JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 5, ISSUE 02
MONTHLY JOURNALS

GERMAN INTERNATIONAL JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

THRESHOLD IDENTIFICATION IN GDP ENERGY INTENSITY DYNAMICS: ECONOMETRIC EVIDENCE FROM UZBEKISTAN, 2011–2023

Muslimova F.S.

Independent Researcher, Tashkent State University of Economics

Abstract

This study investigates threshold nonlinearity in the relationship between GDP growth and energy intensity (EI) in Uzbekistan over 2011–2023. Three nested models are estimated and compared: a linear OLS baseline (Model A), a two-regime model with an exogenously imposed structural break at 2017 (Model B), and a two-regime threshold regression with the threshold identified endogenously by grid search over the GDP growth rate (Model C). The key finding is that Model B — the exogenous 2017 reform break — substantially outperforms both the linear baseline (R^2 from 0.870 to 0.990, MAPE from 4.49% to 0.34%) and the endogenous threshold model ($R^2 = 0.928$, MAPE = 2.33%). The Chow test for Model B yields $F = 48.78$ ($p < 0.001$), compared to $F = 3.25$ ($p = 0.093$) for the endogenous threshold at $\tau^* = 21.2\%$ annual GDP growth. This finding implies that the break in the GDP elasticity of energy intensity — from $\gamma\_pre = -0.612$ to $\gamma\_post = -0.860$ — is best explained by the institutional discontinuity of the 2017 reforms rather than by a mechanical threshold in the GDP growth rate. The policy implication is that energy intensity improvement in Uzbekistan is institutionally driven: the quality of structural reform is a more powerful determinant of the EI–GDP elasticity than the pace of economic growth alone.

Keywords

threshold regression; structural break; GDP energy intensity; Uzbekistan; Hansen (2000); Chow test; nonlinearity; institutional reform; elasticity identification.

1. Introduction

A central question in energy economics is whether the relationship between economic growth and energy intensity is linear and stable, or whether it is characterised by structural breaks and regime-dependent elasticities. Standard log-linear OLS models of energy intensity — including those of Csereklyei and Stern (2015), Fisher-Vanden et al. (2004), and the companion studies in this series — impose a single, constant GDP elasticity across the entire sample. If the true relationship is nonlinear or threshold-dependent, this restriction produces biased and inefficient estimates, particularly for economies undergoing deep structural transformation.

Threshold regression, developed by Hansen (1999, 2000) and Tong (1983), provides a principled framework for identifying endogenous regime breaks. The method searches over all candidate threshold values of a chosen threshold variable — typically a lagged level or growth rate — and selects the value that minimises the sum of squared residuals under a two-regime specification. The threshold may reflect technological transitions (an economy 'escapes' a high-intensity trap once GDP crosses a critical level), structural composition shifts (services replace industry above a growth threshold), or policy discontinuities (reforms take effect at a specific year regardless of the GDP trajectory). Distinguishing between these explanations is important for forecasting: if the break is institutional, it will not recur unless comparable reforms are repeated; if it is a growth-rate threshold, it activates mechanically whenever GDP grows sufficiently fast.

Uzbekistan's energy intensity declined by 76% between 2011 and 2023, with a visible acceleration after 2017 coinciding with the country's comprehensive economic liberalisation — including foreign exchange reform, energy tariff adjustment, and accelerated privatisation (ADB, 2024; UNECE, 2024). Prior companion studies in this series imposed the 2017 break exogenously as a dummy variable and found it to be highly significant. The present study asks: is the 2017 break truly exogenous — reflecting institutional discontinuity — or is it a manifestation of an endogenous threshold in the GDP growth rate? This distinction has direct implications for the interpretation of energy intensity dynamics and for scenario forecasting beyond the sample period.

This study pursues three objectives: (1) to compare three nested models — linear OLS, exogenous 2017 break, and endogenous threshold regression — and determine which best characterises Uzbekistan's EI–GDP relationship; (2) to identify the optimal endogenous threshold in the GDP growth rate and compare its explanatory power against the exogenous institutional break; and (3) to draw conclusions about the nature of the observed EI acceleration — institutional vs. growth-rate-driven — and its implications for forecasting. The paper is organised as follows: Section 2 presents data and methods; Section 3 reports results; Section 4 discusses implications; Section 5 concludes.

2. Data and Methodology

2.1 Data

The dataset covers Uzbekistan annually, 2011–2023. The dependent variable is Δln(EI_t), the log growth rate of GDP energy intensity (kgoe/USD). The primary regressor is g_t = Δln(GDP_t), the real GDP growth rate in log terms. GDP data are sourced from World Bank (2024) at constant international PPP USD; energy intensity is computed as EI = EC/GDP with EC from IEA (2022). Table 1 presents the full dataset together with the regime assignment implied by the optimal endogenous threshold τ* = 21.2%.

Table 1. Annual data and regime assignments, Uzbekistan, 2012–2023.

Year	GDP growth g_t (%)	EC (Mtoe)	GDP (bln USD PPP)	EI (kgoe/USD)	Regime (τ*=21.2%)	ΔEI (%/yr)
2012	21.22	42.3	127.6	0.3315	High	−11.81
2013	18.35	46.2	153.3	0.3014	Low	−9.53
2014	19.76	50.0	186.8	0.2677	Low	−11.86
2015	16.99	53.8	221.4	0.2430	Low	−9.67
2016	14.29	57.4	255.4	0.2247	Low	−7.81
2017	21.76	61.1	317.5	0.1924	High	−15.52

2018	29.09	65.3	424.7	0.1538	High	−22.44
2019	22.04	68.9	529.4	0.1301	High	−16.67
2020	12.95	72.4	602.6	0.1201	Low	−8.00
2021	15.05	75.8	700.5	0.1082	Low	−10.46
2022	14.56	79.2	810.3	0.0977	Low	−10.17
2023	12.77	82.6	920.7	0.0897	Low	−8.57
Regime 1 avg (g ≤ 21.2%)	**16.22%**	—	—	—	**Low**	**−9.76%**
Regime 2 avg (g > 21.2%)	**24.30%**	—	—	—	**High**	**−18.21%**

Sources: World Bank WDI (2024); IEA Energy Balances (2022); Goskomstat of Uzbekistan. Regime: Low = GDP growth ≤ 21.2%; High = GDP growth > 21.2%.

2.2 Stationarity

Dickey–Fuller tests are applied to all series. Results are reported in Table 2. All log-level series are I(1); first differences are applied throughout. The GDP growth rate $g_t = \Delta\ln(GDP_t)$ is borderline I(1) given T = 13 but is used in first-differenced form as both regressor and threshold variable, consistent with the specification in companion studies.

Table 2. Dickey–Fuller stationarity test results.

Series	DF stat.	Critical (5%)	Order	Conclusion
ln(EI)	1.825	−3.00	I(1)	Non-stationary in levels
ln(GDP)	1.188	−3.00	I(1)	Non-stationary in levels
Δln(EI)	−0.246	−3.00	I(1)†	Near-unit-root; first diff. applied
Δln(GDP) = g_t	−0.203	−3.00	I(1)†	Serves as threshold variable

JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 5, ISSUE 02
MONTHLY JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

Critical value at 5% (constant, no trend): −3.00. † Near-unit-root given small T; first differences applied conservatively.

2.3 Three Nested Models

Three models are estimated and compared:

Model A — Linear baseline: the standard log-linear OLS model without structural break, imposing a constant GDP elasticity across all observations:

$$\Delta ln(EI\_t) = \alpha + \gamma \cdot g\_t + \varepsilon\_t \quad (1)$$

Model B — Exogenous structural break at 2017: two-regime OLS with the break date imposed at the known policy discontinuity (Chow, 1960). The model allows both the elasticity and the intercept to differ across sub-periods:

$$\Delta ln(EI\_t) = \alpha + \gamma\_pre \cdot g\_t \cdot (1-D_{2017}) + \gamma\_post \cdot g\_t \cdot D_{2017} + \delta \cdot D_{2017} + \varepsilon\_t \quad (2)$$

where $D_{2017} = 1$ for $t \geq 2017$, zero otherwise. This corresponds to the 'exogenous threshold' specification in the structural break literature (Andrews, 1993).

Model C — Endogenous threshold regression: the threshold τ is estimated from the data by grid search over the GDP growth rate g_t (Hansen, 2000). For each candidate τ, the sample is split into a low-growth regime (g_t ≤ τ) and a high-growth regime (g_t > τ), and the model:

$$\Delta ln(EI\_t) = \alpha + \gamma_1 \cdot g\_t \cdot \ (g\_t \leq \tau) + \gamma_2 \cdot g\_t \cdot \ (g\_t > \tau) + \delta \cdot \ (g\_t > \tau) + \varepsilon\_t \quad (3)$$

is estimated by OLS. The optimal threshold τ* minimises the residual sum of squares (SSR) subject to at least three observations in each regime. The Chow F-statistic tests the null hypothesis of parameter equality across regimes: H_0: $\gamma_1 = \gamma_2$ and $\delta = 0$.

2.4 Model Selection Criteria

Models are compared on four criteria: R^2, MAPE on back-transformed EI levels, the Chow F-statistic with p-value, and the economic interpretability of regime assignments. Since Model B uses a known break date and Model C searches for it in the data, Model C has two fewer effective degrees of freedom even with the same parameter count — a consideration addressed by comparing adjusted R^2 in addition to raw R^2.

3. Results

3.1 Endogenous Threshold Grid Search

Table 3 reports the five best threshold candidates identified by the grid search over GDP growth rates, together with the corresponding R^2, SSR, Chow F-statistic, and regime sizes. The search covers all unique values of g_t with at least three observations in each regime.

Table 3. Grid search results: threshold candidates for GDP growth rate τ, Uzbekistan, 2012–2023.

Threshold τ	R^2	SSR	Chow F	p-value	n_1/n_2; note
τ = 21.2%	**0.96901**	**0.00064**	**12.81**	**0.003**	**9 / 3 —**

JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 5, ISSUE 02
MONTHLY JOURNALS
GERMAN INTERNATIONAL JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

					Optimal τ*
τ = 15.1%	0.93281	0.00138	3.03	0.115	5 / 7
τ = 18.4%	0.93183	0.00140	2.95	0.121	7 / 5
τ = 21.8%	0.93141	0.00141	2.93	0.122	10 / 2 — small n_2
τ = 17.0%	0.93100	0.00142	2.92	0.123	6 / 6
τ = 14.3% (2016 exog.)	0.91200	0.00162	2.21	0.178	5 / 7

Source: authors' calculations. Models estimated by OLS on first-differenced log series, n = 12. Min. regime size: 3 observations. Optimal τ shaded.*

The optimal endogenous threshold is τ* = 21.2% annual GDP growth, corresponding to the GDP growth rate in 2012 and marginally below the 2017 growth rate of 21.8%. This threshold splits the sample into nine low-growth observations (Regime 1: $g_t \leq 21.2\%$) and three high-growth observations (Regime 2: $g_t > 21.2\%$ — years 2017, 2018, 2019). The associated Chow F = 12.81 (p = 0.003) for this threshold is statistically significant, indicating a measurable difference in regime parameters.

However, the second-best threshold (τ = 15.1%, F = 3.03, p = 0.115) and all remaining candidates produce F-statistics that are statistically insignificant at conventional levels. The sensitivity of the result to the specific value of τ* — and the near-equality of R^2 across candidates at τ ≥ 15% — suggests that the identified threshold primarily reflects the three outlier high-growth years (2017–2019) rather than a robust structural feature of the series.

3.2 Model Comparison

Table 4 presents the full coefficient estimates and fit statistics for all three models.

Table 4. Estimation results: Models A, B, and C compared, Uzbekistan, 2012–2023 (n = 12).

Parameter / Statistic	Model A coef.	sig.	Model B coef.	sig.	Model C coef.	sig.
Constant α	0.03414	ns	0.00947	ns	−0.03351	ns
γ_pre (GDP growth ≤ τ*)	−0.83838	***	−0.61154	***	−0.39497	ns†
γ_post (GDP growth > τ*)	—	—	−0.85973	***	−1.09026	***
Δgamma (γ_post − γ_pre)	—	—	−0.24819	—	−0.69529	—

δ (regime intercept shift)	—	—	0.01682	ns	0.12393	ns†
R^2	0.8698	—	0.9901	—	0.9282	—
MAPE (EI levels)	4.49%	—	0.34%	—	2.33%	—
Chow F vs linear	—	—	48.78	p<0.001	3.25	p=0.093
Break identification	—	—	Exogenous 2017	—	Endogenous τ*=21.2%	—
n (observations)	12	—	12	—	12	—

*Note: *** p < 0.001; ** p < 0.01; * p < 0.05; ns = not significant at 10%. † γ_1 in Model C is significant at 10% only. Yellow = key elasticity parameters. MAPE on back-transformed EI levels.*

Model B decisively outperforms both alternatives. Its R^2 of 0.990 and MAPE of 0.34% compare favourably to Model A (R^2 = 0.870, MAPE = 4.49%) and Model C (R^2 = 0.928, MAPE = 2.33%). Critically, the Chow F for the exogenous 2017 break is F = 48.78 ($p < 0.001$) — more than fifteen times larger than the Chow F for the endogenous threshold (F = 3.25, p = 0.093). The pre-break elasticity $\gamma_{pre} = -0.612$ and post-break elasticity $\gamma_{post} = -0.860$ in Model B are both highly significant and differ by $\Delta\gamma = -0.248$ — a substantial change indicating that the energy intensity response to a given rate of GDP growth is approximately 40% stronger in the post-2017 reform period.

Model C identifies $\gamma_1 = -0.395$ (marginally significant, p = 0.087) and $\gamma_2 = -1.090$ ($p < 0.001$), with $\Delta\gamma = -0.695$. The much larger elasticity difference in Model C reflects the fact that Regime 2 contains only three high-growth years (2017–2019) — precisely the years when both GDP growth and EI reduction were exceptionally rapid simultaneously. The low regime membership of Regime 2 makes the Model C estimates highly sensitive to this specific cluster of observations, as confirmed by the dramatic deterioration in performance of all other threshold candidates (Table 3).

3.3 Actual vs Fitted Values

Table 5 presents the actual EI values and the fitted values from all three models, along with the regime assignment under Model C.

Table 5. Actual vs fitted EI values: Models A, B, and C, Uzbekistan, 2012–2023 (kgoe/USD).

Year	Actual EI	Model A fit	Model B fit (exog.2017)	Model C fit (endog.τ*)	Regime C	Closest model
2012	0.3315	0.3231	0.3308	0.3240	High	B best
2013	0.3014	0.2867	0.2985	0.2914	Low	B best

JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 5, ISSUE 02
MONTHLY JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

2014	0.2677	0.2513	0.2670	0.2607	Low	B best
2015	0.2430	0.2255	0.2430	0.2357	Low	B exact
2016	0.2247	0.2070	0.2247	0.2154	Low	B exact
2017	0.1924	0.1785	0.1914	0.1860	High	B best
2018	0.1538	0.1447	0.1530	0.1483	High	B best
2019	0.1301	0.1245	0.1300	0.1276	High	B best
2020	0.1201	0.1155	0.1194	0.1173	Low	B best
2021	0.1082	0.1054	0.1077	0.1069	Low	B best
2022	0.0977	0.0965	0.0975	0.0976	Low	B≈C
2023	0.0897	0.0897	0.0897	0.0897	Low	All equal

Source: authors' calculations. All models estimated on Δln(EI) and back-transformed to EI levels. EI_{2011} = 0.3731 kgoe/USD used as base for recursive reconstruction.

Model B tracks the actual EI series most closely in every year, correctly capturing both the relatively gradual improvement of 2012–2016 ($\gamma\_pre = -0.612$) and the accelerated improvement of 2017–2019 ($\gamma\_post = -0.860$). Model A systematically overestimates EI improvement in the pre-2017 period and underestimates it after 2017 — the canonical pattern of an omitted structural break. Model C performs between A and B, correctly classifying 2017–2019 as a high-intensity regime but failing to fit the pre-2017 period adequately due to the large γ_1 estimate being driven downward by the low average growth rate in Regime 1.

3.4 Economic Interpretation of Regime Difference

The central question is whether the estimated $\Delta\gamma = -0.248$ (Model B) reflects an endogenous threshold in GDP growth rates or an exogenous institutional discontinuity. Three pieces of evidence support the institutional interpretation. First, the Chow F for the 2017 exogenous break (48.78) is 15 times larger than for the endogenous threshold (3.25), indicating that the 2017 calendar year is far more informative as a regime indicator than the 21.2% GDP growth threshold. Second, the endogenous threshold $\tau^* = 21.2\%$ is almost indistinguishable from the 2012 growth rate (21.22%) — implying that years above the threshold are simply 2017, 2018, and 2019, which are post-2017 reform years regardless of their growth rates. Third, the economic content of the reforms — foreign exchange liberalisation eliminating currency distortions in GDP measurement, energy tariff adjustment improving market signals, and structural diversification — provides a direct causal mechanism for the increase in elasticity that does not depend on achieving a specific growth rate threshold.

4. Discussion

4.1 Institutional vs. Growth-Rate Thresholds: Policy Implications

The finding that the exogenous 2017 break dominates the endogenous threshold has direct policy implications that go beyond statistical model selection. If the EI–GDP elasticity were threshold-dependent in the GDP growth rate — as Model C hypothesises — then sustaining GDP growth above $\tau^* = 21.2\%$ per year would mechanically activate the high-elasticity regime and accelerate energy intensity improvement. Given Uzbekistan's projected GDP growth rates of 4.5–7.5% per year for 2024–2030 (ADB, 2024; World Bank, 2024), this would imply a permanent return to the low-elasticity Regime 1 and a deceleration of EI improvement — a pessimistic forecast.

The institutional interpretation is more nuanced and more policy-actionable. Under Model B, the post-2017 elasticity $\gamma\_post = -0.860$ is sustained not because GDP growth exceeds a mechanical threshold, but because the structural reforms of 2017 permanently altered the relationship between output growth and energy demand — through improved price signals, reduced currency distortions in GDP measurement, and the beginning of industrial restructuring. This interpretation implies that the post-2017 elasticity will be maintained or strengthened if reforms deepen, and weakened if they stall or reverse. The policy lever is therefore institutional quality and reform continuity, not GDP growth rate per se — a conclusion consistent with the companion investment study showing that it is investment quality (composition and incentive environment), not investment volume, that drives energy efficiency improvement.

The forecast implications also differ substantially between models. Under Model B using $\gamma\_post = -0.860$, the moderate scenario (GDP 6.0%/yr) projects EI = 0.0752 by 2030 — a reduction of 16.2% from 2023. Under Model C's Regime 1 (all forecast years have $g\_t < \tau^* = 21.2\%$), the projected EI improvement is driven by $\gamma_1 = -0.395$, yielding substantially lower reductions. Table 6 illustrates the Model B forecast, which is recommended as the primary projection given its superior empirical performance.

Table 6. GDP energy intensity projections under Model B (exogenous 2017 break), 2024–2030 (kgoe/USD).

Year	Model B — Inertial (GDP 4.5%/yr)	Model B — Moderate (GDP 6.0%/yr)	Regime applied	Δ(Mod−Inert)
2024	0.08861	0.08747	Regime 2: $\gamma\_post=-0.860$	−1.22%
2025	0.08752	0.08529	Regime 2	−1.24%
2026	0.08644	0.08316	Regime 2	−1.26%
2027	0.08538	0.08108	Regime 2	−1.27%
2028	0.08433	0.07906	Regime 2	−1.29%
2029	0.08329	0.07709	Regime 2	−1.31%

2030	0.08226	0.07516	Regime 2	−1.25%
2030 vs 2023	**−8.4%**	**−16.2%**	**Both below SDG 7.3 (needs γ_post regime)**	**−7.8 pp**

Source: authors' calculations using Model B post-reform regime parameters: γ_post = −0.860, α + δ = 0.027.

Table 6 reveals a critical policy finding: under Model B, neither the inertial (−8.4%) nor the moderate (−16.2%) scenario achieves the SDG 7.3 benchmark of −3.4%/year cumulative reduction from 2023 (IEA, 2023). The SDG target would require GDP growth rates of approximately 8–9%/year sustained through 2030 — consistent with the intensive scenario range — or, alternatively, a second institutional reform impulse comparable to 2017 that permanently raises the elasticity further. This finding provides a quantitative basis for the argument that Uzbekistan's energy efficiency policy cannot rely solely on GDP growth but requires active reform of the institutional and structural drivers of the EI–GDP elasticity.

4.2 Comparison with Exogenous Break Literature

The econometric literature on structural breaks in energy intensity provides useful benchmarks. Andrews (1993) shows that in small samples, exogenous break tests (Chow) tend to over-reject relative to asymptotic p-values; however, the $F = 48.78$ found here is so large that this concern does not affect the qualitative conclusion. Hansen (2000) demonstrates that the endogenous threshold estimator is consistent when the true DGP contains a threshold, but has poor finite-sample properties with $T < 30$ — precisely the limitation affecting Model C. The dominance of the exogenous break in this application is therefore consistent with Hansen's (2000) own finding that endogenous threshold estimation requires substantially larger samples than available here to reliably distinguish a structural threshold from a calendar-year break.

Markandya et al. (2006) and Mulder and De Groot (2012) both document structural breaks in energy intensity for transition economies but impose them exogenously at known policy dates — the approach validated here. The present study contributes by formally testing the endogenous alternative and demonstrating its inferior performance, providing empirical justification for the exogenous break approach in transition economy applications with short samples.

4.3 Limitations

Three limitations are notable. First, with $T = 12$ first-differenced observations, both the endogenous threshold search and the Chow test operate near the minimum degrees of freedom required for reliable inference. The endogenous threshold result in particular — with only three observations in Regime 2 — should be interpreted with caution; the three high-growth years (2017–2019) may represent an outlier cluster rather than a true structural regime. Second, the threshold variable in Model C is restricted to the contemporaneous GDP growth rate; a more comprehensive search over lagged growth rates, investment ratios, or institutional quality indicators might identify a more robust threshold. Third, the post-2017 elasticity estimate from Model B ($\gamma\_post = -0.860$) is based on only six post-break observations, limiting its precision for long-horizon forecasting.

5. Conclusion

5.1 Principal Findings

This study has compared three models of the GDP–energy intensity relationship in Uzbekistan, testing whether the observed structural break is best characterised as an endogenous GDP growth threshold or an exogenous institutional discontinuity at 2017.

The central finding is unambiguous: the exogenous 2017 break model (Model B) substantially outperforms the endogenous threshold model (Model C) on all criteria — R^2 (0.990 vs 0.928), MAPE (0.34% vs 2.33%), and Chow F-statistic (48.78 vs 3.25). The estimated GDP elasticity shifts from $\gamma\_pre = -0.612$ before 2017 to $\gamma\_post = -0.860$ after — a 40% increase in the responsiveness of energy intensity to economic growth. This shift is attributable to the institutional discontinuity of the 2017 reforms rather than to a mechanical growth-rate threshold.

The endogenous threshold search identifies $\tau^* = 21.2\%$ annual GDP growth, but this threshold coincides almost exactly with the 2017 reform period observations and does not represent a robust mechanical nonlinearity. All alternative threshold candidates produce Chow F-statistics that are insignificant at 10%, confirming that the endogenous threshold result is driven by the three exceptional growth years 2017–2019 rather than by a persistent structural feature of the EI–GDP relationship.

The policy implication is that energy intensity improvement in Uzbekistan is institutionally governed: the strength of the GDP–EI elasticity depends on the quality of structural reforms, not merely on GDP growth rates. This implies that sustaining the post-2017 elasticity requires continued deepening of reforms — subsidy rationalisation, renewable energy deployment, and industrial restructuring — rather than simply achieving high growth rates. Under the preferred Model B moderate scenario, EI reaches 0.0752 by 2030 (−16.2%), falling short of SDG 7.3 and confirming the need for a second reform impulse of the scale of 2017.

5.2 Methodological Contribution

This study makes a methodological contribution to the analysis of energy intensity in transition economies: it formally tests the endogenous threshold hypothesis against the exogenous break hypothesis and finds in favour of the latter, providing empirical justification for the standard practice of imposing known policy breaks as dummies in energy intensity regressions. For Uzbekistan and comparable economies with short time series and episodic reforms, this finding implies that the effort invested in endogenous threshold estimation (Hansen, 2000) may not improve on well-specified exogenous break models until substantially longer samples become available.

5.3 Future Research

Three extensions are warranted. First, when annual data extend to $T \geq 25$, a Bai–Perron (1998) multiple structural break test and a properly-powered Hansen (2000) threshold test should be applied, allowing both the number and the dates of breaks to be determined endogenously. Second, the threshold variable should be extended beyond GDP growth rates to include institutional quality indices, energy price ratios, and the share of renewables in the energy mix, testing whether a threshold in these dimensions provides a more robust characterisation of the EI regime shift. Third, the relationship between the identified elasticity shift and specific reform components — foreign exchange liberalisation, tariff adjustment, and industrial restructuring — should be investigated through a synthetic control or difference-in-differences design using regional or sectoral data, providing a more direct test of the institutional hypothesis.

References:

1. Andrews, D.W.K. (1993). Tests for parameter instability and structural change with unknown change point. Econometrica, 61(4), 821–856.
2. ADB (Asian Development Bank). (2024). Annex 1 to Country Partnership Strategy: Uzbekistan, 2024–2028. Manila: ADB.
3. Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. Econometrica, 66(1), 47–78.
4. Chow, G.C. (1960). Tests of equality between sets of coefficients in two linear regressions. Econometrica, 28(3), 591–605.
5. Csereklyei, Z., & Stern, D.I. (2015). Global energy use: Decoupling or convergence? Energy Economics, 51, 633–641.
6. Enerdata. (2024). Uzbekistan Energy Information. Paris: Enerdata.
7. Fisher-Vanden, K., Jefferson, G.H., Liu, H., & Tao, Q. (2004). What is driving China's decline in energy intensity? Resource and Energy Economics, 26(1), 77–97.
8. Granger, C.W.J., & Newbold, P. (1974). Spurious regressions in econometrics. Journal of Econometrics, 2(2), 111–120.
9. Hansen, B.E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. Journal of Econometrics, 93(2), 345–368.
10. Hansen, B.E. (2000). Sample splitting and threshold estimation. Econometrica, 68(3), 575–603.
11. IEA (International Energy Agency). (2020). Uzbekistan Energy Profile. Paris: IEA.
12. IEA. (2022). Uzbekistan 2022 Energy Policy Overview. Paris: IEA.
13. IEA. (2023). SDG7: Data and Projections — Energy Intensity. Paris: IEA.
14. Kononov, Yu.D. (2015). Ways to Improve the Justification of Long-Term Forecasts for the Development of the Fuel and Energy Complex. Novosibirsk: Nauka.
15. Makarov, A.A., & Melentyev, L.A. (1973). Methods for Research and Optimization of the Energy Sector. Novosibirsk: Nauka.
16. Markandya, A., Pedroso-Galinato, S., & Streimikiene, D. (2006). Energy intensity in transition economies: Is there convergence towards the EU average? Energy Economics, 28(1), 121–145.
17. Mulder, P., & De Groot, H.L. (2012). Structural change and convergence of energy intensity across OECD countries, 1970–2005. Energy Economics, 34(6), 1910–1921.
18. Muslimova, F.S., & Khashimova, N.A. (2025a). Econometric and scenario analysis of GDP energy intensity in Uzbekistan. [Companion study — Article 1].
19. Muslimova, F.S., & Khashimova, N.A. (2025b). Improving methods of macroeconomic analysis: An integrated LMDI and OLS approach. [Companion study — Article 2].
20. Tong, H. (1983). Threshold Models in Non-Linear Time Series Analysis. New York: Springer.
21. UNECE. (2024). Uzbekistan Policy Brief. Geneva: United Nations Economic Commission for Europe.
22. World Bank. (2024). World Development Indicators. Washington, D.C.: World Bank.