



Investigating the Threshold Effects of Natural Resource Abundance and International Trade on Economic Development in Selected Developing Countries, with Emphasis on the Role of Institutional Quality

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Abstract

Being placed on the path of economic growth and development has always been one of the fundamental concerns of developing countries. In this regard, extensive theoretical and empirical studies have been conducted by growth theorists, and numerous growth models have been proposed. In explaining the causes of growth, these models examine factors such as institutional arrangements and economic policies. According to these studies, concepts such as good governance and institutional quality can provide a basis for addressing development challenges, democracy, corruption, and other related issues. In general, inefficiency in institutional quality and the absence of effective governance are among the major obstacles to growth in developing countries, to the extent that Montesquieu argued that corruption can easily transform a useful and healthy political system into a harmful and unhealthy one. In this study, model estimation was analyzed using the Panel Smooth Transition Regression method within the framework of panel models (PSTR) in selected oil-exporting countries. The statistical sample of the present study consists of economic data from selected oil-exporting countries in the Middle East over the period 2000 to 2023. The selected countries include Algeria, Bahrain, Egypt, Iraq, Iran, Jordan, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates. Using a PSTR model in which international trade is the transition variable, the economic development function is modeled. The estimation results of the linear part of the model, namely the first regime, show that the variables of institutional quality in natural resource abundance, institutional quality in financial development, and inflation rate have a negative relationship with economic development. Moreover, the estimation results of the nonlinear part of the model, namely the second regime, indicate a positive relationship between oil revenue growth, international trade, and physical capital with economic development.

Keywords: *Natural resource abundance; international trade; economic development; institutional quality; smooth threshold model*

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1. Introduction

Economic development has long been regarded as one of the central objectives of public policy, particularly in developing and resource-dependent economies where structural constraints, institutional weaknesses, exposure to external shocks, and dependence on primary commodities often complicate the transition toward sustainable growth.

Unlike narrow interpretations of growth that focus mainly on increases in output, economic development encompasses broader improvements in income, welfare, human capabilities, institutional performance, financial depth, productive diversification, and long-term resilience. In this regard, studies on welfare measurement and human development have emphasized that development should be understood as a multidimensional process rather than merely



as an increase in gross domestic product. Composite welfare indicators and human development indices provide a broader basis for assessing socioeconomic progress because they include aspects of income, health, education, social well-being, and distributive conditions [1, 2]. Similarly, research on subjective well-being and social trust has shown that development outcomes are influenced not only by material resources but also by social cohesion, public confidence, and institutional credibility [3, 4]. Therefore, explaining economic development in developing countries requires an integrated analytical framework that simultaneously considers resource endowments, institutional quality, international trade, financial development, macroeconomic stability, and human development outcomes.

Natural resource abundance has historically been viewed as a potential driver of development because resource-rich economies can use rents from oil, gas, minerals, and other primary commodities to finance infrastructure, industrialization, education, health, and public investment. However, the empirical literature has shown that abundant natural resources do not automatically generate sustainable economic development. In many cases, resource-rich economies experience slower growth, weak diversification, institutional fragility, rent-seeking, volatility, and fiscal dependence, a phenomenon commonly described as the natural resource curse. The relationship between resources and growth is therefore conditional rather than deterministic. Cross-country evidence has demonstrated that the developmental effects of natural resource abundance depend significantly on governance structures, institutional capacity, and the ability of states to transform resource revenues into productive investment [5]. Similarly, research on resource-dependent economies shows that governance shortcomings can intensify resource-curse dynamics by weakening accountability, encouraging rent-seeking behavior, reducing transparency in resource management, and limiting the productive use of resource revenues [6]. Thus, the abundance of resources may become either an opportunity for development or a source of macroeconomic and institutional vulnerability, depending on the quality of policy and governance systems.

Institutional quality plays a decisive role in determining whether natural resource abundance supports or undermines economic development. Strong institutions can improve the allocation of resource rents, reduce corruption, strengthen property rights, increase regulatory effectiveness, support market competition, and enhance the credibility of economic policy. In contrast, weak institutions may allow resource

revenues to be captured by narrow political or economic groups, reduce incentives for diversification, and weaken the long-term foundations of development. Empirical studies have consistently shown that governance quality moderates the relationship between natural resources and economic growth. Evidence on governance, resources, and growth indicates that better institutional arrangements can reduce the adverse effects of resource dependence and help transform natural resource revenues into growth-enhancing capital [7]. In a similar vein, research on institutional quality and resource-based economic sustainability highlights the mediating role of resource governance, suggesting that resource abundance can contribute to sustainable development only when institutional mechanisms are capable of managing rents effectively and transparently [8]. These findings are especially relevant for oil-exporting developing countries, where the interaction between institutional quality and natural resource abundance may determine whether resource revenues promote broad-based development or reinforce economic dependence.

The role of institutional quality is also crucial in shaping financial development, which represents another key channel through which economies can achieve growth and structural transformation. Financial development contributes to development by mobilizing savings, allocating capital efficiently, reducing transaction costs, supporting investment, and facilitating entrepreneurship. However, the effectiveness of financial development depends greatly on institutional arrangements, legal enforcement, regulatory quality, and governance capacity. In developing economies, weak institutions may restrict access to finance, increase uncertainty, reduce the efficiency of financial intermediation, and prevent financial systems from supporting productive sectors. Evidence from developing countries in the Eurasian region shows that institutional-quality indicators significantly affect financial development, confirming that financial systems cannot function effectively in the absence of stable and credible institutions [9]. Moreover, studies examining the moderating effect of institutional quality on the financial development nexus indicate that institutional frameworks determine whether financial deepening generates desirable economic and environmental outcomes [10]. Therefore, the interaction between institutional quality and financial development is an essential component of economic development analysis, particularly in resource-dependent countries where financial systems may be influenced by oil revenues, public-sector dominance, and external vulnerability.

International trade is another major determinant of development because openness to global markets can enhance productivity, expand export capacity, encourage technology transfer, increase competition, and provide access to intermediate and capital goods. For developing countries, trade openness can support structural transformation by enabling participation in global value chains and reducing the constraints of small domestic markets. However, the effect of trade on development is not necessarily linear. The benefits of trade may depend on a country's productive capacity, institutional quality, financial depth, diversification level, and macroeconomic stability. Research on natural resource abundance, international trade, and financial development has shown that the interaction among these variables plays a significant role in explaining economic development across selected countries [11]. In the Iranian context, research on trade development and economic growth has also shown that trade can influence environmental and developmental outcomes, suggesting that openness must be examined within a broader policy framework rather than treated as an isolated growth driver [12]. Consequently, international trade should be analyzed not only as an independent determinant of development but also as a threshold variable that may alter the magnitude and direction of the effects of natural resources, financial development, and institutional quality.

The importance of trade and external openness becomes even more pronounced in oil-rich developing economies, where international trade often reflects both export dependence on hydrocarbons and import dependence on technology, machinery, food, and intermediate inputs. In such countries, higher trade openness may indicate greater integration into the world economy, but it may also expose the economy to commodity price volatility and external demand shocks. Oil prices, macroeconomic policies, and global market conditions can significantly affect investment, energy transition dynamics, and the allocation of resources between traditional and emerging sectors [13]. In this context, oil dependence may interact with institutional quality and economic growth in complex ways. Evidence based on panel vector autoregression indicates that oil dependence and institutional quality jointly influence economic growth, highlighting the need to examine dynamic relationships rather than simple linear associations [14]. Furthermore, studies focusing on the role of institutional quality in the relationship between natural-resource abundance and economic growth in Iran demonstrate that the effect of resource abundance is not stable over time and can

vary according to changes in institutional and macroeconomic conditions [15]. These findings support the argument that threshold-based and nonlinear econometric approaches are appropriate for analyzing development in oil-dependent economies.

Macroeconomic stability is another necessary condition for sustainable development. Inflation, uncertainty, fiscal volatility, and financial-market instability can weaken investment incentives, reduce real income, distort relative prices, and undermine long-term planning. In emerging and developing economies, uncertainty shocks may originate from both domestic and global sources, affecting business cycles, capital flows, and policy effectiveness. Research on uncertainty and business cycles emphasizes that uncertainty may operate either as an exogenous impulse or as an endogenous response to macroeconomic disturbances, making it important to account for dynamic feedback effects in development models [16]. Similarly, studies of uncertainty shocks in emerging economies show that global-to-local transmission mechanisms can shape domestic macroeconomic outcomes, particularly in economies vulnerable to external fluctuations [17]. Capital-market performance is also influenced by macroeconomic variables, as shown by evidence from Nigeria, where exchange rates, inflation, interest rates, and other macroeconomic indicators affect capital-market behavior and financial performance [18]. These findings justify the inclusion of inflation and investment variables in models of economic development, especially where the development process is exposed to financial and external instability.

Economic diversification has become a major policy priority for resource-dependent developing countries seeking to reduce vulnerability to oil price fluctuations and create more sustainable development pathways. Diversification strengthens resilience by expanding productive sectors, reducing fiscal dependence on natural resource revenues, increasing employment opportunities, and supporting technological upgrading. Recent studies on sustainable development and diversification emphasize that progress toward development goals requires transformation in energy systems, industrial structures, urban development, and responsible production patterns [19]. In Saudi Arabia, evidence on economic complexity and economic development indicates that increasing productive sophistication can contribute to long-term development by improving the structure of output and enhancing the economy's capacity to generate value-added activities [20]. In this regard, resource-rich countries in the Middle East face

the dual challenge of using resource revenues to finance development while simultaneously reducing excessive dependence on those revenues. The interaction between trade openness, resource abundance, institutional quality, and financial development is therefore central to understanding whether these economies can move toward diversified and sustainable development.

Technological transformation and digitalization have also reshaped the determinants of economic development. In contemporary economies, digital transformation, artificial intelligence, venture business development, and innovation ecosystems increasingly affect productivity, competitiveness, and sustainability. Artificial intelligence can support sustainable development goals by improving resource efficiency, decision-making, production systems, and public-service delivery [21]. Similarly, digital transformation creates new opportunities for venture business development by enabling innovation, expanding digital entrepreneurship, and transforming economic structures [22]. Sustainable production systems are also influenced by financial development because access to finance can support technological upgrading, investment in cleaner production, and improved productivity [23]. For developing countries, these trends imply that economic development cannot be assessed only through traditional variables such as capital accumulation and trade; rather, it must also be understood through the institutional and financial capacities that allow countries to absorb technology, diversify production, and adapt to global transformation.

The security and political economy dimensions of natural resource concentration further complicate the development process. Resource concentration can increase the risk of conflict, especially when valuable resources are geographically concentrated, politically contested, or linked to weak state capacity. Evidence on resource concentration and civil wars shows that natural resources can intensify conflict risks under certain political and institutional conditions [24]. This reinforces the argument that institutions mediate the developmental effects of resource abundance not only through economic channels but also through political stability, social cohesion, and conflict prevention. In developing countries, weak institutions may transform resource wealth into social fragmentation, while stronger institutions may use resource revenues to improve public goods, reduce inequality, and expand human capabilities. Therefore, the role of institutional quality must be positioned at the center of any empirical investigation into

the effects of natural resource abundance on economic and human development.

From a methodological perspective, the relationship among natural resources, international trade, institutional quality, financial development, and economic development is unlikely to be purely linear. Development processes often involve thresholds, regime changes, nonlinear adjustments, and asymmetric responses to policy and external shocks. Smooth transition models are especially suitable for capturing such dynamics because they allow the coefficients of explanatory variables to change gradually across regimes according to a transition variable. In economic growth research, smooth transition regression models have been used to examine nonlinear relationships and regime-dependent effects, such as the relationship between life expectancy and economic growth in Iran [25]. These models are particularly relevant when the impact of a variable changes after crossing a critical threshold. In the present context, international trade may function as a transition mechanism through which the effects of natural resource abundance, institutional quality, financial development, investment, and inflation on economic development differ across regimes. This approach can provide a more accurate representation of development dynamics than conventional linear panel models.

The literature therefore suggests several important points. First, economic development is a multidimensional process that requires simultaneous attention to growth, human development, welfare, institutional performance, and macroeconomic stability. Second, natural resource abundance can promote development only when supported by effective institutions and sound governance. Third, international trade and financial development are important channels of development, but their effectiveness depends on institutional quality and the broader macroeconomic environment. Fourth, oil-dependent developing countries are exposed to nonlinear dynamics because the effects of trade openness, resource rents, and financial development may change after specific threshold levels are reached. Fifth, recent global transformations, including digitalization, artificial intelligence, sustainable production, and economic complexity, reinforce the importance of institutional and financial capacity in achieving long-term development. Despite these insights, the empirical literature still requires further evidence on how international trade functions as a threshold variable in the relationship between natural resource abundance, institutional quality, financial

development, and economic development in selected oil-exporting developing countries.

Accordingly, the aim of this study is to investigate the threshold effects of natural resource abundance and international trade on economic development in selected developing oil-exporting countries, with emphasis on the role of institutional quality, using the Panel Smooth Transition Regression model.

2. Methodology

In this study, model estimation was analyzed using the Panel Smooth Transition Regression method within the framework of panel models (PSTR) in selected oil-exporting countries. The statistical sample of the present study consists of economic data from selected oil-exporting countries in the Middle East over the period 2000 to 2023. The selected countries include Algeria, Bahrain, Egypt, Iraq, Iran, Jordan, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates.

The Panel Smooth Transition Autoregressive model (PSTAR) was developed by Teräsvirta and Anderson (1992) and Teräsvirta (1994). Unlike TAR models, which use an indicator function to control the regime-switching process, smooth threshold STAR models use exponential and logistic functions for this purpose. According to van Dijk and Teräsvirta (2002), these models are highly suitable for analyzing asymmetric cycles of variables, and many studies have shown that they fit the regime-switching mechanism well for examining the nonlinear dynamics of variables. In fact, the STAR smooth threshold model uses the transition variable and the value of the slope parameter to model the nonlinear relationship among variables in a continuous manner. Teräsvirta's smooth transition regression model is specified as the following general regression:

$$y_t = \pi' z_t + \theta' z_t F(s_t, \gamma, c) + u_t \quad (1)$$

where z_t is a vector including the exogenous variables of the model; π is the vector of linear parameters; θ is the vector of nonlinear parameters of the model; and u_t is the residual term, which is assumed to be independently and identically distributed with zero mean and constant variance:

$$u_t \approx iid(0, \sigma^2)$$

Moreover, the transition function $F(s_t, \gamma, c)$ can be specified in logistic or exponential form as follows:

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

$$F(s_t, \gamma, c) = 1 - \exp[-\gamma(s_t - c)^2] \quad (3)$$

Equation (2) represents the logistic transition function, while Equation (3) represents the exponential transition function. In the above functions, s_t denotes the transition variable; γ represents the slope parameter; and c denotes the threshold value or the location of regime change. If the slope parameter γ , which indicates the speed of transition from one regime to another, tends toward infinity, the STAR smooth threshold model is transformed into a TAR threshold model. This means that if the transition variable is greater than the threshold value, that is, $c < s_t$, the transition function becomes equal to one, $F = 1$. On the other hand, if $c > s_t$, the value of the transition function becomes equal to zero, $F = 0$. Moreover, if the value of the slope parameter tends toward zero, the STAR model is transformed into a linear model.

The estimation process of the smooth transition autoregressive model is such that, in the first step, the dynamic pattern of the model or the optimal number of lags is selected. Then, the existence of a nonlinear relationship among the variables under study is tested, and based on this, the transition variable and the number of regime changes are selected. In the second step, using the Newton–Raphson algorithm and the maximum likelihood method, the selected STAR smooth threshold model is estimated. Finally, diagnostic tests are performed to ensure that reliable results have been obtained.

Although the linearity test in the STAR smooth threshold model can be conducted by testing the null hypothesis $H_0: \gamma = 0$ or $H_0: \theta = 0$, because the STAR smooth threshold model contains unidentified nuisance parameters under the null hypothesis, the test statistics for both hypotheses are nonstandard. To overcome this problem, Luukkonen proposed using a Taylor approximation of the transition function. For this purpose, the third-order Taylor approximation of the transition function is taken with respect to the parameter around its value. Accordingly, regression Equation (1) can be rewritten as follows:

$$y_t = \pi' z_t + \theta' z_t \gamma F_\gamma(s_t, \gamma = 0, c) + \theta' z_t \gamma^2 F_{\gamma\gamma}(s_t, \gamma = 0, c) + \theta' z_t \gamma^3 F_{\gamma\gamma\gamma}(s_t, \gamma = 0, c) + \theta' z_t \gamma^4 F_{\gamma\gamma\gamma\gamma}(s_t, \gamma = 0, c) + \dots$$

By substituting $\gamma = 0$ and simplifying the first- to third-order derivatives of the transition function, depending on whether the transition variable s_t is included among the variables in z_t or not, one of the following auxiliary regressions can be obtained.

If the transition variable s_t is included among the variables in z_t , then the simplified form of Equation (4) will be as follows:

$$y_t = \beta_0' \tilde{z}_t + \beta_1' \tilde{z}_t s_t + \beta_2' \tilde{z}_t s_t^2 + \beta_3' \tilde{z}_t s_t^3 + v_{1t} \quad (5)$$

where:

$$z_t = (1, \bar{z}_t)'$$

If the transition variable s_t is not included among the variables in z_t , then the simplified form of regression Equation (4) will be as follows:

$$y_t = \beta_0' z_t + \beta_1' z_t s_t + \beta_2' z_t s_t^2 + \beta_3' z_t s_t^3 + v_{2t} \quad (6)$$

The null hypothesis of linearity between the dependent variable and the explanatory variables can be tested against the alternative hypothesis, namely the existence of a nonlinear relationship among the variables, by testing the following coefficient restrictions:

$$H_{01}: \beta_1 = \beta_2 = \beta_3 = 0 \quad (7)$$

The above test statistic follows an F -distribution. If the relationship among the variables is nonlinear, as previously mentioned, the appropriate nonlinear model must be selected. To select the appropriate model, three coefficient tests are proposed with the following null hypotheses. The statistics of these tests follow an F -distribution.

$$H_{02}: \beta_1 = 0 \mid \beta_2 = \beta_3 = 0$$

$$H_{03}: \beta_1 = 0 \mid \beta_3 = 0$$

$$H_{04}: \beta_3 = 0$$

The statistics of the above tests are denoted by F_2 , F_3 , and F_4 , respectively. Rejection of H_{03} means that the optimal STAR model is either the logistic STAR model or the exponential STAR model. By testing the hypothesis $H_0: c_1 = c_2$, one can choose between the 2LSTR and ESTR models. Rejection of the null hypothesis in this test means that the optimal model is 2LSTR. On the other hand, rejection of H_{02} and H_{04} means that the optimal model is a STAR smooth threshold model with one regime change. To select the appropriate transition variable among different

$$\begin{aligned} EG_t &= \alpha_{0t} + \partial_t R_t + v_t RA_t \times \theta + \eta_t RA_t \times FD_t + \pi_t OPEN_t + \pi_t INV_t + \tau_t INF_t + \varepsilon_t \\ HD_t &= \alpha_{0t} + \partial_t R_t + v_t RA_t \times \theta + \eta_t RA_t \times FD_t + \pi_t OPEN_t + \pi_t INV_t + \tau_t INF_t + \varepsilon_t \end{aligned} \quad (1)$$

In the present study, economic development is measured using two indicators: economic growth, represented by gross domestic product per capita based on purchasing power parity (PPP) at constant 2010 U.S. dollars, following Redmond et al. (2020), and the Human Development Index (HD).

$\partial_t R_t$ = oil revenue growth rate as a percentage of GDP

This variable is based on Kansheba et al. (2022).

acceptable candidates for this variable, the variable for which the selected nonlinear model is ultimately estimated—as previously noted—based on the Newton–Raphson algorithm is chosen. Diagnostic tests are also conducted on the residuals obtained from the nonlinear model after fitting the model.

According to Malada and Kim (1998), compared with linear models and instantaneous regime-switching models, the most important reasons for using the Smooth Transition Autoregressive model (STAR) as a gradual regime-switching model are as follows: if we assume that a policy change occurs at time t , in practice, the transition to a new regime does not necessarily have to occur at the same time t . In simpler terms, the change does not need to be instantaneous and abrupt, and there are various reasons for this issue. Some economic agents may anticipate the policy change and adapt themselves to it before it occurs. Others may not believe the policy change or may need time to understand and become informed about it. There will also be adjustment costs related to lags and delays. In addition, another limitation of conventional econometric methods, especially in topics related to examining the existence of a cointegration relationship among variables, concerns unit root testing in time-series variables. Unit root testing has become almost compulsory in applied economics. However, in many cases, this test is unnecessary or misleading. Harvey (1997), in his study on structural time-series models, points out that within the framework of structural models, determining the order of integration of a time-series variable is not necessarily important or critical. As a special case, removing the stochastic trend pattern and converting it into a model with a deterministic slope level rarely occurs. The above factors have led to the proposal of gradual regime-switching models. Smooth transition regression models are among gradual systemic-change models, and these models are referred to as STAR smooth threshold models.

$$v_t RA_t \times \theta$$

To examine the role of institutional quality in the relationship between natural resource abundance and economic growth, the coefficient of the interaction variable between natural resource abundance and institutional quality, α_6 , is used. For natural resource abundance, following the baseline article by Redmond et al. (2020), the sum of coal consumption plus crude oil plus gas divided by

population is used. For institutional quality, normalized governance quality between zero and 2.5 is used.

$$RA_t = \frac{\alpha_1 \times Coal + \alpha_2 \times Oil + \alpha_3 \times Gas}{Population}$$

$\pi_t INV_t$ = physical investment; gross fixed capital formation as a percentage of GDP

$\tau_t INF_t$ = inflation rate; inflation, consumer prices, annual percentage

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

Institutional quality (θ): In this index, zero indicates the lowest institutional value, and five represents the highest institutional quality (Kansheba et al., 2022).

FD: Financial development, measured as broad money, current liabilities as a percentage of GDP, and liquidity as a percentage of GDP (*BMON*; *MCAP*)(Redmond et al., 2020).

among the main indicators of the study, the Levin–Lin–Chu (LLC) unit root test is performed.

3. Findings and Results

In this section of the article, before conducting the panel cointegration test to determine the long-run relationship

Table 1. Results of the Unit Root Test for the Variables

Symbol	Calculated Statistic	Probability Level	Stationarity Level
EG	-1.878	0.030	I(0)
HD	-1.979	0.023	I(0)
R	-4.514	0.000	I(0)
RA	-3.454	0.000	I(0)
FD	-2.813	0.002	I(0)
OPEN	-3.165	0.000	I(0)
INV	-1.943	0.026	I(0)
INF	-2.927	0.001	I(0)
θ	-3.785	0.000	I(0)

The results of Table 1 and the examination of the calculated statistics and their acceptance probabilities indicate that all research variables are stationary at level.

Most economic theories express the long-run relationship among variables in level form. To ensure the existence of a long-run relationship among the variables included in the model, it is necessary for those variables to be stationary; otherwise, if they are nonstationary, they must have the same order of integration. Accordingly, to determine the existence

of a long-run relationship among variables, their stationarity or cointegration must be examined using various tests. Therefore, if the residuals obtained from the estimated regressions are identified as $I(0)$, or stationary, the existence of a long-run relationship among the variables can be confirmed. In the present study, the Kao panel cointegration test was used to ensure the existence of a long-run equilibrium relationship.

Table 2. Results of the Cointegration Test for the Economic Growth Model

Kao Test	Test Statistic	Corresponding Probability
ADF	-58.55675	0.0000

Table 3. Results of the Cointegration Test for the Human Development Model

Kao Test	Test Statistic	Corresponding Probability
ADF	-36.23659	0.0000

As shown in the table above, by conducting the panel cointegration test among the estimated variables, the existence of a relationship among the variables in the

estimated regression is confirmed in the selected countries. In the cointegration test, the hypotheses are defined as follows:

H_0 : No cointegration

H_1 : Cointegration among variables is confirmed

Given that the significance level is below 0.05, the null hypothesis based on the absence of a cointegration relationship among the variables is rejected. Therefore, the variables are cointegrated in the long run, and a long-run relationship exists among them.

To examine the existence of a linear or nonlinear relationship among the variables of the model, it must be determined whether m , the number of regime parameters, is

equal to one or not. It should be noted that, in the following tests, the assumption is that the model is linear, while the alternative hypothesis is either a logistic PSTR model ($m = 1$) or an exponential PSTR model ($m = 2$). The results of the diagnostic test in Tables 3 and 4 show that the linearity of the model, namely the null hypothesis, is rejected. Therefore, a nonlinear relationship exists among natural resource abundance, international trade, financial development, and economic development in the countries under study. Consequently, the PSTR method must be used to estimate the model parameters.

Table 4. Results of the Linearity Hypothesis Test of the Model (BBC Test) in the Economic Growth Model

Null Hypothesis	F Statistic	Significance Level
Wald Test	5.236	0.000
Fisher Test	4.598	0.000
LRT	4.789	0.000

Table 5. Results of the Linearity Hypothesis Test of the Model (BBC Test) in the Human Development Model

Null Hypothesis	F Statistic	Significance Level
Wald Test	3.859	0.000
Fisher Test	3.987	0.000
LRT	3.369	0.000

As is evident from the results of the tests conducted in the above tables, the hypothesis of linearity in the relationship among the variables is rejected. Therefore, the possibility of a linear relationship among the variables is ruled out. It should also be noted that the PSTR model proposed by the selected transition variable is chosen as the optimal model for estimating the model in the selected countries. For this purpose, following González et al. (2005) and Colletaz and Hurlin (2006), the null hypothesis of the existence of a PSTR model with one transition function was tested against the

alternative hypothesis of the existence of a PSTR model with at least two transition functions. The results are presented in Table 5. The results show that the null hypothesis, based on the adequacy of including one transition function in both cases of one and two threshold values, is not rejected. Therefore, one transition function is capable of specifying the nonlinear behavior among natural resource abundance, international trade, financial development, and economic development in the country.

Table 6. Test of the Existence of a Residual Nonlinear Relationship in the Economic Growth Model

M = 2: Two-Threshold Case			M = 1: One-Threshold Case		
LR	LMf	LMw	LR	LMf	LMw
1.425	1.239	1.258	1.236	1.116	1.012
(0.489)	(0.532)	(0.521)	(0.542)	(0.612)	(0.687)

$$H_0: r = 1, H_1: r = 2$$

Table 7. Test of the Existence of a Residual Nonlinear Relationship in the Human Development Model

M = 2: Two-Threshold Case			M = 1: One-Threshold Case		
LR	LMf	LMw	LR	LMf	LMw
1.337	1.489	1.268	1.569	1.378	1.236
(0.423)	(0.396)	(0.559)	(0.356)	(0.403)	(0.512)

$$H_0: r = 1, H_1: r = 2$$

After confirming the existence of a nonlinear relationship among the variables and the adequacy of one transition function for specifying nonlinear behavior, the optimal case between a transition function with one threshold value and a transition function with two threshold values must be selected. For this purpose, the PSTR model corresponding to each of these cases is estimated, and among them, based on the residual sum of squares, Schwarz criterion, and Akaike criterion, the PSTR model with one threshold value is selected as the optimal model. Therefore, a PSTR model with one transition function and one threshold value is selected to examine the nonlinear behavior among the variables under study.

Using a PSTR model in which international trade is the transition variable, the economic growth function is modeled. The estimation results of the linear part of the model, namely the first regime, show that the variables of institutional quality in natural resource abundance, institutional quality in financial development, and inflation rate have a negative relationship with economic growth. Moreover, the estimation results of the nonlinear part of the model, namely the second regime, indicate a positive relationship between oil revenue growth, international trade, and physical capital with economic growth.

Table 8. Model Estimation Using the PSTR Model

Linear Part of the Model				
Variable	Coefficient	Standard Error	t-Statistic	Probability
CONSTANT	5.215560	3.001930	1.737401	0.0823
R	0.071610	0.029185	2.453674	0.0147
$RA \times \theta$	-0.038076	0.004899	-7.771932	0.0000
$RA \times FD$	-0.134509	0.025286	-5.319560	0.0000
OPEN	0.289564	0.208206	1.390754	0.1664
INV	0.139694	0.048299	2.892296	0.0038
INF	-0.035862	0.014372	-2.495362	0.0129
Nonlinear Part of the Model				
Variable	Coefficient	Standard Error	t-Statistic	Probability
CONSTANT	5.337570	3.078490	1.733825	0.0829
R	0.265979	0.021786	12.20875	0.0000
$RA \times \theta$	-0.177326	0.070478	-2.516070	0.0126
$RA \times FD$	-0.164212	0.061974	-2.649681	0.0092
OPEN	0.007565	0.001745	4.335478	0.0000
INV	0.199451	0.024551	8.124038	0.0000
INF	-0.092975	0.015336	-6.062719	0.0000
Threshold Value () C	-0.211146	0.02365	-8.927949	0.0000
Slope Parameter () γ	3.620499	0.723642	5.003163	0.0000

$$R^2_{\text{adjusted}} = 0.85$$

The comparison of coefficients in the two different regimes is conducted based on the transition variable and its values. The value of the transition variable can determine the transition function and, consequently, the prevailing regime. In the above estimation, the transition variable is international trade, and the estimated threshold value for this variable is -0.21 percent. Based on the distance of economic growth from this threshold value, the pattern follows two different limiting regimes. By comparing the coefficients of

the pattern in the two different regimes, it is observed that when international trade passes the threshold value (-0.21), that is, when the model moves from the linear part to the nonlinear part, the response of economic growth to changes in this variable increases substantially. Thus, as international trade increases, policymakers have attempted to respond more strongly to it in order to improve economic growth and provide the basis for its increase.

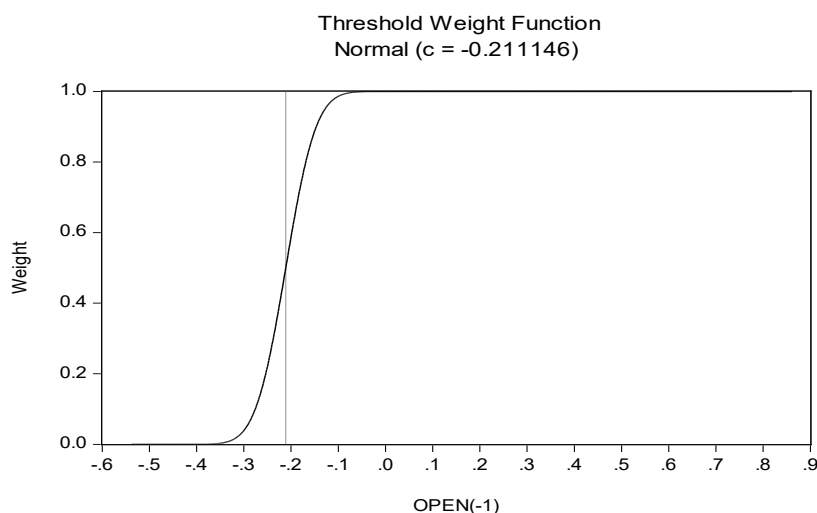


Figure 1. Relationship Between the Transition Function and the International Trade Transition Variable

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

Table 9. Results of the Autocorrelation Test

F Statistic	Prob.	Durbin–Watson
1.458	0.48	2.398

As shown in the table above, the results of the Durbin–Watson autocorrelation test indicate that there is no correlation among the disturbance components. Therefore, the third classical standard assumption, namely the absence of autocorrelation among error terms, is not violated.

Accordingly, the estimators possess the required properties, namely minimum variance and efficiency.

Another classical standard assumption is homoscedasticity. In the present study, the Breusch–Pagan–Godfrey test is used.

Table 10. Results of the Heteroskedasticity Test

F Statistic	Prob.	Breusch–Pagan–Godfrey
0.698	0.812	1.139

As shown in the table, the test results indicate the absence of heteroskedasticity.

Another suitable measure for evaluating the quality of the estimated model is examining changes in the coefficients

between the two regimes. If the estimated model provides an appropriate estimation, the coefficients are expected to remain stable and unchanged with regime change.

Table 11. Results of the Smooth Transition Parameter Stability Test

Null Hypothesis	F Statistic	Prob.
$b_1 = b_2 = b_3 = b_4 = 0$	1.236	0.653
$b_1 = b_2 = b_3 = 0$	1.326	0.574
$b_1 = b_2 = 0$	1.348	0.512
$b_1 = 0$	1.487	0.456

As is evident from the table, the test of coefficient stability between the two regimes shows that the coefficients do not change as a result of regime change.

Using a PSTR model in which international trade is the transition variable, the human development function is modeled. The estimation results of the linear part of the model, namely the first regime, show that the variables of

institutional quality in natural resource abundance, institutional quality in financial development, and inflation rate have a negative relationship with human development. Moreover, the estimation results of the nonlinear part of the

model, namely the second regime, indicate a positive relationship between oil revenue growth, international trade, and physical capital with human development.

Table 12. Model Estimation Using the PSTR Model

Linear Part of the Model				
Variable	Coefficient	Standard Error	t-Statistic	Probability
CONSTANT	0.606596	0.052468	11.56128	0.0000
R	0.105587	0.049589	2.129247	0.0345
$RA \times \theta$	-0.092592	0.039749	-2.329430	0.0207
$RA \times FD$	-0.083179	0.038798	-2.143912	0.0331
OPEN	0.091314	0.053985	1.691467	0.0923
INV	0.073317	0.058397	1.255494	0.2107
INF	-0.072988	0.040778	-1.789885	0.0749
Nonlinear Part of the Model				
Variable	Coefficient	Standard Error	t-Statistic	Probability
CONSTANT	0.530693	0.136269	3.894459	0.0001
R	0.175549	0.071785	2.445475	0.0153
$RA \times \theta$	-0.265475	0.078286	-3.391090	0.0008
$RA \times FD$	-0.110433	0.028554	-3.867560	0.0001
OPEN	0.068757	0.014853	4.629124	0.0000
INV	0.104390	0.041223	2.532328	0.0121
INF	-0.144645	0.037615	-3.845384	0.0002
Threshold Value () C	0.217254	0.009450	22.989	0.0000
Slope Parameter () γ	0.618469	0.056286	10.98804	0.0000

$$R^2_{\text{adjusted}} = 0.88$$

The comparison of coefficients in the two different regimes is conducted based on the transition variable and its values. The value of the transition variable can determine the transition function and, consequently, the prevailing regime. In the above estimation, the transition variable is international trade, and the estimated threshold value for this variable is 0.21percent. Based on the distance of human development from this threshold value, the pattern follows two different limiting regimes. By comparing the

coefficients of the pattern in the two different regimes, it is observed that when international trade passes the threshold value (0.21), that is, when the model moves from the linear part to the nonlinear part, the response of human development to changes in this variable increases substantially. Thus, as international trade increases, policymakers have attempted to respond more strongly to it in order to improve human development.

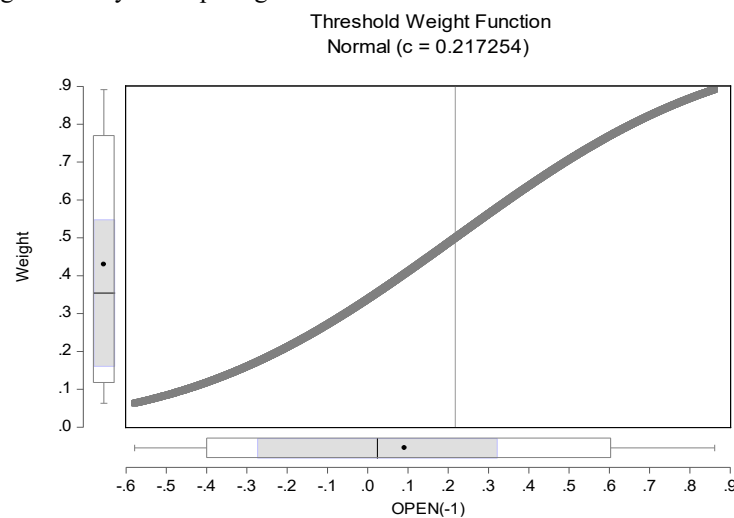


Figure 2. Relationship Between the Transition Function and the International Trade Transition Variable

In the present study, the Durbin–Watson test was used to examine autocorrelation.

Table 13. Results of the Autocorrelation Test

F Statistic	Prob.	Durbin–Watson
1.236	0.69	2.247

As shown in the table above, the results of the Durbin–Watson autocorrelation test indicate that there is no correlation among the disturbance components. Therefore, the third classical standard assumption, namely the absence of autocorrelation among error terms, is not violated.

Accordingly, the estimators possess the required properties, namely minimum variance and efficiency. Another classical standard assumption is homoscedasticity. In the present study, the Breusch–Pagan–Godfrey test was used.

Table 14. Results of the Heteroskedasticity Test

F Statistic	Prob.	Breusch–Pagan–Godfrey
0.896	0.789	1.265

As shown in the table, the test results indicate the absence of heteroskedasticity.

Another suitable measure for evaluating the quality of the estimated model is examining changes in the coefficients

between the two regimes. If the estimated model provides an appropriate estimation, the coefficients are expected to remain stable and unchanged with regime change.

Table 15. Results of the Smooth Transition Parameter Stability Test

Null Hypothesis	F Statistic	Prob.
$b_1 = b_2 = b_3 = b_4 = 0$	1.126	0.563
$b_1 = b_2 = b_3 = 0$	1.187	0.512
$b_1 = b_2 = 0$	1.214	0.478
$b_1 = 0$	1.236	0.452

As is evident from the table, the test of coefficient stability between the two regimes shows that the coefficients do not change as a result of regime change.

4. Discussion and Conclusion

The present study examined the threshold effects of natural resource abundance and international trade on economic development in selected developing oil-exporting countries, with particular emphasis on the role of institutional quality. The results first confirmed the stationarity of all study variables at level based on the Levin–Lin–Chu unit root test. The Kao panel cointegration test further indicated the existence of a long-run equilibrium relationship among the variables in both the economic growth model and the human development model. These preliminary findings suggest that natural resource abundance, institutional quality, financial development, trade openness, physical investment, inflation, oil revenue growth, economic growth, and human development are not

merely short-term fluctuating indicators but are connected through stable long-term relationships in the selected countries. This finding is consistent with the broader development literature, which emphasizes that economic development is a multidimensional and persistent process shaped by structural, institutional, financial, and macroeconomic determinants rather than by isolated short-term shocks [1, 2]. It also aligns with studies that consider welfare, human development, social trust, and subjective well-being as long-run outcomes of institutional and socioeconomic arrangements [3, 4].

The results of the linearity tests showed that the assumption of a linear relationship among the variables was rejected in both the economic growth and human development models. Therefore, the findings confirmed that the relationships among natural resource abundance, international trade, financial development, institutional quality, and economic development are nonlinear and regime-dependent. This is an important empirical result

because many conventional development models assume stable marginal effects across all levels of trade openness, resource abundance, and institutional quality. However, the present findings indicate that the effects of these variables change after the transition variable, namely international trade, crosses a specific threshold. This result supports the methodological logic of smooth transition models and is consistent with earlier applications of smooth transition regression in economic research, where nonlinear relationships and gradual regime changes were found to better explain development-related dynamics [25]. In the context of oil-dependent developing economies, such nonlinearity is theoretically expected because the effects of trade, oil revenues, financial development, and institutions may differ substantially across low- and high-openness regimes.

In the economic growth model, the PSTR results showed that the threshold value of international trade was estimated at approximately (-0.21), and the slope parameter was statistically significant. This indicates that international trade functions as a meaningful transition variable in explaining how the determinants of economic growth operate across regimes. In the first, or linear, regime, oil revenue growth and physical investment had positive effects on economic growth, whereas the interaction of natural resource abundance with institutional quality, the interaction of resource abundance with financial development, and inflation had negative effects. In the second, or nonlinear, regime, oil revenue growth, international trade, and physical investment showed positive and significant effects on economic growth, while the interaction terms involving resource abundance and institutional quality, resource abundance and financial development, and inflation remained negative. These findings suggest that although oil revenues, trade openness, and physical investment can stimulate growth, the developmental contribution of natural resources is constrained when institutional and financial structures are unable to transform resource abundance into broad-based productive capacity.

The positive effect of oil revenue growth on economic growth in both regimes is consistent with the economic structure of oil-exporting developing countries, where government revenues, public investment, foreign exchange earnings, and aggregate demand are often strongly connected to oil income. This finding supports the view that natural resources may provide an important source of capital accumulation and fiscal capacity when revenues are directed toward productive investment. However, the persistence of

negative coefficients for the interaction between resource abundance and institutional quality suggests that the mere presence of institutional indicators does not automatically neutralize the resource curse. Rather, institutional quality must be effective, operational, transparent, and capable of controlling rent-seeking behavior. This interpretation is aligned with studies showing that the relationship between governance, resources, and growth is highly conditional and that weak governance can prevent resource abundance from becoming a sustainable growth engine [5, 7]. It also supports the argument that governance shortcomings intensify resource-curse mechanisms in resource-dependent economies by weakening accountability and reducing the efficiency of resource allocation [6].

The negative coefficient of the interaction between natural resource abundance and institutional quality may appear counterintuitive at first because stronger institutions are generally expected to improve the resource-growth relationship. However, in oil-dependent developing countries, this result can be interpreted as evidence that institutional quality remains insufficient to offset the structural vulnerabilities created by resource dependence. In other words, if institutional reforms are incomplete, formal indicators of governance may coexist with rent concentration, bureaucratic inefficiency, weak transparency, and policy volatility. In such conditions, institutional quality may not yet be strong enough to convert natural resource abundance into inclusive and sustainable growth. This result is consistent with research on Iran showing that the role of institutional quality in the relationship between natural resource abundance and economic growth may vary over time and may not always generate positive effects when institutional mechanisms remain weak or unstable [15]. It also aligns with evidence indicating that oil dependence and institutional quality interact dynamically in shaping economic growth, particularly in economies exposed to resource revenue volatility [14].

The negative effect of the interaction between resource abundance and financial development also requires careful interpretation. Financial development is usually expected to promote growth by mobilizing savings, allocating capital, and supporting investment. However, in resource-dependent economies, financial development may be distorted by oil revenues, state dominance, rent-based credit allocation, and limited private-sector diversification. If financial systems are not sufficiently competitive, transparent, and institutionally regulated, financial development may reinforce dependence on resource-based sectors rather than

promote productive transformation. This finding is consistent with studies emphasizing that institutional quality affects the ability of financial systems to support development [9]. It also corresponds with evidence that institutional quality moderates the broader consequences of financial development, indicating that financial expansion without effective governance may not produce desirable developmental outcomes [10]. Moreover, research on sustainable production systems highlights that financial development contributes to sustainability only when it supports productive and technologically efficient sectors [23].

The positive effect of international trade in the nonlinear regime of the economic growth model indicates that once trade openness passes the estimated threshold, its contribution to growth becomes stronger and statistically meaningful. This result suggests that international trade may generate development benefits only after countries reach a sufficient degree of openness, market integration, and absorptive capacity. In oil-exporting economies, trade openness may support growth through export revenues, import of capital goods, technology transfer, market expansion, and increased competition. This finding is consistent with evidence showing that international trade, natural resource abundance, and financial development jointly shape economic development in selected countries [11]. It also aligns with research on trade development and economic growth, which emphasizes that trade can influence broader economic and environmental outcomes depending on the policy context [12]. Therefore, the threshold effect identified in the present study confirms that trade openness should not be treated as a uniform linear driver of growth; rather, its effects depend on whether the economy has passed a critical level of integration with international markets.

The positive effect of physical investment in both regimes confirms the importance of gross fixed capital formation in supporting economic growth. In developing countries, physical investment expands productive capacity, strengthens infrastructure, improves industrial performance, and creates the material foundation for long-term development. This result is consistent with the broader literature on economic complexity and structural development, which emphasizes that capital accumulation and productive sophistication are central to development outcomes [20]. It also corresponds with arguments that economic diversification and sustainable development require investment in energy systems, urban infrastructure, productive sectors, and responsible production capacities

[19]. In oil-exporting economies, this result implies that resource revenues can support growth when transformed into productive investment; however, the negative interaction effects found in the model indicate that this transformation depends on institutional and financial efficiency.

The negative effect of inflation on economic growth in both regimes is consistent with macroeconomic theory and empirical evidence. Inflation weakens purchasing power, increases uncertainty, distorts investment decisions, and reduces the reliability of long-term economic planning. In resource-dependent countries, inflationary pressures may arise from oil revenue fluctuations, fiscal expansion, import dependence, exchange-rate instability, and weak monetary discipline. This finding is supported by studies showing that uncertainty and macroeconomic shocks influence business cycles and development outcomes [16, 17]. It is also consistent with research on macroeconomic variables and capital-market performance, which shows that inflation and other macroeconomic indicators can significantly affect financial-market functioning and economic performance [18]. Therefore, the negative coefficient of inflation confirms that macroeconomic stability remains a necessary condition for transforming trade openness and resource revenues into sustainable economic growth.

In the human development model, the PSTR results showed that international trade also served as the transition variable, with an estimated threshold value of approximately (0.21). The results indicated that oil revenue growth had a positive effect on human development in both regimes, while the interaction terms between resource abundance and institutional quality and between resource abundance and financial development had negative effects. Inflation also had a negative effect, particularly in the nonlinear regime. International trade and physical investment became positive and statistically significant in the nonlinear regime. These findings suggest that human development improves when oil revenues, trade openness, and investment are effectively mobilized, but the resource-institution and resource-finance interactions may constrain human development when institutions and financial systems do not adequately convert resource wealth into improvements in education, health, welfare, and living standards. This is consistent with studies emphasizing that human development depends on a broad combination of economic, social, and institutional factors rather than income growth alone [2, 4].

The positive effect of oil revenue growth on human development can be explained by the fiscal role of oil

revenues in financing public services, social infrastructure, education, healthcare, housing, and welfare programs. In oil-rich developing countries, government expenditure on human development indicators is often indirectly tied to oil income. However, the negative interaction between resource abundance and institutional quality suggests that oil revenues do not automatically produce human development unless governance systems ensure equitable allocation, transparency, and accountability. This result aligns with research on institutional quality and resource-based economic sustainability, which highlights the mediating role of resource governance in determining whether resource wealth supports sustainable development [8]. It also corresponds with the argument that resource concentration can generate instability and social conflict when institutional systems fail to manage distributional tensions effectively [24]. Thus, in the absence of strong and inclusive institutions, resource abundance may fail to generate proportional improvements in human development.

The positive and significant effect of international trade on human development in the nonlinear regime indicates that trade openness contributes not only to output growth but also to broader welfare outcomes after crossing a threshold level. Increased international trade may improve human development by expanding income opportunities, increasing access to goods and services, facilitating technology diffusion, improving employment prospects, and supporting public revenues. In contemporary development contexts, trade may also support access to digital technologies, clean energy systems, and knowledge-based production. This interpretation is compatible with recent arguments that artificial intelligence and digital technologies can support sustainable development goals when economies have the institutional and productive capacity to adopt them [21]. It also aligns with the view that digital transformation and venture business development can strengthen economic modernization and create new development pathways [22]. Therefore, the threshold role of trade openness in the human development model suggests that global integration becomes development-enhancing when accompanied by sufficient absorptive capacity, investment, and institutional readiness.

Overall, the findings of this study support a threshold-based interpretation of development in selected oil-exporting developing countries. Natural resource abundance, international trade, institutional quality, financial development, investment, and inflation do not influence economic growth and human development

through fixed and uniform effects. Instead, their effects vary across regimes determined by the level of international trade. The results are broadly consistent with previous studies emphasizing the conditional nature of the resource-growth relationship, the central role of governance, the importance of financial and institutional capacity, and the nonlinearity of development processes [6-8, 11]. The findings also extend the literature by showing that international trade can operate as a threshold mechanism through which the effects of natural resources and macroeconomic variables on both economic growth and human development change. This reinforces the importance of designing integrated development policies that combine trade expansion, institutional reform, financial-sector efficiency, inflation control, investment promotion, and resource governance.

This study has several limitations that should be considered when interpreting the findings. First, the analysis was limited to selected oil-exporting developing countries, and therefore the results may not be directly generalizable to non-oil economies or developed countries with different institutional, financial, and productive structures. Second, the study used macro-level panel data, which are useful for cross-country comparison but may not fully capture country-specific institutional reforms, political conditions, sectoral differences, or distributional effects. Third, the indicators used for institutional quality, natural resource abundance, financial development, and economic development may not reflect all qualitative aspects of governance, resource management, financial inclusion, welfare, and human capability. Fourth, although the PSTR model is appropriate for identifying nonlinear and threshold effects, it cannot fully explain all causal mechanisms behind the observed relationships. Finally, data limitations across countries and years may affect the precision of estimation, especially in economies where statistical reporting systems differ in quality and consistency.

Future studies can extend the present research in several ways. First, future research should compare oil-exporting and non-oil developing countries to determine whether the threshold effects of international trade differ across resource-dependent and diversified economies. Second, future studies may use disaggregated institutional indicators, such as control of corruption, rule of law, government effectiveness, political stability, regulatory quality, and voice and accountability, to identify which institutional dimensions most strongly affect the resource-development relationship. Third, researchers may examine alternative transition variables, such as financial development,

institutional quality, oil price volatility, economic complexity, or inflation, to determine whether different thresholds produce different development regimes. Fourth, future studies can apply country-specific nonlinear models to examine whether the threshold values differ across individual economies. Finally, combining quantitative panel analysis with qualitative institutional assessment may provide deeper insight into how governance reforms, fiscal rules, and resource-management systems shape the developmental effects of natural resource abundance.

The findings suggest that policymakers in resource-dependent developing countries should avoid relying solely on natural resource revenues as a source of development and should instead focus on converting resource income into productive, inclusive, and sustainable investment. Strengthening institutional quality should be a central policy priority, particularly through improving transparency, reducing corruption, enhancing public-sector accountability, and strengthening the governance of natural resource revenues. Financial development should be directed toward productive sectors, small and medium-sized enterprises, technological upgrading, and diversification rather than rent-based or consumption-oriented activities. Trade policies should aim to expand international integration while simultaneously improving domestic absorptive capacity, export diversification, infrastructure, and human capital. Maintaining macroeconomic stability, particularly through inflation control and prudent fiscal management, is also essential. Finally, governments should use oil revenues strategically to finance education, health, innovation, digital transformation, and infrastructure so that resource wealth can support both economic growth and human development.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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