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# The Effect of Government Size, Resource Governance, and Institutional Quality on the Human Development Index in Iran Using the Nonlinear Autoregressive Distributed Lag (NARDL) Threshold Approach

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A B S T R A C T

This study investigates the effects of government size, resource governance, and institutional quality on the Human Development Index (HDI) in Iran using the nonlinear autoregressive distributed lag (NARDL) threshold approach to estimate long-run coefficients, short-run dynamics, and the error correction mechanism (ECM). The short-run estimation results indicate that negative shocks to government size exert a positive effect, while positive shocks have a negative effect on the Human Development Index; thus, government size influences human development asymmetrically. Furthermore, positive shocks to institutional quality and resource governance have a positive effect, whereas negative shocks exert a negative effect on the Human Development Index, highlighting the direct and asymmetric role of these variables in human development. Financial development, physical investment, population, and foreign direct investment demonstrate positive and statistically significant effects on human development, while inflation and external debt exert negative impacts. The ECM coefficient, estimated at -0.723252, indicates a high speed of adjustment from short-run disequilibrium toward long-run equilibrium and confirms model convergence. Diagnostic tests, including the normality test, Wald test for symmetry, heteroskedasticity test, serial correlation test, and functional form specification test, confirm the validity of the model and indicate the absence of statistical issues. The Banerjee and Dolado test also confirms the existence of a long-run relationship (cointegration) among the variables. Long-run coefficients reveal a negative effect of government size and inflation rate, and a positive effect of institutional quality, resource governance, financial development, investment, population, and foreign direct investment on the Human Development Index, all statistically significant at the 95% confidence level. Finally, structural stability tests (CUSUM and CUSUMSQ) confirm the stability of the model and indicate the absence of structural breaks. The findings emphasize the importance of considering the asymmetric effects of economic and institutional shocks and their critical role in enhancing the Human Development Index.

***Keywords:*** *Human Development Index, Government Size, Institutional Quality, Resource Governance, Financial Development*

## 1. Introduction

Human development has increasingly emerged as a central objective of economic policy, reflecting a multidimensional approach to welfare that extends beyond mere income growth to encompass education, health, and overall quality of life. The Human Development Index (HDI), introduced by the United Nations Development Programme, captures these dimensions and provides a comprehensive measure of societal progress. In recent decades, scholars have emphasized that achieving sustainable human development requires not only economic expansion but also the effective functioning of institutions, sound governance of natural resources, and an optimal configuration of government intervention (Rodrik, 2021; Sachs & Warner, 2019). These elements interact in complex ways, shaping both the distribution of resources and the efficiency of policy implementation across economies.

A growing body of literature highlights the pivotal role of institutional quality in fostering human development outcomes. Institutions define the rules of the game within which economic and social interactions occur, influencing investment decisions, public service delivery, and the allocation of resources. Empirical evidence suggests that strong institutions—characterized by transparency, accountability, and rule of law—are associated with higher levels of human development and reduced poverty (Ayoade et al., 2023; Jungo, 2022). Conversely, institutional weaknesses, such as corruption and inefficiency, undermine development efforts by distorting incentives and reducing the effectiveness of public expenditures (Kazemi & Nazari, 2022; Soltani & Hosseini, 2022). In this regard, institutional quality is not merely a background condition but an active determinant of development trajectories.

In parallel, the role of government size has been extensively debated in the economic literature. While classical economic theories often advocate for limited government intervention, contemporary perspectives recognize that the size and scope of government can have both positive and negative implications for human development. On the one hand, government spending on education, healthcare, and social protection can enhance human capabilities and improve welfare outcomes. On the other hand, excessive government size may lead to inefficiencies, bureaucratic expansion, and misallocation of resources (Friedman & Denti, 2022). Empirical studies in the Iranian context indicate that the relationship between government size and human development is complex and potentially nonlinear, with both beneficial and adverse effects depending on the composition and efficiency of public expenditures (Mohammadi & Hosseini, 2023; Mousavi & Bahrami, 2022). Moreover, recent findings suggest that this relationship may exhibit asymmetric dynamics, where increases and decreases in government size do not exert identical effects on development outcomes (Ghasemi & Ahmadi, 2023).

Another critical factor influencing human development is the governance of natural resources. Countries endowed with abundant natural resources often face the so-called "resource curse," whereby resource wealth does not translate into improved welfare due to weak institutions and poor governance structures (Sachs & Warner, 2019). In such contexts, resource revenues may fuel rent-seeking behavior, corruption, and macroeconomic instability, thereby hindering human development. However, when managed effectively within a robust institutional framework, natural resources can serve as a catalyst for economic diversification and social investment (Rafiei & Sharifi, 2022; Rahimi & Bagheri, 2022). Empirical evidence from Iran demonstrates that the interaction between resource governance and institutional quality plays a decisive role in determining the developmental impact of resource endowments (Jalali & Sadeghi, 2022; Najafi & Karimi, 2023). This underscores the importance of examining resource governance not in isolation but in conjunction with institutional performance.

In addition to these core determinants, several complementary factors contribute to human development. Financial development, for instance, enhances access to credit and facilitates investment in human capital, thereby promoting inclusive growth (Singh, 2023). Advances in financial technologies and credit systems further expand these opportunities by improving efficiency and reducing transaction costs (Mirzaei et al., 2026). Similarly, economic stability, infrastructure development, and digitalization are increasingly recognized as key enablers of sustainable development pathways (Sun et al., 2025). Entrepreneurial activity and access to financial resources also play a significant role in fostering economic dynamism and improving living standards (Taghavi, 2025; Tan et al., 2025). These factors highlight the multifaceted nature of human development and the need for integrated policy approaches.

The interaction between these variables becomes particularly salient in developing economies such as Iran, where structural challenges and institutional constraints shape development outcomes. Iran's economy is characterized by a significant reliance on natural resources, particularly oil revenues, which makes the governance of these resources a critical determinant of economic and social performance. At the same time, institutional quality and government policies play a central role in mediating the effects of resource wealth on human development. Previous studies have shown that improvements in institutional quality can mitigate the adverse effects of resource dependence and enhance the effectiveness of public spending (Rafiei & Sharifi, 2022; Rahimi & Bagheri, 2022). However, persistent challenges such as corruption, inefficiency, and limited transparency continue to constrain development efforts (Soltani & Hosseini, 2022).

Furthermore, the dynamics of government size in Iran reflect a complex interplay between fiscal policy, public sector efficiency, and socio-economic objectives. While government intervention has been instrumental in providing essential services and supporting vulnerable populations, concerns have been raised بشأن the efficiency and sustainability of public expenditures. Empirical evidence suggests that the impact of government size on human development is contingent upon the quality of governance and the allocation of resources (Mohammadi & Hosseini, 2023; Mousavi & Bahrami, 2022). This indicates that simply expanding or contracting the size of government is insufficient; rather, the focus should be on optimizing its structure and performance.

Despite the growing body of research on these topics, there remains a gap in understanding the asymmetric effects of key economic and institutional variables on human development. Traditional linear models often fail to capture the differential impacts of positive and negative shocks, thereby overlooking important dynamics in the relationship between variables. The nonlinear autoregressive distributed lag (NARDL) approach offers a robust framework for addressing this limitation by allowing for the estimation of asymmetric short-run and long-run effects. This methodology has been increasingly applied in recent studies to explore complex relationships in macroeconomic analysis, providing more nuanced insights into policy implications.

In light of the above considerations, this study seeks to contribute to the existing literature by examining the asymmetric effects of government size, resource governance, and institutional quality on the Human Development Index in Iran using the NARDL approach, with the aim of identifying both short-run and long-run dynamics and providing policy-relevant insights for sustainable human development.

## 2. Methods and Materials

The present study is applied in terms of purpose and descriptive–analytical in nature. It is also categorized as an ex post facto study. The statistical population consists of macroeconomic data for Iran over the annual period from 1991 to 2023 (Gregorian calendar). The nonlinear autoregressive distributed lag (NARDL) time-series model is employed to estimate the model using EViews software. To estimate the model, the specification of the model and the introduction of variables are first presented. Subsequently, the Phillips–Perron unit root test is used to examine the stationarity of variables, followed by cointegration tests, and finally the model is estimated using the NARDL approach.

In this study, to estimate the Human Development Index (HDI) model in Iran, based on the literature and prior studies such as Albirri et al. (2020), Imran Hunjra et al. (2020), Ahmad et al. (2021), and Siaw et al. (2022), the research model is specified as follows:

$$GG_i = \beta_0 + \beta_1 GS_i + \beta_2 RQ_i + \beta_3 RA_i + \beta_4 FIN_i + \beta_5 INF_i + \beta_6 INV_i + \beta_7 ED_i + \beta_8 POP_i + \beta_9 FDI_i + \varepsilon_{it}$$

By rewriting Equation (1) in an error correction form and decomposing the variables (government size $GS$, resource governance $RA$, and institutional quality $RQ$) into positive and negative partial sums of changes, the nonlinear (asymmetric) short-run and long-run effects can be estimated. The positive partial sums are defined as:

$$POSE = \sum_{j=1}^{t} \Delta G\,S^{+}, POSS = \sum_{j=1}^{t} \Delta R\,A^{+}, POSE = \sum_{j=1}^{t} \Delta R\,Q^{+}$$

and the negative partial sums as:

$$NEGE = \sum_{j=1}^{t} \Delta G\,S^{-}, NEGS = \sum_{j=1}^{t} \Delta R\,A^{-}, NEGE = \sum_{j=1}^{t} \Delta R\,Q^{-}$$

Thus, the nonlinear NARDL specification is expressed as:

$$GG_t = \mu + \sum_{i=1}^{n_1} \beta_i \,\Delta GS_{t-i} + \sum_{i=1}^{n_2} \beta_i \,\Delta RA_{t-i} + \sum_{i=1}^{n_3} \beta_i \,\Delta RQ_{t-i} + \sum_{i=1}^{n_4} \beta_i \,\Delta X_{t-i} + \sum_{i=1}^{n_5} \beta_{1,i} \,\Delta\ln\, POSE_{t-i} + \sum_{i=1}^{n_6} \beta_{2,i} \,\Delta\ln\, NEGE_{t-i} + \sum_{i=1}^{n_7} \beta_{3,i} \,\Delta\ln\, POSS_{t-i} + \sum_{i=1}^{n_8} \beta_{4,i} \,\Delta\ln\, NEGS_{t-i} + \varepsilon_t$$

GG: Human Development Index

RQ: Institutional quality, measured as the average of five components: (1) size of government, (2) legal system and property rights, (3) accountability and transparency, (4) international trade openness, and (5) regulation of credit, labor, and business. The Fraser Institute constructs this index on a scale from 0 (lowest institutional quality) to 5 (highest institutional quality).

RA: Resource abundance, calculated as total coal consumption plus crude oil plus gas consumption divided by population:

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

GS: Government size, used as an indicator of government effectiveness, measured on a scale from 0 to 100

FIN: Financial development, measured as liquidity as a percentage of GDP

INF: Inflation rate

INV: Physical investment, measured as gross fixed capital formation (% of GDP)

ED: Total external debt as a percentage of GDP

POP: Population growth rate

FDI: Foreign direct investment

## 3. Findings and Results

If time series exhibit co-movement, such synchronization implies the existence of a potential long-run equilibrium relationship. In other words, two time series that move together may be characterized by a long-term equilibrium relationship, commonly referred to as cointegration. Cointegration occurs when two series move along a similar stochastic trend or "wavelength." In economic theory, it is generally assumed that variables are linked by long-run equilibrium relationships. However, in applied econometric analysis, assumptions of constant mean and variance over time often do not hold, leading to non-stationarity. In such cases, classical $F$and $t$statistics become invalid and may yield spurious regression results. Therefore, it is essential to test for stationarity and convergence among variables.

Cointegration analysis, recognized as a major advancement in econometrics since the mid-1980s, examines whether non-stationary variables move together over time. Even if variables exhibit trends, their linear combination may still form a stationary relationship, indicating long-run equilibrium. If no such linear relationship exists, the variables are not cointegrated. Cointegration thus provides a framework for estimating long-run equilibrium parameters in models with non-stationary variables and allows for testing economic theories. Additionally, it enables estimation of short-run dynamics through error correction models (ECM), linking short-run fluctuations to long-run equilibrium values.

A time series is strictly stationary if its joint probability distribution does not depend on time. In practice, weak stationarity is more commonly used, requiring constant mean and variance and time-invariant autocovariance. Stationarity is crucial because shocks to a stationary series are temporary and dissipate over time, whereas shocks to non-stationary series may have permanent effects.

Non-stationary time series may arise from deterministic trends:

$$x_t = \beta_0 + \beta_1 t + u_t$$

or stochastic trends (random walk processes):

$$x_t = x_{t-1} + u_t$$

where $u_t$is a white noise error term. Differencing can be used to transform non-stationary series into stationary ones:

$$\Delta x_t = x_t - x_{t-1}$$

A series is said to be integrated of order $d$, denoted $I(d)$, if it becomes stationary after differencing $d$times.

To test for stationarity, the Phillips–Perron (PP) test is employed. The null hypothesis $H_0$indicates non-stationarity (unit root), while the alternative hypothesis $H_1$indicates stationarity.

**Table 1**

*Phillips–Perron Unit Root Test Results*

| Variable | Test Statistic | Probability | Integration Order |
|---|---|---|---|
| ED | 0.499018 | 0.8177 | --- |
| D(ED) | -7.245129 | 0.0000 | I(1) |
| FDI | -1.008525 | 0.2747 | --- |
| D(FDI) | -6.506971 | 0.0000 | I(1) |
| FIN | -3.117958 | 0.0029 | I(0) |
| GG | -0.557989 | 0.4675 | --- |
| D(GG) | -15.216663 | 0.0000 | I(1) |
| GS | -0.502884 | 0.4905 | --- |
| D(GS) | -12.767470 | 0.0000 | I(1) |
| INF | -0.179377 | 0.6137 | --- |
| D(INF) | -9.809054 | 0.0000 | I(1) |
| INV | -1.425946 | 0.1406 | --- |
| D(INV) | -13.707540 | 0.0000 | I(1) |
| POP | -1.333090 | 0.1652 | --- |
| D(POP) | -6.467929 | 0.0000 | I(1) |
| RA | -0.060136 | 0.6551 | --- |
| D(RA) | -6.776930 | 0.0000 | I(1) |
| RQ | 0.722060 | 0.8659 | --- |
| D(RQ) | -9.701317 | 0.0000 | I(1) |

Given that the variables are not integrated of the same order, conventional cointegration tests such as the Johansen test cannot be applied. Therefore, the NARDL model is used for estimation. One of the key advantages of the NARDL approach is that it does not require variables to be integrated of the same order and allows for consistent estimation of long-run coefficients regardless of whether variables are I(0), I(1), or a combination of both.

Two major techniques are commonly used to examine convergence: the Engle–Granger method and the Johansen method. In the Engle–Granger approach, only one long-run relationship between two or more variables is examined. If the number of variables exceeds two, this method encounters difficulties in identifying long-run relationships because only one error term is incorporated into the equation. In addition, part of the information is lost due to differencing. Compared with other cointegration tests, the Johansen method has greater advantages. One of its advantages is that it does not require differencing to render variables stationary, because differencing leads to the loss of long-run equilibrium properties among variables. By calculating the error correction term and incorporating it into equations formulated in differenced form, this method preserves long-run equilibrium properties. In this approach, the cointegrating vectors are determined and estimated; that is, the coefficients associated with long-run equilibrium relationships among variables are obtained. The relationship between the model and cointegration makes it possible to derive cointegrating vectors easily from the coefficients of the vector autoregressive model. In the Johansen–Juselius cointegration test, which is used in this study to examine the long-run relationship among the model variables, the first step is to determine the order of integration of the model variables, which is of particular importance. In the second step, after determining the order of integration of the variables and establishing that the model variables are cointegrated, the analysis proceeds.

Based on Johansen's proposed method, the trace test ($\lambda_{\text{Trace}}$)and the maximum eigenvalue test ($\lambda_{\max}$)are used to determine the cointegrating vectors. As shown in the table, in the ($\lambda_{\text{Trace}}$)test, the null hypothesis that no cointegrating vector exists is rejected, and the alternative hypothesis indicating the existence of more than one cointegrating vector is accepted. The difference between the ($\lambda_{\max}$)and ($\lambda_{\text{Trace}}$)statistics is that the alternative hypothesis in the ($\lambda_{\max}$)statistic is specifically defined. It is possible for the results of the ($\lambda_{\max}$)and ($\lambda_{\text{Trace}}$)tests to be inconsistent. In fact, the ($\lambda_{\max}$)test has a clearer and more specific alternative hypothesis. Nevertheless, in the event of inconsistency, selecting the minimum number of cointegrating vectors is preferable. The results are presented in the following table.

**Table 2**

*Trace and Maximum Eigenvalue Tests*

| Hypothesis | Eigenvalue | Trace Statistic | 0.05 Critical Value | p-value |
|---|---|---|---|---|
| None * | 0.998019 | 582.7300 | 239.2354 | 0.0000 |
| At most 1 * | 0.969956 | 389.7824 | 197.3709 | 0.0000 |
| At most 2 * | 0.949643 | 281.1240 | 159.5297 | 0.0000 |
| At most 3 * | 0.886344 | 188.4766 | 125.6154 | 0.0000 |
| At most 4 * | 0.736408 | 121.0647 | 95.75366 | 0.0003 |
| At most 5 * | 0.606687 | 79.73072 | 69.81889 | 0.0066 |
| At most 6 * | 0.515116 | 50.80307 | 47.85613 | 0.0257 |
| At most 7 | 0.449678 | 28.36384 | 29.79707 | 0.0725 |
| At most 8 | 0.200871 | 9.849043 | 15.49471 | 0.2925 |
| At most 9 | 0.089242 | 2.897804 | 3.841466 | 0.0887 |

*Trace test indicates 7 cointegrating equations at the 0.05 level.*

*Unrestricted Cointegration Rank Test (Maximum Eigenvalue)*

| Hypothesis | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | p-value |
|---|---|---|---|---|
| None * | 0.998019 | 192.9476 | 64.50472 | 0.0001 |
| At most 1 * | 0.969956 | 108.6584 | 58.43354 | 0.0000 |
| At most 2 * | 0.949643 | 92.64738 | 52.36261 | 0.0000 |
| At most 3 * | 0.886344 | 67.41199 | 46.23142 | 0.0001 |
| At most 4 * | 0.736408 | 41.33394 | 40.07757 | 0.0359 |
| At most 5 | 0.606687 | 28.92764 | 33.87687 | 0.1739 |
| At most 6 | 0.515116 | 22.43923 | 27.58434 | 0.1987 |
| At most 7 | 0.449678 | 18.51480 | 21.13162 | 0.1118 |
| At most 8 | 0.200871 | 6.951238 | 14.26460 | 0.4949 |
| At most 9 | 0.089242 | 2.897804 | 3.841466 | 0.0887 |

*Trace test indicates 5 cointegrating equations at the 0.05 level.*

In both tests, the hypothesis of the existence of at least five cointegrating vectors is confirmed.

Engle and Granger (1987) stated that if the Dickey–Fuller test is performed on the residuals of the model and the residual time series is stationary, this confirms cointegration. However, caution must be exercised when using this method because the conventional critical values are not fully appropriate, and the critical values provided by Engle and Granger should instead be used. In this case, stationarity and non-stationarity are examined through the Dickey–Fuller unit root test.

**Table 3**

*Cointegration Test: Engle–Granger Test*

| Test Statistic | p-value |
|---|---|
| -5.730189 | 0.0000 |

To estimate the Human Development Index model, the dynamic coefficients of the model and the ECM specification are estimated in order to determine the speed of adjustment of deviations from long-run equilibrium. The NARDL model is selected to estimate the long-run coefficients, the coefficient of the error correction term, and the short-run coefficients associated with the equation. The results of estimating the dynamic coefficients of this model are presented in Table 4.

**Table 4**

*Estimation Results of the Human Development Index Model*

| Variable | Coefficient | Standard Error | t-Statistic | p-value |
|---|---|---|---|---|
| GG(-1) | 0.196692 | 0.095788 | 2.053411 | 0.0549 |
| DLnGS_POS | -0.474573 | 0.124633 | -3.807772 | 0.0066 |
| DLnGS_NEGE | 0.112346 | 0.033569 | 3.346760 | 0.0036 |
| DLnRQ_POS | 0.116226 | 0.039950 | 2.909323 | 0.0094 |
| DLnRQ_NEGE | -0.203325 | 0.054194 | -3.751771 | 0.0045 |
| DLnRA_POS | 0.137959 | 0.041832 | 3.297954 | 0.0040 |
| DLnRA_NEGE | -0.850933 | 0.336984 | -2.525142 | 0.0212 |
| DLnFIN | 0.513400 | 0.157400 | 3.262762 | 0.0098 |
| DLnINF | -0.593920 | 0.289288 | -2.053044 | 0.0703 |
| DLnINV | 0.228524 | 0.054462 | 4.196024 | 0.0005 |
| DLnED | -0.242560 | 0.040182 | -6.036585 | 0.0002 |
| DLnPOP | 0.521203 | 0.272529 | 1.912466 | 0.0974 |
| DLnFDI | 0.123968 | 0.028846 | 4.297628 | 0.0004 |
| ECM(-1) | -0.723252 | 0.050810 | -14.23457 | 0.0000 |
| Diagnostic Tests | | | | |
| Normality Test | Wald Test | Heteroskedasticity Test | LM Test | Normality Test |
| 87.9865 (0.0000) | 45.15060 (0.0000) | 0.2684 (0.9586) | 0.45263 (0.6123) | 87.9865 (0.0000) |

To examine the statistical significance of the coefficients of the independent variables, the $t$-statistic is used. The null hypothesis in the $t$-test is as follows:

$$H_0: \beta_i = 0$$

The validity of this hypothesis is examined by the following statistic:

$$t = \frac{\hat{\beta}_i}{SE(\hat{\beta}_i)}$$

To decide whether to accept or reject the null hypothesis, the calculated $T$-statistic is compared with the tabulated $t$-value computed with $N-K$degrees of freedom at the 95% confidence level. If the absolute value of the calculated $T$-statistic is greater than the tabulated $t$-value, that is, if

$$| T_{\text{calculated}} | > t_{\text{table}},$$

the numerical value of the test function falls within the critical region and the null hypothesis $(H_0)$is rejected. In this case, at the 95% confidence level, the relevant coefficient $(\beta_i)$is statistically significant, indicating the existence of a relationship between the independent and dependent variables.

The results of the Wald test reported in the lower part of the above table, which examine the symmetry or asymmetry of positive and negative shocks to government size, resource governance, and institutional quality on the Human Development Index in the short run, indicate that the null hypothesis of equality of the coefficients of positive and negative shocks to government size, resource governance, and institutional quality is rejected, and the alternative hypothesis is accepted. Therefore, the asymmetric effects of positive and negative shocks in government size, resource governance, and institutional quality on the Human Development Index are confirmed.

The results indicate that the model variables are statistically significant. The findings show that negative fluctuations in government size have a positive effect, whereas positive fluctuations in government size have a negative effect on the Human Development Index in the short run. Therefore, in this model, government size has an inverse effect on the Human Development Index. By separating negative and positive fluctuations in government size, the related coefficients indicate that the response of the Human Development Index to each of these fluctuations differs; therefore, their effects are asymmetric. To examine the validity of the asymmetric effects more precisely, the $t$-test is employed. Since the null hypothesis of the $t$-test, which states that the coefficients are equal, is rejected, the inequality of coefficients is established, confirming the asymmetric nature of the effects of fluctuations in government size on the Human Development Index.

The findings also show that negative fluctuations in institutional quality have a negative effect, while positive fluctuations in institutional quality have a positive effect on the Human Development Index in the short run. Therefore, in this model, the institutional quality index has a direct effect on the Human Development Index. By separating negative and positive fluctuations in the institutional quality index, the related coefficients show that the response of the Human Development Index to each type of fluctuation differs; hence, the effects are asymmetric. To verify the validity of the asymmetric effects more accurately, the $t$-test is used. Since the null hypothesis of the $t$-test regarding equality of coefficients is rejected, the inequality of coefficients is confirmed, which supports the argument that the effects of fluctuations in the institutional quality index on the Human Development Index are asymmetric.

The findings further indicate that negative fluctuations in resource governance have a negative effect, while positive fluctuations in resource governance have a positive effect on the Human Development Index in the short run. Therefore, in this model, the resource governance index has a direct effect on the Human Development Index. By separating negative and positive fluctuations in the resource governance index, the relevant coefficients show that the response of the Human Development Index to each of these fluctuations differs; thus, the effects are asymmetric. To examine the validity of the asymmetric effects more accurately, the $t$-test is again employed. Since the null hypothesis of the $t$-test regarding equality of coefficients is rejected, the inequality of coefficients is confirmed, providing support for the asymmetric nature of the effects of fluctuations in the resource governance index on the Human Development Index.

The short-run coefficients extracted from the asymmetric error correction equation indicate that the coefficients of financial development, physical investment, population, and foreign direct investment are positive and equal to 0.513400, 0.228524, 0.521203, and 0.123968, respectively. Based on the reported p-values, which are less than 0.05 (with the exception of population), these variables are statistically significant at the 95% confidence level. Moreover, the inflation rate and total external debt have negative effects on the Human Development Index. Considering the probability level associated with external debt, this variable has a statistically significant effect on the Human Development Index at the 95% confidence level. However, the calculated p-value for the inflation rate exceeds 0.05, indicating that this variable does not have a statistically significant effect on the Human Development Index at the 95% confidence level, although it is acceptable at the 90% confidence level. Finally, the value of the error correction term is $ECM = -0.72$, which indicates two facts. First, because the $ECM$ coefficient is negative, convergence from short-run equilibrium toward long-run equilibrium is confirmed. Second, the magnitude of the $ECM$ coefficient indicates the speed at which short-run equilibrium converges toward long-run equilibrium.

To ensure the validity and reliability of the estimated model results, diagnostic tests for serial autocorrelation and heteroskedasticity were conducted on the residuals of the NARDL model.

**Table 5**

*Results of the Model Diagnostic Tests*

| Diagnostic Tests | Result |
|---|---|
| LM serial correlation test | Prob = 0.4852 |
| Breusch–Pagan–Godfrey heteroskedasticity test | Prob = 0.2268 |
| Ramsey RESET specification error test | Prob = 0.3690 |

As the results of the diagnostic tests in the above table indicate, the estimated model does not suffer from heteroskedasticity, specification error, or serial autocorrelation. This supports the validity of the estimated model results.

In addition, to calculate the long-run statistic of the model (Banerjee and Dolado), the same dynamic model is used. The long-run coefficients associated with the $X$ variables are obtained from the following relationship:

$$\text{Long-run coefficients} = \frac{\text{coefficients of } X}{1 - \sum \text{coefficients of lagged dependent variable}}$$

To verify that the long-run relationship obtained from this method is not spurious, the following hypothesis is tested:

$H_0$:No cointegration or no long-run relationship exists

$H_1$:Cointegration or a long-run relationship exists

The null hypothesis indicates the absence of cointegration or a long-run relationship. The condition for the short-run dynamic relationship to converge toward long-run equilibrium is that the sum of the coefficients must be less than one. The alternative hypothesis, therefore, indicates the existence of cointegration or a long-run relationship.

To perform the test, the value of one must be subtracted from the sum of the coefficients of the lagged dependent variable, and the result must then be divided by the sum of the standard errors of those coefficients.

$$t = \frac{\sum\hat{\beta} - 1}{\sum SE(\hat{\beta})}$$

If the absolute value of the calculated $t$-statistic is greater than the absolute value of the critical values reported by Banerjee, Dolado, and Mestre, the null hypothesis is rejected and cointegration, or the existence of a long-run relationship, is accepted.

The calculated statistic is equal to $-8.38$. Since the absolute value of this number is greater than the critical value reported by Banerjee, Dolado, and Mestre ( $-3.27$), the null hypothesis of no long-run relationship is rejected. Therefore, the model variables are cointegrated.

The calculated statistic is obtained as follows:

$$\frac{0.196692 - 1}{0.095788} = -8.386311$$

The long-run NARDL estimation results are presented in Table 6.

**Table 6**

*Long-Run NARDL Estimation*

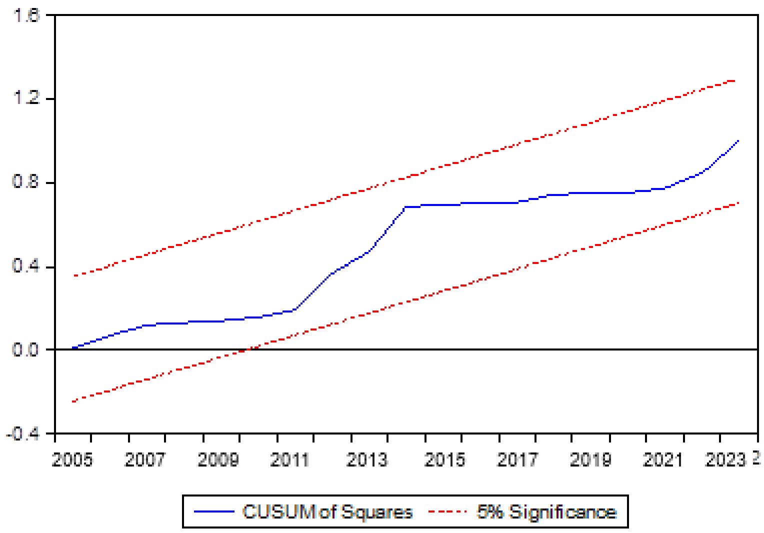
| Variable | Coefficient | Standard Error | t-Statistic | p-value |
|---|---|---|---|---|
| LnGS | -0.237409 | 0.102221 | -2.322508 | 0.0321 |
| LnRQ | 0.123066 | 0.026111 | 4.713159 | 0.0002 |
| LnRA | 0.225637 | 0.062077 | 3.634768 | 0.0019 |
| LnFIN | 0.251691 | 0.097504 | 2.581332 | 0.0188 |
| LnINF | -0.063825 | 0.023099 | -2.763094 | 0.0145 |
| LnINV | 0.070174 | 0.026734 | 2.624946 | 0.0191 |
| LnED | -0.437643 | 0.207664 | -2.107460 | 0.0494 |
| LnPOP | 0.379810 | 0.141282 | 2.688308 | 0.0150 |
| LnFDI | 0.181210 | 0.065910 | 2.749323 | 0.0149 |
| C | 0.376683 | 0.176713 | 2.131606 | 0.0471 |

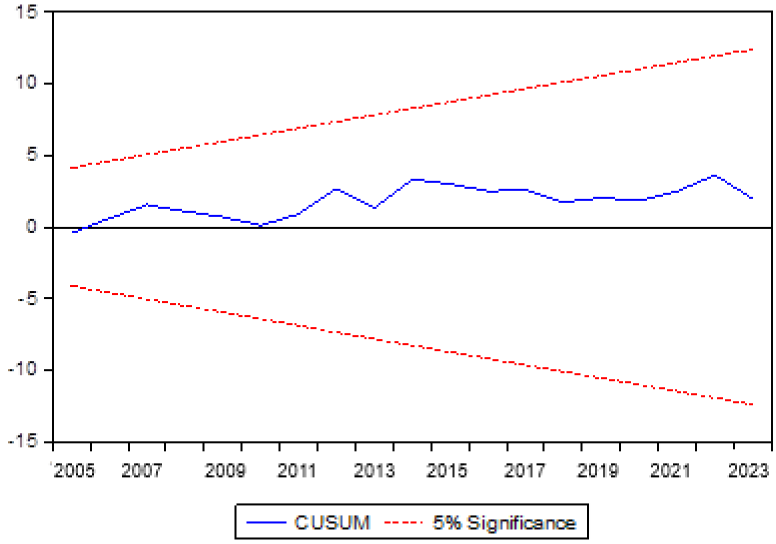
The obtained results indicate that all model variables are statistically significant in the long run at the 5% error level.

To test structural stability, the cumulative sum of recursive residuals and the cumulative sum of squares of recursive residuals, proposed by Brown, are used.

**Figure 1**

*CUSUM and CUSUMSQ Tests*






As can be observed, the plots of the cumulative residuals and the cumulative squared residuals lie between the two straight lines representing the 95% confidence interval.

If the plotted line remains within the confidence interval, the null hypothesis of no structural break is accepted. If the plotted line moves outside the confidence interval, that is, crosses the confidence bounds, the null hypothesis of no structural break is rejected and the existence of a structural break is accepted. In addition, the cumulative residual statistic is used to identify systematic changes in the regression coefficients, whereas the cumulative squared residual statistic is used when deviations from coefficient stability occur in a random and sudden manner.

## 4. Discussion and Conclusion

The findings of the present study provide robust empirical evidence regarding the asymmetric effects of government size, institutional quality, and resource governance on the Human Development Index (HDI) in Iran within both short-run and long-run frameworks. The estimated nonlinear autoregressive distributed lag (NARDL) model demonstrates that negative shocks to government size exert a positive effect on human development, whereas positive shocks have a negative effect. This result indicates that expansions in government size may reduce efficiency and hinder human development, while contractions may improve resource allocation and institutional performance. These findings are consistent with the argument that excessive government intervention may lead to bureaucratic inefficiencies and misallocation of resources, thereby negatively affecting development outcomes (Friedman & Denti, 2022). Similarly, empirical evidence from Iran suggests that the impact of government size is not uniform and depends on its structure and efficiency (Mohammadi & Hosseini, 2023; Mousavi & Bahrami, 2022). Moreover, the asymmetric nature of these effects aligns with the findings of (Ghasemi & Ahmadi, 2023), who highlight that increases and decreases in government size do not produce equivalent effects on human development, emphasizing the importance of nonlinear modeling approaches.

The results also reveal that institutional quality has a direct and asymmetric impact on human development, with positive shocks enhancing HDI and negative shocks deteriorating it. This finding underscores the critical role of institutions in shaping development outcomes, as strong institutions improve governance, reduce corruption, and enhance the effectiveness of public policies. The positive relationship between institutional quality and human development is well-documented in the literature, with studies demonstrating that improvements in governance structures lead to better social and economic outcomes (Ayoade et al., 2023; Jungo, 2022). Furthermore, the negative impact of deteriorating institutional quality is consistent with the findings of (Soltani & Hosseini, 2022) and (Kazemi & Nazari, 2022), who argue that institutional inefficiencies and corruption significantly undermine human development by distorting incentives and reducing the effectiveness of public expenditures. The asymmetry observed in this study further suggests that institutional deterioration may have more pronounced and potentially irreversible effects compared to improvements, highlighting the importance of maintaining institutional stability.

Resource governance is another key determinant examined in this study, and the results indicate that positive shocks to resource governance improve human development, while negative shocks have adverse effects. This finding is particularly relevant in the context of resource-rich economies such as Iran, where the management of natural resources plays a crucial role in determining development outcomes. The results support the resource curse hypothesis, which posits that poor governance of natural resources can hinder economic and social progress (Sachs & Warner, 2019). However, the positive effects of improved resource governance observed in this study suggest that effective management of resource revenues can contribute significantly to human development, particularly when combined with strong institutional frameworks (Rafiei & Sharifi, 2022; Rahimi & Bagheri, 2022). These findings are also consistent with the evidence presented by (Najafi & Karimi, 2023) and (Jalali & Sadeghi, 2022), who emphasize the importance of institutional quality in mediating the relationship between resource abundance and development outcomes.

In addition to the core variables, the results indicate that financial development, physical investment, population growth, and foreign direct investment (FDI) have positive and statistically significant effects on human development in the short run. These findings highlight the importance of economic and structural factors in supporting development processes. Financial development facilitates access to credit and investment opportunities, thereby enhancing economic activity and improving living standards (Singh, 2023). The role of financial innovation and FinTech in expanding access to financial services further reinforces this relationship (Mirzaei et al., 2026). Similarly, investments in physical capital contribute to infrastructure development and productivity improvements, which are essential for sustainable growth. The positive impact of FDI reflects its role in transferring technology, creating employment opportunities, and enhancing economic efficiency. These findings are in line with the broader literature on development economics, which emphasizes the importance of investment and financial systems in promoting human development.

On the other hand, the results show that inflation and external debt have negative effects on human development. High inflation rates erode purchasing power, reduce real incomes, and create economic uncertainty, which negatively affects welfare and living standards. Similarly, excessive external debt can constrain fiscal space and limit the ability of governments to invest in social sectors, thereby hindering development. These findings are consistent with theoretical and empirical studies that highlight the adverse effects of macroeconomic instability on development outcomes. The lack of statistical significance of inflation at the 95% confidence level, however, suggests that its impact may be context-dependent and influenced by other macroeconomic factors.

The estimated error correction term (ECM) is negative and statistically significant, indicating a high speed of adjustment from short-run disequilibrium toward long-run equilibrium. This finding confirms the existence of a stable long-run relationship among the variables and highlights the dynamic nature of the adjustment process. The magnitude of the ECM coefficient suggests that deviations from equilibrium are corrected relatively quickly, which reflects the responsiveness of the system to changes in economic and institutional conditions. This result is consistent with the theoretical framework of cointegration and error correction modeling, which emphasizes the importance of long-run equilibrium relationships in economic systems.

The long-run results further reinforce the importance of institutional quality and resource governance, as both variables exhibit positive and significant effects on human development. These findings align with the arguments of (Rodrik, 2021), who emphasizes that high-quality institutions are essential for achieving sustainable and inclusive growth. Similarly, the positive impact of financial development and investment in the long run highlights the importance of structural and policy factors in shaping development trajectories. The negative effects of government size and inflation in the long run suggest that maintaining macroeconomic stability and optimizing government intervention are critical for achieving sustainable development outcomes.

Overall, the findings of this study contribute to the existing literature by providing empirical evidence on the asymmetric effects of key economic and institutional variables on human development. The use of the NARDL approach allows for a more nuanced understanding of these relationships, capturing the differential impacts of positive and negative shocks. The results underscore the importance of considering asymmetries in policy analysis, as ignoring these dynamics may lead to incomplete or misleading conclusions. Furthermore, the findings highlight the interconnected nature of economic and institutional factors, suggesting that effective development strategies must adopt a holistic approach that integrates multiple dimensions of policy and governance.

One of the main limitations of this study is the reliance on aggregated national-level data, which may mask regional disparities and heterogeneity in development outcomes. Additionally, the measurement of institutional quality and resource governance is subject to data constraints and may not fully capture all relevant dimensions of these constructs. The use of annual data may also limit the ability to capture short-term fluctuations and dynamic adjustments. Furthermore, the model does not account for potential external shocks such as geopolitical factors or global economic crises, which may influence the results.

Future studies could extend the analysis by incorporating regional or provincial data to capture spatial variations in human development and governance. The inclusion of additional variables, such as environmental sustainability or technological innovation, could provide a more comprehensive understanding of development processes. Researchers may also explore alternative nonlinear modeling techniques or compare the NARDL approach with other econometric methods. Longitudinal studies using higher-frequency data could offer deeper insights into short-run dynamics and policy impacts.

Policymakers should prioritize improving institutional quality through measures that enhance transparency, accountability, and governance efficiency. Effective management of natural resources should be emphasized to ensure that resource revenues contribute to sustainable development. Efforts should also be made to optimize government size by focusing on the quality and efficiency of public expenditures rather than their scale. Strengthening financial systems and promoting investment can further support human development, while maintaining macroeconomic stability is essential for long-term progress.

## Authors' Contributions

Authors contributed equally to this article.

## Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

## Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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## Declaration of Interest

The authors report no conflict of interest.

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## Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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