSTR model. In Iran's time-series analysis, Phillips–Perron and Johansen tests confirmed long-run equilibrium, while linearity tests justified the application of the LSTR model. The LSTR estimates indicate that external debt negatively affects sustainable economic growth under nonlinear conditions, with the adverse effect strengthening after crossing the −0.459 threshold. Furthermore, institutional quality, regulatory quality, smart governance, digital transformation, financial development, trade openness, and the rule of law exhibit positive and significant effects, whereas inflation and budget deficits negatively affect growth. Diagnostic tests confirm coefficient stability and the absence of autocorrelation and heteroscedasticity. Overall, the findings suggest that strengthening smart governance, institutional quality, and digital transformation can mitigate the adverse effects of external debt, providing a robust framework for fiscal and debt policy formulation in Middle Eastern oil-producing countries and Iran. **©authors**

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Introduction

In recent decades, sustainable economic growth has become one of the most important macro-goals of countries; especially in the oil economies of the Middle East, which are heavily dependent on natural resource revenues, achieving sustainable growth faces several structural challenges (Obeidat, 2025). One of the most important of these challenges is the increase in external debt and its consequences for economic stability and long-term growth. Although external debt can help finance development projects in the short term, if not managed properly, it may lead to increased economic vulnerability, pressure on the balance of payments, and reduced productive investments (Reinhart & Rogoff, 2010; Panizza & Presbitero, 2014).

In the theoretical literature, the relationship between external debt and economic growth has not always been analyzed in a linear manner. Many studies have shown that this relationship can be nonlinear and dependent on the institutional and structural conditions of countries (Cecchetti et al., 2011). In other words, the effect of external debt on economic growth may be positive at low debt levels and negative at high levels. This threshold feature doubles the importance of examining the institutional and policy conditions of countries.

In the meantime, the role of the institutional quality of the government as one of the key factors determining the efficiency of the use of financial resources and external debt is very prominent (Shi et al, 2025). Efficient institutions can moderate the negative effects of debt by reducing corruption, increasing transparency, and improving economic governance and paving the way for sustainable growth (Robinson & Acemoglu, 2012). In contrast, institutional weakness can cause the waste of debt resources and increase economic inefficiency (ul Ain et al, 2025).

On the other hand, in recent years, the concepts of smart governance and digital transformation have been proposed as two new driving forces in economic systems. Smart governance is based on the use of data, digital technologies, decision-making systems, and information transparency that can increase government efficiency and optimize resource allocation (OECD, 2020). Digital transformation also plays an important role in promoting sustainable growth by creating information and communication technology infrastructure, developing e-government, and increasing economic productivity (World Bank, 2022). However, in many oil-producing countries in the Middle East and Iran, the degree of integration of digital technologies into governance and debt management processes is still limited and uneven.

Oil-producing economies in the Middle East are exposed to financial and economic vulnerabilities due to their high dependence on oil revenues, severe income fluctuations, and heterogeneous institutional structures (Masuch et al, 2017; Shajarati et al, 2025). In such countries, external debt is often used as a tool to offset budget deficits and stabilize the economy, but the lack of strong institutional infrastructure and weakness in economic governance can exacerbate its negative effects. Iran, as one of the important economies in the region, also faces challenges such as economic sanctions, external financial restrictions, and institutional inefficiency, which makes it more necessary to examine the relationship between external debt and sustainable growth in this country.

Empirical studies have also provided mixed results on the effect of external debt on economic growth. Some studies have reported a significant negative effect of debt on growth (Eberhardt & Presbitero, 2015), while others have shown that, under appropriate institutional conditions, debt can play a growth-enhancing role. These contradictions indicate that moderating variables such as institutional quality, level of digital development, and smart governance should be included in the analyses.

From the perspective of endogenous growth theories, human capital, technology, and institutional quality are among the most important determinants of sustainable growth. In this framework, the introduction of digital technologies and smart governance can increase capital and labor productivity and reduce the negative effects of external debt. Also, the

digital economy allows for optimal debt management by creating financial transparency and reducing transaction costs (UNCTAD, 2021).

Despite the importance of this issue, there is a significant gap in the existing research literature in simultaneously examining the impact of external debt on sustainable economic growth by considering a combination of three key variables: institutional quality, smart governance, and digital transformation. Most previous studies have either focused solely on the linear relationship between debt and growth or have examined the role of institutional quality alone, while the role of new technologies and data-driven governance has received less attention (Arabi et al, 2025).

Consequently, the main issue of this research is to determine how external debt affects sustainable economic growth in the Middle East oil countries and Iran and whether this effect changes under the influence of institutional quality, the level of smart governance, and the extent of digital transformation. In other words, this research seeks to answer the fundamental question of whether the development of efficient institutions and digital infrastructure can moderate the negative effects of external debt and pave the way for achieving sustainable economic growth?

This issue is doubly important because the countries under study are in economic transition and under financial pressure, and adopting appropriate policies in the areas of debt management, institutional reform, and digital development can play a decisive role in their future economic growth. Therefore, examining the nonlinear relationship between external debt and sustainable economic growth in terms of institutional quality, smart governance, and digital transformation can help fill theoretical gaps and provide practical policy recommendations (Hajihassani et al, 2024).

The policy implications of this study should be interpreted within the scope of the selected sample, namely Middle Eastern oil-producing countries and Iran. Although the findings provide valuable evidence regarding the interaction between external debt, institutional quality, smart governance, digital transformation, and sustainable economic growth, they should not be generalized to all oil-dependent economies without caution. Differences in institutional arrangements, levels of digital maturity, governance capacity, economic diversification, and external economic conditions may lead to different outcomes in other regions. Therefore, the proposed policy recommendations are most relevant for countries with similar structural and institutional characteristics. Future research is encouraged to extend the analysis to a larger group of oil-exporting and resource-dependent economies to examine the robustness and external validity of the proposed framework.

Despite the growing body of literature on external debt and economic growth, several important research gaps remain. First, most empirical studies have focused on the direct or linear relationship between external debt and growth, while comparatively few have examined nonlinear debt-growth dynamics through threshold models, despite growing evidence that the economic effects of debt depend on debt regimes and country-specific characteristics (Pattillo, Poirson, & Ricci, 2004; Panizza & Presbitero, 2014). Second, although institutional quality has increasingly been recognized as an important determinant of debt sustainability and economic performance (Acemoglu & Robinson, 2012; North, 1990), previous studies have generally examined institutional variables in isolation and have rarely integrated them with emerging dimensions of smart governance and digital transformation. Third, empirical evidence for oil-producing economies in the Middle East remains limited, despite the fact that these countries exhibit unique structural characteristics, including heavy dependence on hydrocarbon revenues, exposure to commodity-price volatility, heterogeneous institutional environments, and ongoing digital transformation initiatives (International Monetary Fund, 2024; World Bank, 2023).

Accordingly, this study extends the existing literature in several important ways. First, it simultaneously examines the joint roles of institutional quality, smart governance, and digital transformation in shaping the nonlinear relationship between external debt and

sustainable economic growth. Second, unlike previous studies that mainly employ linear panel estimators, this research applies Panel Smooth Transition Regression (PSTR) and Logistic Smooth Transition Regression (LSTR) models to identify regime-dependent effects and critical debt thresholds. Third, by combining a cross-country panel analysis of Middle Eastern oil-producing countries with a country-specific nonlinear analysis for Iran, the study provides evidence on both regional patterns and country-level dynamics. Therefore, this research contributes not only to the debt-growth literature but also to the emerging literature on digital governance and institutional economics by demonstrating how institutional capacity and digital transformation can moderate the growth effects of external debt in resource-dependent economies.

Literature Review

External Debt and Economic Growth

In macroeconomic literature, external debt is considered as a development financing tool that can compensate for domestic investment constraints in the short term. According to classical debt theories, the optimal use of external resources can enhance economic growth when the rate of return on investment is higher than the cost of debt. However, within the framework of the "Debt Overhang" theory, increasing debt levels in developing economies may reduce investment incentives and increase economic uncertainty (Arčabić et al, 2018). Recent studies have also shown that the relationship between debt and economic growth is often nonlinear and the existence of debt thresholds can explain the change in the sign of the effect (Eberhardt & Presbitero, 2015).

In oil economies, this relationship is more complex, as dependence on oil revenues causes severe income fluctuations and increases the use of external debt during recessions. In such circumstances, the efficiency of debt use is highly dependent on the quality of economic institutions (Sarabdeen et al, 2024).

Sustainable economic growth

Sustainable economic growth, within the framework of endogenous growth theory, refers to growth that, in addition to increasing production, also ensures environmental sustainability, financial stability, and improved long-term welfare. In this view, human capital, technology, and efficient institutions play a key role in sustaining growth (Aghion & Howitt, 2008). In recent years, the concept of economic sustainability has been increasingly linked to the quality of governance and institutional capacity of countries.

World Bank studies show that countries with institutional stability and transparent policymaking have greater capacity to convert financial resources (including external debt) into sustainable growth (World Bank, 2022). Therefore, sustainable growth is not only an economic variable, but also an institutional-structural phenomenon.

Smart Governance, Digital Transformation and Its Institutional Role in Growth

Smart governance refers to the use of big data, digital technologies, artificial intelligence and decision support systems in policy-making and public management processes. In this context, governments can increase transparency, accountability and efficiency in resource allocation by using digital technologies (OECD, 2020). Digital transformation, as the process of integrating new technologies into economic and institutional structures, also provides the basis for increasing productivity and reducing transaction costs (UNCTAD, 2021).

According to the theory of digital governance, countries with a higher level of government and economic digitalization have greater ability to control debt, manage finances and reduce macroeconomic risks. Also, digital technologies improve institutional quality by increasing financial transparency and reducing corruption (OECD, 2023). As a result, smart governance can act as a moderating variable in the relationship between external debt and sustainable growth.

In the oil economies of the Middle East and Iran, although investment in digital infrastructure is increasing, the digital divide and weak institutional integration still prevent the full exploitation of smart governance capacities (Olofin, 2023).

Based on theoretical foundations, the relationship between external debt and sustainable economic growth is not a simple linear relationship, but is influenced by institutional quality and the level of digital development. In conditions where smart governance and digital transformation are developed, the negative effects of external debt can be reduced and even turned into positive effects. In contrast, institutional weakness and the lack of digital infrastructure can exacerbate the negative effects of debt.

The relationship between external debt and sustainable economic growth has long been debated in the economic literature. Traditional development theories argue that external borrowing can accelerate economic growth by relaxing domestic savings constraints and providing financial resources for productive investment, infrastructure development, human capital formation, and technological progress (Chenery & Strout, 1966). In this context, external debt can complement domestic capital accumulation and support long-term economic development, particularly in developing and resource-dependent economies facing financing gaps.

However, the beneficial effects of external debt depend critically on its size and utilization. The debt overhang hypothesis suggests that when external debt exceeds a country's repayment capacity, investors anticipate that a substantial share of future returns will be used to service debt, thereby discouraging private investment and reducing economic growth (Krugman, 1988; Sachs, 1989). Similarly, excessive debt servicing may crowd out productive public expenditures on infrastructure, education, and technological innovation, leading to lower productivity and weaker long-term growth.

Institutional quality represents one of the most important mechanisms through which external debt affects economic performance. According to institutional economics, effective institutions improve resource allocation, reduce corruption, strengthen fiscal discipline, and enhance government accountability, thereby increasing the productivity of externally borrowed resources (North, 1990; Acemoglu, Johnson, & Robinson, 2005). Countries characterized by high regulatory quality, government effectiveness, and the rule of law are more capable of channeling external borrowing toward productive investment, while weak institutions often result in inefficient spending, rent-seeking behavior, and debt mismanagement.

Moreover, smart governance and digital transformation further reinforce institutional capacity by improving transparency, public financial management, and evidence-based policymaking. Digital technologies facilitate real-time monitoring of public expenditures, strengthen debt management systems, reduce information asymmetry, and improve government responsiveness. Consequently, digital transformation enhances the effectiveness of institutions and enables governments to manage external debt more efficiently while promoting sustainable economic growth. Therefore, the overall impact of external debt depends not only on the level of indebtedness but also on the quality of institutions, governance effectiveness, and the degree of digital transformation

The impact of external debt on sustainable economic growth is transmitted through several channels. Moderate external borrowing can finance productive investment, infrastructure development, and technological upgrading, thereby stimulating long-run growth. However, excessive debt may generate debt overhang, crowd out productive public expenditure, increase debt-servicing costs, and discourage private investment. Institutional quality moderates these effects by improving fiscal discipline, transparency, and public investment efficiency. Moreover, smart governance and digital transformation strengthen institutional effectiveness through digital public services, data-driven decision-making, and transparent debt management systems, enabling governments to utilize borrowed resources more efficiently.

Method

The statistical population includes selected oil countries in the Middle East along with Iran in specific time periods. Also, the statistical sample of the research includes economic data of these countries from 2000 to 2023 and for Iran from 1370 to 1403 on an annual basis. The research model, based on previous studies, examines the impact of external debt on sustainable economic growth by considering the heterogeneity of regulatory quality and government institutional quality. For this purpose, the smooth transition regression (STAR) model was used, which allows for nonlinear analysis and gradual transition between regimes. The STAR model models the nonlinear relationship between variables in a continuous manner using the logistic and exponential transfer function, and its linear and nonlinear parameters are estimated through the maximum likelihood method and the Newton-Raphson algorithm. Econometric methods of threshold autoregressive (TAR) models and the STAR model were used to analyze the data, and the characteristics of abrupt transition in TAR and gradual transition in STAR were identified. Also, methods for determining the number of breaks, the lag parameter, and the selection of the transfer function were performed. In the following, data reliability and stationarity tests in panel data were presented, including the LL, IPS, and Fisher tests, and methods for examining the cointegration of variables in combined data were explained. In this study, the effect of external debt on sustainable economic growth is examined by considering heterogeneity in regulatory quality and government institutional quality (testing the nonlinear effects of smooth transition) for selected Middle Eastern oil countries and Iran. The present study consists of two parts.

The study employs two complementary empirical frameworks with different temporal coverage due to data availability and research objectives. The panel analysis covers the period 2000–2023 because consistent cross-country data for institutional quality, smart governance, and digital transformation indicators are only available for all selected Middle Eastern oil-producing countries during this interval. In contrast, the country-specific time-series analysis for Iran utilizes annual data from 1991 to 2024 to exploit the longest available dataset and better capture long-run relationships. Therefore, the two analyses are intended to provide complementary evidence rather than directly comparable estimates, and their findings are interpreted within their respective temporal and methodological contexts.

The nonlinear framework was selected because the relationship between external debt and sustainable economic growth is expected to vary across different debt regimes. Linear models assume constant marginal effects, whereas PSTR and LSTR models allow the impact of external debt to change smoothly after a critical threshold is reached. Unlike Threshold Autoregressive (TAR) models, which assume abrupt regime changes, Smooth Transition Regression (STAR) models capture gradual transitions between regimes. The LSTR model represents the time-series version of the STAR framework, while the PSTR model extends this approach to panel data. Given that debt accumulation typically influences economic performance progressively rather than instantaneously, the PSTR/LSTR approach is considered more appropriate for the present study.

The selected countries are major oil-producing economies in the Middle East that share common structural characteristics, including dependence on hydrocarbon revenues, exposure to oil-price fluctuations, and similar fiscal challenges associated with external borrowing. The panel period (2000–2023) was determined by the availability of consistent cross-country data for institutional quality, governance, and digital transformation indicators. For Iran, a longer time-series period (1991–2024) was employed to capture long-run nonlinear dynamics using the maximum available observations.

Part One: Selected Middle Eastern Oil Countries

In the first part, the issue is examined in selected oil countries using the Star Panel Soft Threshold Model. The Star Panel Soft Threshold Model (PSTAR) was developed by

Terrasorta and Anderson (1992) and Terrasorta (1994). Unlike TAR models that use an indicator function to control the regime change process, the Star Soft Threshold Model uses exponential and logistic functions for this purpose. According to Van Dijk and Terrasorta (2002), these models are very suitable for analyzing asymmetric cycles of variables, and many studies have shown that they fit the regime change mechanism well for examining the nonlinear dynamics of variables. In fact, the Star soft threshold model models the nonlinear relationship between variables in a continuous manner using the transition variable and the value of the slope parameter. The Trasorta soft transition regression model is specified as a general regression as follows.

(1)

$$y_t = \pi' z_t + \theta' z_t + F(s_t, \gamma, c) + u_t$$

where z_t is a vector containing the exogenous variables of the model; π is a vector of linear parameters; θ is a vector of nonlinear parameters of the model; u_t is a residual component that is assumed to be identically and independently distributed with zero mean and constant variance $(u_t \approx iid(0, \sigma^2))$. Also, the transfer function $F(s_t, \gamma, c)$ can be specified as a logistic or exponential function in the form of the following relation.

(2)

$$F(s_t, \gamma, c) = \left[\frac{1}{1 + \exp(-\gamma(s_t - c))} - \frac{1}{2} \right]$$

(3)

$$F(s_t, \gamma, c) = \left[1 - \exp(-\gamma(s_t - c))^2 \right]$$

So that equation (2) represents the logistic transfer function and equation (3) represents the exponential transfer function. In the above functions, s_t represents the transfer variable; γ represents the slope parameter; c represents the threshold or the place where the regime change occurs. If the slope parameter γ, which represents the speed of the transition from one regime to another, tends to infinity, the STAR soft threshold model becomes a TAR threshold model, meaning that if the transfer variable is greater than the threshold;

($c < s_t$) the transfer function becomes one (F=1). On the other hand, if ($c > s_t$) the value of the transfer function will be zero (F=0). Also, if the value of the slope parameter tends to zero, the STAR model will become a linear model. The final model can be specified as follows:

(4)

$$SD_{it} = \alpha_0 + \beta_1 ED_{it} + \beta_2 RQ_{it} + \beta_3 IQ_{it} + \beta_4 FD_{it} + \beta_5 POP_{it} + \beta_6 OPEN_{it} + \beta_7 INF_{it} + \beta_8 RL_{it} + \beta_9 BD_{it} (\theta_1 FAC_{it} + \theta_2 ED_{it} + \theta_3 RQ_{it} + \theta_4 IQ_{it} + \theta_5 FD_{it} + \theta_6 POP_{it} + \theta_7 OPEN_{it} + \theta_8 INF_{it} + \theta_9 BD_{it}) F(S_t, \gamma, c) + u_{it}$$

Part Two: Iran

In the second part, the issue is examined in Iran using the Star soft threshold model.

The final model can be stated as follows:

(5)

$$SD_{\mathrm{i}} = \alpha_0 + \beta_1 ED_t + \beta_2 RQ_t + \beta_3 IQ_t + \beta_4 FD_t + \beta_5 POP_t + \beta_6 OPEN_t + \beta_7 INF_t + \beta_8 RL_t + \beta_9 BD_t \ (\theta_1 FAC_t + \theta_2 ED_t + \theta_3 RQ_t + \theta_4 IQ_t + \theta_5 FD_t + \theta_6 POP_t + \theta_7 OPEN_t + \theta_8 INF_t + \theta_9 BD_t) F(S_t, \gamma, c) + u_t$$

Operational definition of study variables

SD: Sustainable economic growth; Various studies use various indicators to show the sustainable economic growth of countries. In this study, the Sustainable Development Index, which is provided by the World Bank and provides the most recent and comprehensive information on global development, is used. This index measures the average achievements of a country in the dimensions of poverty, health, hunger, global warming, gender inequality, water scarcity, energy, environmental degradation, and is ranked from zero to 1, with a higher score indicating countries with a high level of sustainable development and a lower score indicating countries with less sustainable development. (Data source: World Bank, 2020).

Institutional Quality (RQ): Average of the Institutional Quality Index: To measure the quality of institutions, five different categories or subcategories are combined: (1) Size of government (2) Legal system and property rights (3) Accountability and transparency (4) International free trade (5) Credit, labor, and business regulations. There are major components in these five areas, and these components include sub-components that lead to an overall index of independent variables. The Fraser Institute uses a scale for each category that averages these five indicators to obtain a complete index for each country. In this index, zero represents the smallest institutional value and five represents the highest institutional quality

BD: Government budget deficit

ED: Total external debt measured as a percentage of GDP

FD: Financial development measured as a percentage of GDP

OPEN: Trade openness measured as the ratio of exports plus imports to GDP (trade share).

RO: Regulatory Quality: In this study, the percentile rank is a measure between 0 and 100, and the closer the country's rank is to 100, the better the regulatory quality index is

RL: Role or Rule of Law: In this study, the percentile rank is a measure between 0 and 100, and the closer the country's rank is to 100, the better the rule of law index is

POP: Population growth rate

INF: Inflation rate

Findings

In this part of the chapter, and before conducting the panel cointegration test, the Levin-Lin-Chow unit root (LLC) test is performed to determine the long-run relationship between the main indicators of the study.

Table 1. *Unit root test results for variables*

Abbreviation	Selected Countries		Reliability level
	LLC W-stat		
	Calculated statistic	Probability level	
BD	3.59707	0.0002	I(0)
ED	-2.49838	0.0062	I(0)
FD	-2.19661	0.0140	I(0)
INF	-5.66308	0.0000	I(0)
OPEN	-2.60541	0.0046	I(0)
POP	-5.34528	0.0000	I(0)
RL	-3.25844	0.0006	I(0)
RO	-9.47306	0.0000	I(0)
RQ	-4.31890	0.0000	I(0)
SD	-11.7389	0.0000	I(0)

The results of Table 1 and the examination of the calculated statistical values and their probability of acceptance show that all research variables are at a stable level.

Convergence test:

Most economic theories express the long-term relationship between variables in the form of a level (LEVEL FORM). In the present study, the Kao panel cointegration test has been used to ensure the existence of a long-term equilibrium relationship.

Table 2. *Cointegration test results*

KAO TEST		
	Test statistic	Corresponding probability
ADF	-7.398890	0.0000

Linearity test, selection of transition variable and model type

The results of the diagnostic test in Table (3) show that the linearity of the model (null hypothesis) is rejected; therefore, there is a nonlinear relationship between institutional quality, external debt and sustainable development in the countries under study and, as a rule, it is necessary to use the PSTR method to estimate the model parameters

Table 3. *Results of the linearity hypothesis test (BBC test)*

Significance level	Statistics F	Null hypothesis	Selected countries
0.000	30785	Wald test	
0.001	2.638	Fisher test	
0.012	2.957	LRT test	

As can be seen from the results of the test in the table above, the hypothesis of linearity between the variables is rejected, so the possibility of a linear relationship between the variables is rejected. It should also be noted that the proposed (PSTR) model is selected by the selected transfer variable as the optimal model for estimating the model in the selected countries. The results show that the null hypothesis of the adequacy of considering a transfer function in both cases of one and two thresholds is not rejected; therefore, a transfer function is able to specify the threshold effects of external debt on sustainable economic growth by considering heterogeneity in the quality of regulations and the institutional quality of the government.

Table 4. Test for the existence of a residual nonlinear relationship

The state of existence of one threshold limitM=1			The state of existence of two threshold limits M=2		
Selected oil countries					
LMw	LM_f	LR	LMw	LM_f	LR
1.352	1.471	1.432	1.425	1.362	1.297
(0.743)	(0.630)	(0.654)	(0.675)	(0.751)	(0.802)
H_0: r=1, H_1: r=2					

By confirming the existence of a nonlinear relationship between the variables and the adequacy of a transfer function to specify the nonlinear behavior, the optimal state between the transfer function and one or two thresholds should be selected. For this purpose, the PSTR model corresponding to each of these states will be estimated, and among them, based on the criteria of the sum of squared residuals, Schwartz and Akaike, the PSTR model with a threshold is the optimal model; therefore, a PSTR model with a transfer function and a threshold is selected to examine the nonlinear behavior between the variables under study.

Model Estimation Results

Using a PSTR model in which the transfer variable is external debt, the sustainable development function is modeled. Considering the confirmation of the nonlinear model, the results of the nonlinear part of the model are analyzed. According to the result of the model estimation, the coefficient of the external debt variable (ED) in the nonlinear part is -0.49, which indicates the negative impact of external debt on sustainable development in the selected countries. Considering the probability corresponding to this coefficient, which is 0.0069 and less than 0.05, this effect is significant at the 95% confidence level. Also, the coefficient of the variable and the computational probability for the variables of institutional quality, regulatory quality, and rule of law are 0.016, 0.089, and 0.235, respectively, and the computational probabilities for these variables are 0.0355, 0.0015, and 0.0053. It can be stated that the impact of the variables of regulatory quality, institutional quality, and rule of

law on improving sustainable development is positive and significant. The variables of inflation and government budget deficit have a negative and significant impact on sustainable development, as estimated by the model. Regarding the trade openness variable, it can be stated that, considering the coefficient of this variable, which is equal to 0.05, and the computational probability for this variable, which is equal to 0.0165, trade openness has a positive and significant effect on sustainable development in the selected oil-producing countries under study.

Table 5. *Model estimation using the PSTR model*

Selected Middle East oil-producing countries				
Estimation of the linear part of the model				
Probability	T-Statistic	Standard Deviation	Coefficient	Variable
0.0234	2.418698	0.136048	0.329059	CONSTANT
0.0419	-2.091051	0.075984	-0.158886	ED
0.0149	2.438644	0.239013	0.582868	RQ
0.0003	3.637702	0.026454	0.096233	RO
0.0491	1.982849	0.055542	0.110132	FD
0.0356	2.353357	0.090308	0.212527	POP
0.0201	2.757139	0.142781	0.393667	OPEN
0.0200	-2.782475	0.230948	-0.642607	INF
0.0008	3.380603	0.028983	0.097980	RL
0.0218	-2.718959	0.159418	-0.433451	BD
Estimation of the nonlinear part of the model				
0.0049	2.796881	0.006021	0.016839	CONSTANT
0.0069	-2.825358	0.175702	-0.496421	ED
0.0355	2.335214	0.007091	0.016559	RQ
0.0015	3.195642	0.027937	0.089278	RO
0.0201	2.324058	0.085146	0.197885	FD
0.0274	2.205968	0.010298	0.022717	POP
0.0165	2.396934	0.022425	0.053752	OPEN
0.0077	-2.675502	0.004822	-0.012901	INF
0.0053	2.762255	0.085117	0.235516	RL
0.0378	-2.245690	0.006607	-0.014838	BD
0.0000	-4.984412	0.042362	-0.211146	(C)Threshold
0.0007	3.41115	0.21569	0.73577	(γ)Slope parameter
Adjusted coefficient (R^2) = 0.85				

The comparison of coefficients in two different regimes is based on the transfer variable and its values, and the value of the transfer variable can determine the transfer function and, consequently, the ruling regime. In the above estimation, the transfer variable is the external debt, and the estimated threshold value for this variable was equal to -0.21 for the selected countries. Based on the distance of the external debt from this threshold value, the model follows two different limit regimes. By comparing the coefficients of the model in two different regimes, it is observed that when the external debt crosses the threshold (0.21) (transition from the linear to the nonlinear part), the response of sustainable development to changes in this variable has increased sharply, so that the higher the external debt, the more sustainable development is affected by it.

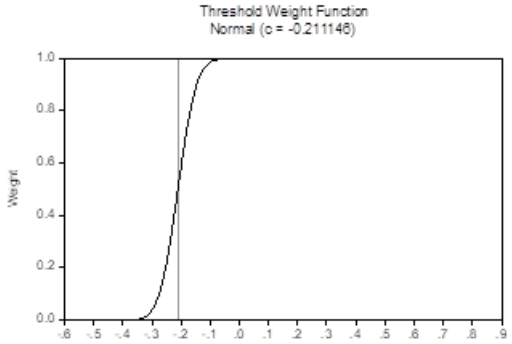

Figure 1. *Relationship between transfer function and transfer variable*

Tests for detecting disordered sentences

In the present study, the Durbin-Watson test is used to examine autocorrelation.

Table 6. *Results of the autocorrelation test*

	Durbin-Watson	Prob	Statistics F
Selected Middle East oil countries	0.236	0.69	1.235

As can be seen in the table above, the results of the Durbin-Watson autocorrelation test show that there is no correlation between the disturbance components, so the third assumption of the classical standard that there is no autocorrelation between the error terms is not violated. Therefore, the estimators have the necessary properties (minimum variance and efficiency).

Another assumption of the classical standard is the assumption of homogeneity of variance, in the present study the Brosch-Pagan-Godfrey test is used.

Table 7. *Results of the heterogeneity of variance test*

Brosch-Pagan-Godfrey	Prob	Statistics F
1.327	0.556	1.298

As can be seen in the table, the test results indicate the absence of variance heterogeneity.

Test of the stability of coefficients between two regimes

Another suitable measure for assessing the quality of the estimated model is the examination of the changes in the coefficients between two regimes. If the estimated model is a good estimate, the coefficients are expected to remain constant and unchanged with the regime change.

Table 8. *Results of the stability test of the smooth transition parameter*

	Prob	Statistics F	Null assumption
Selected Middle East oil countries	0.754	0.745	b1=b2=b3=b4=0
	0.712	0.798	b1=b2=b3=0
	0.695	0.821	b1=b2=0
	0.674	0.836	b1=0

As can be seen in the table, the test of the stability of the coefficients between the two regimes shows that the coefficients do not change due to the change in the regime.

Part Two: Model Estimation in Iran

Reliability and Cointegration Test

Therefore, the classic F, t tests resulting from estimation methods in which the behavioral stability or stationarity of the variables is not realized are not valid and will yield misleading results. In this study, the conventional Phillips Perron test has been used.

Table 9. *Results of the pp test on the level of model variables*

Statistic pp			
Variables	**Statistics**	**Probability**	**Variable status**
SD	-3.045255	0.1359	---
D(SD)	-7.852144	0.0000	I(1)
BD	1.531340	0.9737	---
D(BD)	-17.41740	0.0001	I(1)
ED	0.075892	0.9589	---
D(ED)	-3.565203	0.0124	I(1)
FD	0.361050	0.9780	---
D(FD)	-5.728964	0.0000	I(1)
INF	8.841559	0.9985	---
D(INF)	-5.409196	0.0012	I(1)
OPEN	-2.803699	0.2060	---
D(OPEN)	-8.094433	0.0000	I(1)
POP	-1.116311	0.6975	---
D(POP)	-9.090994	0.0000	I(1)
RL	0.483068	0.9835	---
D(RL)	-5.871005	0.0000	I(1)
RO	-0.882434	0.7812	---
D(RO)	-5.787813	0.0000	I(1)
RQ	-1.363864	0.5877	---
D(RQ)	-4.774377	0.0005	I(1)

Considering the theoretical foundations of reliability tests, the null hypothesis H is defined in these tests as the lack of reliability of the variable, and considering the test results, it can be stated that all variables in the model are stable at the first level I (1).

Cointegration test results

As can be seen, the null hypothesis of the absence of a cointegration vector is rejected in contrast to the presence of a cointegration vector between the variables in the model, therefore, there is at least one cointegration vector between the variables under study.

Table 10. *Summary of results of the number of cointegration vectors*

Pattern	Fifth Pattern	Fourth Pattern	Third Pattern	Second Pattern	First Pattern
Effect test	**7**	5	**8**	6	7
Maximum specific value test	**5**	6	**7**	6	5

The results of the model estimation and the examination of the cointegration tests related to this model in the third case are reported in the table below. According to the results based on the effect test, the existence of 8 cointegration vectors and based on the results of the maximum eigenvalue test, the existence of 7 cointegration vectors is confirmed at the 5% level. As Johansson states, in case of contradiction between the results, since the maximum eigenvalue test has a stronger counter-hypothesis, this test is preferable to the effect test. Therefore, the existence of 7 cointegration vectors between the model variables can be accepted.

Table 11. *Cointegration test results*

Test statistic Maximum eigenvalues	Critical quantity at 95% level	Probability level	Test statistic Effect	Critical quantity at 95% level	Probability level	Hypothesis H_1	Hypothesis H_0
163.2733	64.50472	0.0000	633.3970	239.2354	0.0000	r=1	r=0
123.3030	58.43354	0.0000	470.1238	197.3709	0.0001	r=2	r≤1
115.1964	52.36261	0.0000	346.8208	159.5297	0.0000	r=3	r≤2
83.51150	46.23142	0.0000	231.6244	125.6154	0.0000	r=4	r≤3
44.13914	40.07757	0.0165	148.1129	95.75366	0.0000	r=5	r≤4
41.00136	33.87687	0.0060	103.9738	69.81889	0.0000	r=6	r≤5
32.49926	27.58434	0.0107	62.97241	47.85613	0.0010	r=7	r≤6
19.06261	21.13162	0.0950	30.47315	29.79707	0.0417	r=8	r≤7
9.844335	14.26460	0.2223	11.41054	15.49471	0.1875	r=9	r≤8
1.566204	3.841466	0.2108	1.566204	3.841466	0.2108	r=10	r≤9

Linearity test, selection of transition variable and model type

To estimate the smooth transition regression model, in order to select the transition variable, all variables in the model have been tested by the Phillips Perron reliability test and all study variables were found to be stable at the (I1) level, also all variables in the model were tested for selection of the transition variable. The results of Table 12 show that the transition variable in the estimated model is foreign debt and the null hypothesis of linearity of the model is rejected and the first-order (LSTR) model is confirmed and the main emphasis of the study is on the results of the nonlinear part.

Table 12. *Linearity test, selection of transition variable and model type*

Variable	Statistics F	Statistics F4	Statistics F3	Statistics F2	Proposed model
ED (t)	**0.8958**	**0.7745**	**0.5425**	**0.3896**	1LSTR

Model estimation results

In the next step, using a 1LSTR model in which the transfer variable is external debt, the effect function of external debt on sustainable economic growth will be modeled by considering heterogeneity in the quality of regulations and institutional quality of the government. For this purpose, first, initial values were selected for the threshold value of the transfer variable (C) and the slope parameter (γ), and then, using these initial values and using the Newton-Raphson algorithm, the model parameters were estimated by the likelihood maximization method, the results of which are reported in the table (below). Based on the results of the linearity test, the external debt variable was selected as the transfer variable.

The estimation results of the nonlinear part of the model (second regime) show that the government external debt variable has a negative effect on sustainable economic growth (sustainable development) and the coefficient of this variable is -0.33. Considering that the computational probability for this variable is less than 0.05, the effect of this variable on sustainable economic growth is significant at the 95% confidence level.

Regarding other variables of the model, it can be stated that, in accordance with the expectation, the effects of the variables of institutional quality, regulatory quality, financial development, degree of economic openness and rule of law on sustainable economic growth have coefficients of 0.225470, 0.252515, 0.016000, 0.149610 and 0.060326, respectively. Considering the computational probability for these variables, which are equal to 0.0062, 0.0011, 0.0000, 0.0001 and 0.0001, respectively, the effects of these variables on sustainable economic development are significant at the 5% error level. The population variable does not have a significant effect on sustainable economic development in the nonlinear part of the model. Finally, the effects of the variables of inflation rate and government budget deficit are also negative and significant at the 95% confidence level, in accordance with the results of the model estimation.

***Table 13**. Estimation of the sustainable economic growth model in Iran*

Iran				
Estimation of the linear part of the model				
Probability	T-Statistic	Standard Deviation	Coefficient	Variable
0.0823	1.737401	0.300193	0.521556	CONSTANT
0.0129	-2.495362	0.014372	-0.035862	ED
0.0038	2.892296	0.048299	0.139694	RQ
0.0683	1.835536	0.177539	0.325879	RO
0.0829	1.733825	0.307849	0.533757	FD
0.1664	1.390754	0.208206	0.289564	POP
0.0264	2.240616	0.096662	0.216582	OPEN
0.0126	-2.516070	0.070478	-0.177326	INF
0.0514	1.963091	0.079766	0.156587	RL
0.0000	-4.559580	0.096353	-0.439329	BD
Estimation of the nonlinear part of the model				
0.0676	1.840850	0.323988	0.596413	CONSTANT
0.0000	-6.572944	0.050711	-0.333319	ED
0.0062	2.776776	0.081198	0.225470	RQ
0.0011	3.317570	0.076114	0.252515	RO
0.0000	8.869412	0.001804	0.016000	FD
0.5618	0.581396	1.251277	0.727488	POP
0.0001	3.884575	0.038514	0.149610	OPEN
0.0000	-4.889962	0.004973	-0.024316	INF
0.0001	4.158281	0.014507	0.060326	RL
0.0031	-3.001677	0.039940	-0.119888	BD
0.0000	5.307807	0.086541	-0.459343	(C)Threshold
0.0000	7.395055	0.943148	6.974631	(γ)Slope parameter
Adjusted coefficient (R^2) = 0.88				

The comparison of coefficients in two different regimes is based on the transfer variable and its values, and the value of the transfer variable can determine the transfer function and, consequently, the governing regime. In fact, the transfer variable being less or more than the threshold limit can create two different regimes in the estimated function. In the above estimation, the transfer variable is the external debt, and the estimated threshold limit value for this variable was equal to -0.45 in the model. Based on the distance of the external debt from this threshold value, the model follows two different limit regimes. By comparing the model coefficients in two different regimes, it is observed that when the external debt crosses the threshold limit (-0.45), the response of sustainable economic growth to changes in this variable has increased sharply, so that the higher the external debt, the more severe the reduction in sustainable economic growth.

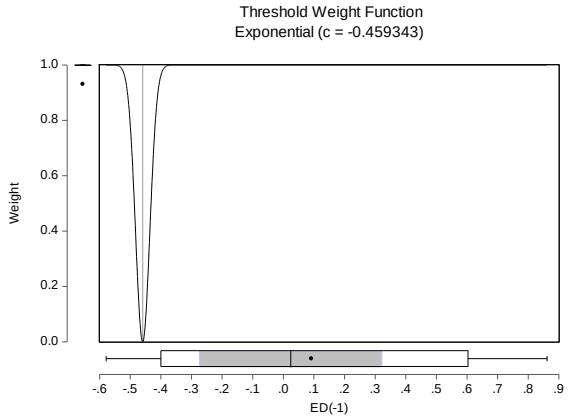

Figure 2. *Relationship between the transfer function and the external debt transfer variable*

Diagnostic tests

According to the estimation, there is no correlation error and variance heterogeneity in the estimated LSTR1 model. The test for the absence of residual nonlinearity also shows that the LSTR1 model has specified all the nonlinear behaviors present in the model.

Table 14. *Diagnostic test results*

Test	P-value	F-value
ARCH LM-test	0.6525	0.9748
No remaining nonlinearity test	0.4785	1.4525
Parameters constancy test	0.3968	1.5414

The results of the parameter stability test in different regimes also show that the null hypothesis of the test based on the stability of the coefficients and parameters of the model in two different regimes is rejected, and this result, i.e. the coefficients of the explanatory variables in two different regimes, is acceptable, and the asymmetric effects on the dependent variable, i.e. sustainable economic growth, are confirmed. Therefore, based on the estimated results of the model and the diagnostic tests performed, it seems that the 1LSTR model is a suitable model for analyzing the impact of external debt on sustainable economic growth, taking into account the heterogeneity in the quality of regulations and the institutional quality of the government, and we can trust the accuracy of the results obtained from the estimation of this model.

Discussion

The findings of this study show that the relationship between external debt and sustainable economic growth in the Middle East oil countries and Iran is nonlinear and dependent on institutional conditions; such that an increase in external debt has a negative and significant effect on sustainable economic growth at the overall level, but the severity of this effect increases when crossing certain thresholds. This result is consistent with the "excessive debt" literature and financial constraint theories, which state that increasing debt weakens long-term growth by reducing investment incentives and increasing uncertainty (Vo et al., 2019). In oil economies, this effect is exacerbated due to structural dependence on natural resource revenues and severe income fluctuations (Gherghina et al, 2025).

In contrast, the results showed that institutional quality, regulatory quality, and the rule of law have a positive and significant effect on sustainable economic growth. This finding confirms the view of new institutionalists who believe that efficient institutions provide the basis for the optimal use of financial resources, including foreign debt, by reducing transaction costs, increasing transparency, and controlling corruption (Buttiglione et al, 2014; Dixit, 2021). In the oil-producing countries studied, differences in institutional quality have caused significant heterogeneity in the impact of foreign debt; so that in countries with stronger institutions, the negative effect of foreign debt is smaller and its possibility of being converted into sustainable growth is greater. The findings of the Iranian time series also show that there is a long-term relationship between the variables and that foreign debt has a negative and significant effect on sustainable growth within the framework of the nonlinear

model (LSTR1). This effect intensifies after crossing a certain threshold, which indicates the high sensitivity of the Iranian economy to external financial shocks and institutional constraints in efficiently absorbing debt resources. This result is in line with recent World Bank studies that emphasize that economies with institutional constraints are more vulnerable to foreign debt (World Bank, 2024; Okere et al, 2026).

The estimated threshold parameters indicate that the adverse impact of external debt is regime-dependent rather than constant. Before the threshold is reached, external borrowing may contribute to economic activity by financing productive investment. However, once debt exceeds the estimated threshold, its negative effect on sustainable economic growth becomes significantly stronger, reflecting higher debt-servicing burdens, lower investment efficiency, and increased macroeconomic vulnerability. This nonlinear behavior supports the debt overhang hypothesis and demonstrates that the sustainability of external borrowing depends not only on debt levels but also on institutional capacity and governance quality.

Conclusion

One of the important findings of this study is the moderating role of smart governance and digital transformation. Although the model does not directly examine the disaggregated effect, the interpretation of the results shows that countries with a higher level of government digitalization, e-government development, and the use of big data in fiscal policymaking have been able to reduce the negative effects of external debt. This is consistent with the OECD (2024) report, which shows that digital governance improves the efficiency of public debt by increasing financial transparency and reducing corruption.

Digital transformation also plays an important role in enhancing sustainable growth by improving institutional efficiency and reducing transaction costs. UNCTAD (2024) studies show that developing economies with a higher level of digital readiness have greater ability to manage financial and debt risks. In the oil economies of the Middle East, the digital divide and lack of financial data integration are considered one of the limiting factors in the optimal use of external debt (Jafari et al, 2024).

From a policy perspective, the results of this study show that simply increasing or decreasing external debt alone cannot guarantee sustainable growth, but rather the institutional quality and level of smart governance play a decisive role in turning debt into an opportunity or a threat. In other words, in conditions where digital infrastructure is developed and economic institutions are transparent, external debt can act as a complementary tool for growth; but in the case of institutional weakness and digital backwardness, it becomes an aggravating factor for economic instability (Yin et al, 2026).

Overall, the findings of this study emphasize the importance of a combined "institutional-digital" approach in analyzing external debt and show that the future of sustainable growth in the Middle East oil countries and Iran depends on the simultaneous implementation of institutional reforms, the development of smart governance, and the acceleration of digital transformation.

The findings of this study showed that the relationship between external debt and sustainable economic growth in the Middle East oil countries and Iran is not a simple and linear relationship, but rather has a nonlinear nature and depends on institutional conditions. External debt has a negative impact on sustainable economic growth at the general level, and the intensity of this impact increases when certain thresholds are crossed. This indicates that in the economies under study, the capacity to absorb and utilize external financial resources is limited, and in many cases, external debt becomes a factor in increasing economic instability rather than playing a role as a growth driver.

In contrast, the results showed that institutional quality, regulatory quality, and the rule of law play an important role in improving economic performance and reducing the negative effects of external debt. Also, smart governance and digital transformation, as new factors in the economic governance structure, have significant capacity to enhance transparency, improve

resource allocation, and increase policymaking efficiency. These factors collectively can moderate the negative effects of external debt and pave the way for sustainable economic growth.

The policy implications of this study extend beyond conventional debt management strategies. For Middle Eastern oil-producing countries and Iran, strengthening institutional quality should be accompanied by investments in digital governance systems, including digital public financial management, integrated debt-monitoring platforms, and data-driven fiscal decision-making. These measures can improve transparency, reduce inefficiencies in debt utilization, and enhance governments' capacity to maintain sustainable economic growth under increasing external financial pressures. Therefore, digital transformation should be regarded as a strategic complement to institutional reform in achieving long-term debt sustainability.

In general, the results of the study emphasize that simply paying attention to the level of external debt is not enough, but the quality of institutions and the extent of use of new technologies in economic governance play a decisive role in turning debt into an opportunity or a threat. Therefore, the path to achieving sustainable growth in oil-producing countries and Iran requires a combined approach of institutional reforms and the development of digital infrastructure. Based on the empirical findings, several policy recommendations can be proposed for Middle Eastern oil-producing countries and Iran. First, policymakers should strengthen institutional quality by enhancing regulatory quality, reinforcing the rule of law, reducing corruption, and improving transparency and accountability in public financial management. Stronger institutions can increase the productive use of external borrowing and mitigate its adverse effects on sustainable economic growth.

Second, governments should adopt prudent external debt management strategies by establishing sustainable debt thresholds, strengthening debt-monitoring mechanisms, and directing external borrowing toward productive investments with high economic returns. Such measures can reduce debt-servicing pressures and prevent the economy from entering the high-debt regime identified by the nonlinear model.

Third, greater investment in smart governance and digital transformation is essential. Expanding e-government services, integrating digital public financial management systems, utilizing big data and artificial intelligence for debt monitoring, and developing digital decision-support platforms can improve fiscal transparency, strengthen debt management, and increase the efficiency of public resource allocation.

Fourth, financial development, trade openness, and institutional reforms should be implemented in a coordinated manner. Integrating fiscal policy with digital governance initiatives and institutional reforms will improve governments' capacity to respond to external economic shocks while supporting sustainable economic growth.

Finally, given the structural dependence of Middle Eastern oil economies on hydrocarbon revenues, policymakers should combine debt management reforms with economic diversification strategies and digital modernization programs. Such an integrated policy framework would enhance economic resilience, reduce vulnerability to external shocks, and promote long-term sustainable growth.

Declaration of Competing Interest

The author declares that he has no competing financial interests or known personal relationships that would influence the report presented in this article.

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