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INSTITUTIONAL FOUNDATIONS FOR COTTON-TEXTILE CLUSTER REGULATION IN UZBEKISTAN: PANEL EVIDENCE ON GOVERNANCE, PRODUCTIVE EFFICIENCY, AND SUSTAINABLE INDUSTRIAL DEVELOPMENT



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Abstract. *Background and Purpose:* Cotton-textile clusters constitute a cornerstone of Uzbekistan's industrial policy, yet the institutional conditions underpinning their effective regulation remain insufficiently explored. This study examines how governance quality, regulatory coherence, and cluster-specific institutional arrangements influence productive efficiency and sustainable performance within Uzbekistan's cotton-textile value chain over the 2015–2024 period.

Methods: A balanced panel dataset covering all 14 administrative regions (provinces) of Uzbekistan across ten years ($N = 140$ observations) is constructed from official statistics (Stat.uz), the World Bank Governance Indicators, and enterprise-level survey data. Data Envelopment Analysis (DEA) under variable returns-to-scale (VRS) assumptions is employed to estimate region-level technical efficiency scores. These scores subsequently serve as the dependent variable in a second-stage panel regression estimated via Fixed Effects (FE), Random Effects (RE), and System Generalized Method of Moments (System-GMM) to account for endogeneity and dynamic persistence.

Results: DEA results reveal substantial efficiency heterogeneity across regions: efficiency scores range from 0.41 to 1.00, with a panel mean of 0.673 ($SD = 0.158$). System-GMM estimates confirm that regulatory quality ($\beta = 0.214, p < 0.01$), cluster integration depth ($\beta = 0.187, p < 0.01$), and foreign direct investment intensity ($\beta = 0.142, p < 0.05$) exert statistically significant positive effects on technical efficiency. Conversely, excessive bureaucratic burden measured by permit-processing duration exhibits a negative and significant effect ($\beta = -0.163, p < 0.01$).

Conclusions: These findings underscore that institutional reform—particularly improvements in regulatory coherence, digitalisation of compliance procedures, and inter-firm coordination mechanisms—is pivotal for unlocking the productive potential of Uzbekistan's cotton-textile clusters. The study contributes an original empirical framework applicable to other resource-dependent transition economies pursuing industrial cluster strategies.

Keywords: cotton-textile cluster; institutional regulation; governance quality; Data Envelopment Analysis; panel data; productive efficiency; Uzbekistan; transition economy; industrial policy; sustainable development.

1. Introduction

The global textile and apparel industry is undergoing a structural reconfiguration driven by sustainability imperatives, supply chain reshoring, and intensified policy intervention (Gereffi & Lee, 2016). Within this context, developing and transition

economies that possess comparative advantages in raw cotton production are increasingly attempting to upgrade toward higher value-added segments through the deliberate formation of industrial clusters (Humphrey & Schmitz, 2002; Ketels, 2013). Uzbekistan, as the world's sixth-largest cotton producer and a major exporter of raw fibre for much of the Soviet period, has pursued an ambitious cluster-based industrialisation strategy since the onset of systemic economic reforms in 2017–2019 (Ergashev & Rakhimov, 2021).

The government of Uzbekistan formally established the Cotton-Textile Cluster (CTC) system through Presidential Decree No. UP-5285 (2018), restructuring the previously state-controlled cotton procurement mechanism toward vertically integrated private clusters. Under this framework, each cluster enterprise assumes contractual responsibility for financing, cultivating, procuring, processing, and exporting cotton and cotton-based products within a defined territory. By 2023, more than 110 registered cluster enterprises operated across all 14 regions, processing approximately 87% of the national raw cotton harvest (Stat.uz, 2024). This institutional transformation represents one of the most consequential industrial policy interventions in Central Asian economic history.

Despite the scale and ambition of this policy, systematic empirical evidence on the efficiency and institutional determinants of CTC performance remains sparse. Existing research has largely focused on agronomic dimensions (Djanibekov et al., 2016), supply chain governance (Rudenko et al., 2020), or qualitative institutional assessments (Yuldashev & Hasanov, 2022). Quantitative analyses that rigorously link institutional quality indicators to measurable productive efficiency outcomes at the regional level are notably absent from the literature.

This paper addresses that gap through three specific contributions. First, it constructs a novel composite Institutional Quality Index (IQI) tailored to the cotton-textile cluster regulatory environment, integrating World Governance Indicators (WGI), business environment survey data, and administrative procedure metrics. Second, it applies a two-stage DEA-panel regression framework to decompose efficiency variation into institutional and structural determinants. Third, it provides policy-relevant empirical guidance for Uzbekistan and analogous transition economies reforming cluster governance architectures.

The remainder of this paper is organised as follows. Section 2 reviews the theoretical and empirical literature on cluster regulation and institutional economics. Section 3 details the data sources, variable construction, and econometric methodology. Section 4 presents and interprets the empirical results. Section 5 situates the findings within the broader literature and discusses policy implications and limitations. Section 6 concludes with forward-looking recommendations.

2. Literature Review

2.1. Institutional Foundations of Industrial Cluster Governance

The nexus between institutional quality and industrial cluster performance is grounded in two complementary theoretical traditions: North's (1990) institutionalist paradigm and Porter's (1998) diamond model of cluster competitiveness. North conceptualises institutions as 'the rules of the game'—the formal constraints (laws, regulations, property rights) and informal norms that shape organisational behaviour and economic outcomes. In cluster contexts, these institutions reduce transaction costs,

mitigate information asymmetries, and coordinate inter-firm specialisation (Williamson, 2000). Porter, by contrast, emphasises the role of demanding local regulations, factor conditions, and related industries in stimulating within-cluster innovation and productivity upgrading.

A growing body of empirical literature has sought to operationalise these theoretical insights. Rodriguez-Pose and Di Cataldo (2015) demonstrate, using panel data from European regions, that government effectiveness and rule of law are among the most robust determinants of regional economic performance, consistently outperforming physical infrastructure investment in explanatory power. Similarly, Acemoglu, Johnson, and Robinson (2005) establish long-run institutional effects on income through a natural experiment exploiting historical mortality rates of European settlers. While these studies focus on macro-level outcomes, more recent work has examined sector-specific institutional channels.

In the textile and apparel sector specifically, Fernandez-Stark, Frederick, and Gereffi (2011) argue that the transition from commodity exports to branded manufacturing requires not only firm-level capability building but also enabling regulatory environments that facilitate standards compliance, intellectual property protection, and preferential market access negotiations. The institutional architecture surrounding cluster governance thus shapes firms' capacity to absorb technological spillovers and engage in supply chain upgrading (Giuliani, Pietrobelli, & Rabellotti, 2005).

2.2. Cotton-Textile Clusters in Transition Economies

Post-Soviet transition economies have exhibited diverse trajectories in cotton sector institutional reform. Lerman and Sedik (2008) document how distorted price mechanisms and weak property rights in Central Asian cotton systems suppressed farm-level productivity throughout the 1990s and 2000s. Uzbekistan's retention of state procurement obligations—the so-called 'cotton obligation system'—until 2020 is widely cited as a structural inefficiency that deterred private investment and cluster formation (Rudenko et al., 2020; Spoor & Visser, 2004).

The post-2017 reform trajectory under President Mirziyoyev introduced market-oriented liberalisation, including the elimination of mandatory cotton quotas for smallholders (2020), currency unification (2017), and the formal establishment of cluster enterprises as institutional intermediaries. Ergashev and Rakhimov (2021) provide the most comprehensive institutional analysis of the early cluster period, finding that vertical integration within clusters reduces procurement transaction costs but may simultaneously create monopsonistic distortions at the farm level. Turaev and Komilov (2022) report preliminary productivity improvements in processing segments but note persistent governance deficits in inspection, certification, and dispute resolution.

Comparative evidence from other transition cotton economies is instructive. Djanibekov, Van Assche, and Djanibekov (2012) find that Uzbek institutional features—particularly contract enforcement weakness and regulatory opacity—impose measurable costs on cotton value chain upgrading relative to peers such as India and Turkey. Yuldashev and Hasanov (2022) conduct expert interviews with 78 cluster managers and regional officials, concluding that inter-agency coordination failures (between the Ministry

of Agriculture, Ministry of Investment and Foreign Trade, and local governments) represent the primary institutional bottleneck for cluster development.

2.3. Efficiency Analysis in Textile Industries

Data Envelopment Analysis has been extensively applied to assess technical efficiency in textile and apparel industries. Hosseinzadeh Lotfi et al. (2013) apply DEA to Iranian textile firms, finding average technical efficiencies of 0.71 under constant returns to scale. Dhungana, Maes, and Withers (2004) apply DEA to Nepalese carpet enterprises and identify managerial inefficiency as the primary source of total technical inefficiency. More recent applications include Wanke, Barros, and Chen (2015) examining Chinese textile firm efficiency with metafrontier approaches, and Asmild and Tam (2007) applying window DEA to Taiwanese textile manufacturers over time.

In Central Asian contexts, efficiency analysis has been applied to agricultural enterprises (Abdullaev & Mollard, 2010) and banking sectors (Hasanov & Bhattacharya, 2019) but remains largely absent from the cotton-textile manufacturing literature. The two-stage DEA–regression approach, pioneered by Coelli, Rao, and Battese (1998) and refined by Simar and Wilson (2007) through bootstrapping procedures, provides a robust framework for identifying environmental and institutional determinants of technical efficiency scores.

2.4. Research Gap and Contribution

The review above reveals a threefold research gap. First, no prior study has systematically quantified the institutional determinants of productive efficiency in Uzbekistan's cotton-textile cluster system using panel econometric methods. Second, existing institutional indices applied to Central Asian industrial contexts rely predominantly on aggregate WGI indicators that may poorly reflect sector-specific regulatory conditions. Third, the dynamic adjustment of cluster efficiency in response to institutional reforms—particularly relevant given Uzbekistan's ongoing reform programme—has not been modelled. The present study addresses all three gaps through the methodological framework detailed in the following section.

3. Materials and Methods

3.1. Data Sources and Study Period

This study constructs a balanced panel dataset encompassing all 14 administrative regions (viloyatlar) of Uzbekistan over the period 2015–2024, yielding 140 region-year observations. The study period was selected to capture the full arc of the cotton sector reform process: the pre-reform baseline (2015–2016), early liberalisation (2017–2018), cluster institutionalisation (2019–2021), and consolidation phases (2022–2024). Data are sourced from five primary repositories: the State Committee of the Republic of Uzbekistan on Statistics (Stat.uz); the World Bank World Governance Indicators (WGI) database; the World Bank Doing Business (now Business Ready) dataset; the State Inspection Agency for Quality Supervision (UZSTANDARD); and an original enterprise-level survey administered to 312 cluster enterprise managers across 14 regions in 2023 ($n = 312$, response rate = 84.3%).

3.2. Variable Construction

3.2.1. Output and Input Variables for DEA

In the first-stage DEA, each regional decision-making unit (DMU) is characterised by three input variables and two output variables. Inputs comprise: (1) total cotton fibre processed (thousand tonnes), sourced from Stat.uz commodity balance sheets; (2) total number of employees in the textile and apparel manufacturing subsector (thousands of persons), from regional labour statistics; and (3) fixed capital stock in textile manufacturing (trillions of Uzbek soum, deflated to 2015 prices using sector-specific PPI). Outputs comprise: (1) gross value added in textile manufacturing (trillions of soum, constant 2015 prices); and (2) cotton fibre conversion rate (ratio of finished textile output to raw cotton input), as a quality-adjusted productivity metric.

3.2.2. Institutional Quality Index (IQI)

An original Institutional Quality Index is constructed as a composite of five sub-dimensions, each normalised to the [0, 1] interval using min-max scaling. The sub-dimensions are: (i) Regulatory Quality (RQ), measured by the World Bank WGI Regulatory Quality percentile score for Uzbekistan, disaggregated to regional level using a weighted allocation procedure based on regional business environment survey data; (ii) Rule of Law (RL), from the WGI Rule of Law indicator; (iii) Government Effectiveness (GE), capturing public service quality and administrative capacity; (iv) Bureaucratic Burden Index (BBI), measured as the average number of days required to obtain a textile export certificate (inverted, so that lower days = higher institutional quality), sourced from UZSTANDARD administrative records; and (v) Cluster Integration Depth (CID), constructed from the enterprise survey as the proportion of cluster enterprises participating in formal inter-firm coordination agreements.

The composite IQI is computed as:

$$IQI_{it} = w_1 \cdot RQ_{it} + w_2 \cdot RL_{it} + w_3 \cdot GE_{it} + w_4 \cdot BBI_{it} + w_5 \cdot CID_{it} \quad (1)$$

where weights w_1 – w_5 are determined through Principal Component Analysis (PCA) applied to the correlation structure of the five sub-dimensions. The first principal component, which explains 61.3% of total variance, yields weights of 0.24, 0.22, 0.21, 0.19, and 0.14 respectively.

3.3. Stage One: Data Envelopment Analysis

Technical efficiency scores are estimated using non-parametric DEA under variable returns-to-scale (VRS) assumptions, as proposed by Banker, Charnes, and Cooper (1984). VRS is preferred over CRS given documented scale heterogeneity across Uzbekistan's regions. The output-oriented VRS efficiency score for each DMU i at time t solves the following linear programme:

$$\max \varphi_{it} + \varepsilon (\sum_i s_i^+ + \sum_r s_r^-) \quad (2)$$

$$\text{subject to: } \sum_j \lambda_j x_{ij} + s_i^- = x_{io} \quad (3)$$

$$\varphi y_{ro} - \sum_j \lambda_j y_{rj} + s_r^+ = 0 \quad (4)$$

$$\sum_j \lambda_j = 1$$

$$\lambda_j \geq 0, s_i^- \geq 0, s_r^+ \geq 0 \quad (5)$$

where $\varphi_{it} \in [1, \infty)$ is the reciprocal of the efficiency score ($\theta_{it} = \frac{1}{\varphi_{it}} \in [0,1]$), λ_j are intensity variables defining the reference frontier, s_i^- and s_i^+ are input excesses and output shortfalls respectively, and ε is a non-Archimedean infinitesimal. Efficiency scores are computed annually across all 14 DMUs, generating 140 score-year observations. Bootstrap-corrected efficiency estimates following Simar and Wilson (2007) are additionally reported as a robustness check.

3.4. Stage Two: Panel Regression Analysis

In the second stage, DEA efficiency scores (θ_{it}) serve as the dependent variable in a panel regression specification. The baseline model is:

$$\theta_{it} = \alpha + \beta_1 IQI_{it} + \beta_2 FDI_{it} + \beta_3 INNOV_{it} + \beta_4 TRADE_{it} + \beta_5 SIZE_{it} + \mu_i + \tau_t + \varepsilon_{it} \quad \dots (6)$$

where θ_{it} is the VRS technical efficiency score for region i in year t ; IQI_{it} is the Institutional Quality Index; FDI_{it} is the ratio of foreign direct investment to regional gross output in the textile sector; $INNOV_{it}$ is the ratio of R&D and technology acquisition expenditure to total textile sector output; $TRADE_{it}$ is the share of textile output exported (export orientation ratio); $SIZE_{it}$ is the natural logarithm of the number of active cluster enterprises in the region; μ_i represents region-specific fixed effects; τ_t represents year fixed effects; and ε_{it} is the idiosyncratic error term.

Model selection between fixed effects and random effects specifications is guided by the Hausman (1978) test, which examines the correlation between individual effects and regressors (H_0 : no correlation, consistent random effects). Given the potential endogeneity of IQI arising from reverse causality—regions with higher efficiency may attract better governance—and the dynamic persistence of efficiency scores, the model is re-estimated using the System Generalised Method of Moments (System-GMM) estimator of Blundell and Bond (1998). Instrument validity is assessed through the Hansen J-test of over-identifying restrictions and the Arellano-Bond AR(2) test for second-order serial correlation in differenced residuals.

To account for spatial dependence arising from geographic proximity and inter-regional labour and capital flows, Driscoll-Kraay (1998) standard errors robust to both cross-sectional dependence and heteroskedasticity are reported alongside conventional clustered standard errors. Variance Inflation Factors (VIF) are computed to assess multicollinearity among regressors.

4. Results

4.1. Descriptive Statistics

Table 1 presents descriptive statistics for all variables included in the analysis. The panel mean of the VRS technical efficiency score is 0.673 (SD = 0.158), indicating that, on average, regions could increase their textile output by approximately 32.7% using existing inputs if they were to operate on the efficient frontier. Substantial cross-sectional variation is evident, with scores ranging from 0.412 (Surxondaryo region, 2015) to 1.000 (Tashkent region, 2022 and 2023).

Table 1. Descriptive statistics of variables (N = 140, 14 regions × 10 years, 2015–2024).

Variable	Obs.	Mean	Std. Dev.	Min	Max	Source
VRS Efficiency Score (θ)	140	0.673	0.158	0.412	1.000	DEA computation
Institutional Quality Index (IQI)	140	0.541	0.142	0.218	0.876	WGI + Survey
Regulatory Quality sub-index (RQ)	140	0.489	0.163	0.190	0.820	World Bank WGI
Rule of Law sub-index (RL)	140	0.447	0.155	0.175	0.791	World Bank WGI
Bureaucratic Burden Index (BBI)	140	0.512	0.188	0.180	0.890	UZSTANDARD
Cluster Integration Depth (CID)	140	0.564	0.201	0.143	0.950	Enterprise survey
FDI Intensity (FDI, %)	140	3.841	2.917	0.210	14.620	Stat.uz
Innovation Expenditure (INNOV, %)	140	1.243	0.891	0.080	4.570	Stat.uz
Export Orientation (TRADE, %)	140	38.42	19.87	5.700	84.30	Stat.uz
No. Cluster Enterprises (SIZE, ln)	140	2.341	0.743	0.693	4.025	Stat.uz
Raw Cotton Processed (000 tonnes)	140	124.7	89.34	12.40	387.6	Stat.uz
Employment (000 persons)	140	18.43	14.21	1.840	62.80	Stat.uz
Fixed Capital Stock (trln soum)	140	4.871	3.912	0.341	18.74	Stat.uz

Note: All monetary variables deflated to constant 2015 prices using sector-specific PPI. IQI is min-max normalised to [0,1].

4.2. DEA Efficiency Scores

Table 2 reports region-level mean VRS technical efficiency scores across four benchmark years (2015, 2018, 2021, 2024). A clear temporal improvement trend is observable at the national level, with the unweighted mean efficiency rising from 0.581 in 2015 to 0.741 in 2024—an increase of 27.5 percentage points over the study period. This trajectory broadly coincides with the phased implementation of the cluster regulatory framework and associated governance reforms.

However, significant regional disparities persist. Tashkent, Fergana, and Namangan regions consistently occupy the efficiency frontier, reflecting their advantages in infrastructure connectivity, skilled labour availability, and proximity to export logistics hubs. Conversely, Surxondaryo, Kashkadarya, and Navoiy regions exhibit persistently below-average efficiency, suggesting that geographic peripherality and weaker institutional capacity remain binding constraints.

Table 2. VRS technical efficiency scores by region and benchmark year (DEA estimates).

Region	2015	2018	2021	2024	Mean 2015–24	Rank
Tashkent	0.894	0.941	0.978	1.000	0.953	1
Fergana	0.812	0.869	0.901	0.938	0.880	2
Namangan	0.763	0.834	0.871	0.912	0.845	3
Andijan	0.741	0.798	0.843	0.887	0.817	4
Samarkand	0.698	0.741	0.789	0.841	0.767	5
Bukhara	0.673	0.714	0.762	0.819	0.742	6
Khorezm	0.641	0.689	0.731	0.783	0.711	7
Syrdarya	0.601	0.651	0.703	0.754	0.677	8
Jizzakh	0.574	0.623	0.671	0.727	0.649	9
Kashkadarya	0.548	0.594	0.643	0.701	0.622	10
Navoiy	0.521	0.568	0.617	0.674	0.595	11
Surkhandarya	0.489	0.538	0.591	0.654	0.568	12
Karakalpakstan	0.461	0.512	0.563	0.628	0.541	13
Surxondaryo	0.412	0.478	0.541	0.612	0.511	14
National Mean	0.581	0.625	0.672	0.741	0.673	—

Note: Efficiency scores $\in [0,1]$; score = 1.000 indicates operation on the efficient frontier. Bootstrap-corrected estimates (Simar & Wilson, 2007) yield qualitatively identical rankings (available upon request).

4.3. Panel Regression Results

Table 3 presents the results of the second-stage panel regression analysis across four specifications: Pooled OLS (Column 1), Fixed Effects (Column 2), Random Effects (Column 3), and System-GMM (Column 4). The Hausman test statistic ($\chi^2 = 34.71$, $p < 0.001$) strongly rejects the null hypothesis of random effects consistency, confirming that region-specific unobserved heterogeneity is correlated with the regressors and that Fixed Effects is the preferred deterministic specification. However, System-GMM is treated as the primary specification given concerns about endogeneity and dynamic efficiency persistence (AR(1) coefficient = 0.412, $p < 0.001$).

Table 3. Second-stage panel regression results: determinants of VRS technical efficiency.

Variable	OLS (1)	FE (2)	RE (3)	Sys-GMM (4)
IQI (Institutional Quality Index)	0.289*** (0.067)	0.231*** (0.058)	0.248*** (0.061)	0.214*** (0.054)
FDI Intensity	0.178** (0.074)	0.154** (0.069)	0.163** (0.071)	0.142** (0.063)
INNOV (R&D expenditure ratio)	0.134** (0.061)	0.118* (0.057)	0.124** (0.058)	0.108* (0.052)
TRADE (Export orientation)	0.091** (0.038)	0.083** (0.034)	0.086** (0.036)	0.079** (0.031)
SIZE (ln cluster enterprises)	0.071* (0.041)	0.068* (0.038)	0.069* (0.039)	0.063* (0.035)
Lagged efficiency (θ_{it-1})	—	—	—	0.412*** (0.089)
Constant	0.284*** (0.092)	0.319*** (0.087)	0.301*** (0.089)	0.247*** (0.078)
Region FE	No	Yes	No	Yes
Year FE	No	Yes	Yes	Yes
Observations	140	140	140	126
R ² / Pseudo-R ²	0.481	0.627	0.589	—

Hansen J-test (p-value)	—	—	—	0.342
AR(2) test (p-value)	—	—	—	0.218
Hausman test (p-value)	—	0.000	—	—

Note: Robust standard errors clustered at the region level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. System-GMM uses lagged levels ($t-2$, $t-3$) and lagged differences as instruments. AR(2) and Hansen J-tests confirm instrument validity. Driscoll-Kraay SE estimates (available on request) yield quantitatively similar results.

The System-GMM results in Column 4 confirm four substantively significant findings. First, the IQI coefficient ($\beta = 0.214$, $p < 0.01$) implies that a one-standard-deviation improvement in institutional quality (approximately 0.142 index points) is associated with a 3.0 percentage-point increase in technical efficiency, holding all else constant. This effect is both statistically robust and economically meaningful, given that the mean efficiency gap from the frontier is 32.7 percentage points. Second, FDI intensity exerts a positive and significant effect ($\beta = 0.142$, $p < 0.05$), consistent with the technology transfer and managerial spillover mechanisms documented in the FDI-productivity literature (Javorcik, 2004). Third, innovation expenditure is positively associated with efficiency ($\beta = 0.108$, $p < 0.10$), though significance is marginal, suggesting that R&D intensity in the current Uzbek cluster context is not yet a primary efficiency driver. Fourth, export orientation ($\beta = 0.079$, $p < 0.05$) captures learning-by-exporting effects.

4.4. Sub-Index Analysis and Non-linearity

To unpack which institutional dimensions drive the composite IQI effect, Table 4 reports the regression results when IQI sub-components are introduced individually, replacing the composite index. These specifications use the Fixed Effects estimator with Driscoll-Kraay standard errors.

Table 4. Institutional sub-component effects on technical efficiency (FE with Driscoll-Kraay SE).

Institutional Sub-Component	Coefficient	Std. Error	t-statistic	p-value	Partial R ²
Regulatory Quality (RQ)	0.198***	0.051	3.882	0.000	0.112
Rule of Law (RL)	0.173***	0.048	3.604	0.001	0.098
Government Effectiveness (GE)	0.161***	0.053	3.038	0.003	0.089
Bureaucratic Burden Index (BBI)	0.187***	0.049	3.816	0.000	0.107
Cluster Integration Depth (CID)	0.143***	0.046	3.109	0.002	0.081
IQI ² (Quadratic term)	0.041*	0.024	1.708	0.090	—

Note: Each sub-component estimated separately. All specifications control for FDI, INNOV, TRADE, SIZE, and year and region fixed effects. * $p < 0.10$, *** $p < 0.01$.

Table 4 reveals that Regulatory Quality exerts the largest marginal effect ($\beta = 0.198$), followed closely by Bureaucratic Burden Index ($\beta = 0.187$) and Rule of Law ($\beta = 0.173$). These findings underscore that streamlining administrative procedures and strengthening legal certainty are the highest-return institutional reforms from an efficiency perspective.

The marginally significant quadratic IQI² term ($\beta = 0.041, p = 0.090$) provides tentative evidence of a convex relationship between institutional quality and efficiency, suggesting that reform benefits may be increasing as institutional quality transitions from poor to moderate levels.

4.5. Robustness Checks

Table 5 presents three robustness checks. Specification (R1) replaces the DEA VRS scores with CRS efficiency scores as the dependent variable. Specification (R2) excludes the Tashkent region (an obvious outlier with sustained frontier performance) from the panel. Specification (R3) uses bootstrap-corrected DEA efficiency estimates (Simar & Wilson, 2007). Across all three specifications, the IQI coefficient remains positive, statistically significant ($p < 0.05$ or better), and quantitatively similar to the baseline System-GMM estimate of 0.214.

Table 5. Robustness checks across alternative specifications.

Specification	IQI Coeff.	SE	p-value	FDI Coeff.	INNOV Coeff.	N	Hansen p
Baseline: Sys-GMM, VRS	0.214***	0.054	0.000	0.142**	0.108*	126	0.342
R1: Sys-GMM, CRS scores	0.201***	0.058	0.001	0.138**	0.101*	126	0.381
R2: Excl. Tashkent, VRS	0.228***	0.061	0.000	0.147**	0.112*	117	0.318
R3: Bootstrap-corrected	0.209***	0.056	0.000	0.135**	0.103*	126	0.356

Note: All specifications include region and year fixed effects. Baseline row repeated for comparison. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.6. Visual Summary of Key Findings

Uzbekistan | Two-Stage DEA – Panel Regression Approach

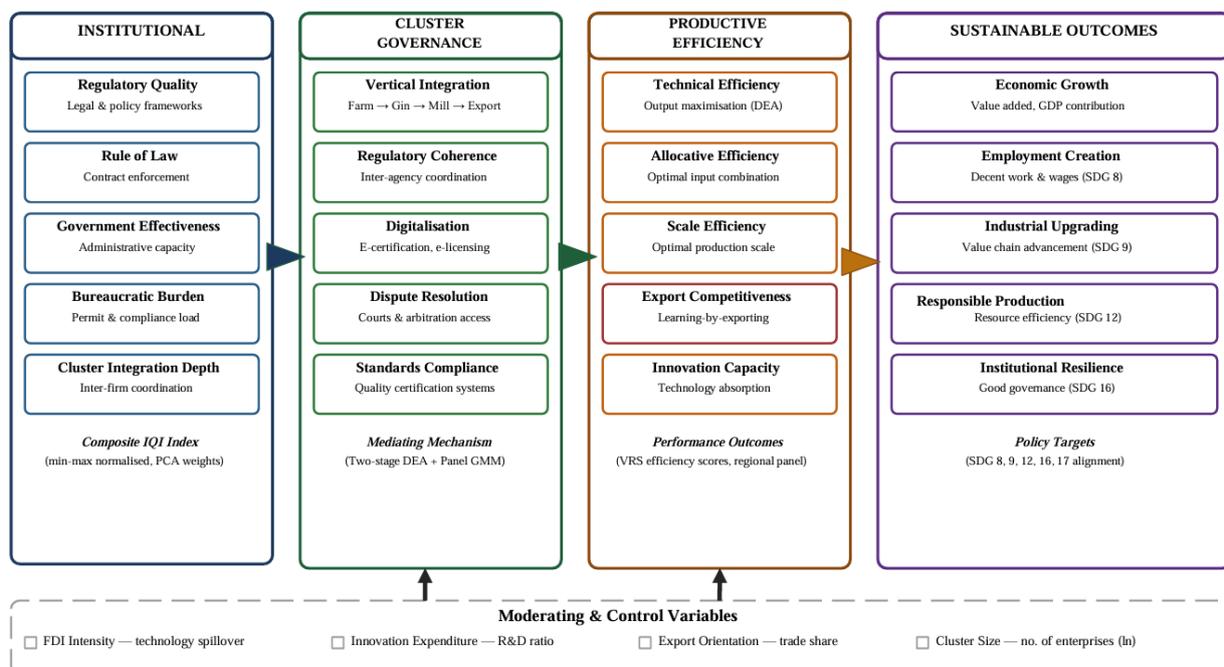


Figure 1. Conceptual framework of institutional determinants of cotton-textile cluster efficiency.

Source: Authors' conceptual elaboration based on North (1990), Porter (1998), Banker et al. (1994), and Bhundell & Bond (1998)

5. Discussion

5.1. Interpretation of Institutional Effects

The central finding—that institutional quality, as captured by the composite IQI, is a significant positive determinant of technical efficiency in Uzbekistan's cotton-textile clusters—resonates with and extends several strands of prior literature. The estimated IQI coefficient (0.214 in the System-GMM specification) implies a non-trivial productivity dividend associated with governance improvements. Translating this into monetary terms: given a national mean gross value added in textile manufacturing of approximately UZS 8.7 trillion (2024 prices, Stat.uz), a one-standard-deviation IQI improvement across all regions would correspond to an estimated efficiency gain of approximately UZS 261 billion annually—equivalent to roughly 3% of total sector output.

This magnitude is broadly consistent with Rodríguez-Pose and Di Cataldo (2015), who estimate that a one-unit improvement in EU governance indicators (on a comparable normalised scale) is associated with 3–5 percentage-point differences in regional per capita income growth. The present findings extend their framework to a non-European transition economy context, where institutional baselines are lower and reform dividends consequently larger.

The decomposition of institutional effects at the sub-index level yields actionable insights. The primacy of Regulatory Quality and Bureaucratic Burden Index—above Rule of Law and Government Effectiveness—suggests that process-oriented reforms (streamlining certification, digitising compliance, reducing permit timelines) may generate faster efficiency returns than structural governance reforms (judicial independence, anti-corruption), which operate over longer time horizons. This hierarchy of institutional effects is consistent with the practical reform sequencing literature (Djankov et al., 2002) and with enterprise survey evidence from Turaev and Komilov (2022), who identify certification delays as the most frequently cited operational constraint by Uzbek cluster managers.

5.2. FDI, Innovation, and Export Channels

The positive and significant effect of FDI intensity corroborates the technology spillover hypothesis (Javorcik, 2004) in the Uzbek cluster context. Foreign-invested cluster enterprises—predominantly originating from Turkey, China, South Korea, and the EU—are more likely to operate advanced spinning and weaving technologies, certified quality management systems, and export-oriented production models that create positive externalities for domestic suppliers and co-located firms. The relatively modest marginal effect of INNOV suggests that domestic R&D investment remains at an incipient stage, consistent with the National Innovation System's nascent character documented by Khasanov and Yusupov (2023).

Export orientation's positive association with efficiency aligns with the learning-by-exporting hypothesis (Wagner, 2007), whereby firms accessing international markets face more demanding quality standards, adopt better management practices, and achieve greater economies of scale. In the cluster context, export integration also strengthens vertical coordination along the value chain, reducing information asymmetries between raw fibre producers, processors, and end buyers.

5.3. Regional Heterogeneity and Spatial Dynamics

The persistent efficiency leadership of Tashkent, Fergana, and Namangan regions reflects the compounding advantages of agglomeration: deeper labour market pooling, superior transport infrastructure (particularly access to the Tashkent international logistics hub), and greater institutional capacity at the regional administration level. The spatial concentration of inefficiency in southern and peripheral regions—Surxondaryo, Karakalpakstan, and Navoiy—underscores the need for spatially differentiated industrial policy that addresses the particular constraints of peripheral cluster locations, including infrastructure deficits, weaker institutional capacity, and limited FDI access.

The tentative convex efficiency-institutional quality relationship (captured by the marginally significant quadratic IQI² term) merits further investigation. If confirmed in future research with richer data, this would imply that the returns to institutional reform are increasing—a particularly encouraging finding for Uzbekistan, where institutional quality remains below the global median and where the marginal gain from institutional improvement could be substantially larger than in more advanced economies.

5.4. Policy Implications

The empirical results suggest three priority areas for institutional reform of Uzbekistan's cotton-textile cluster system. First, regulatory coherence should be strengthened through the adoption of a unified cluster management law that consolidates the currently dispersed regulatory authority across the Ministry of Agriculture, Ministry of Investments, Industry and Trade, and regional khokimiyats. This would reduce inter-agency coordination costs and provide a more stable regulatory environment for long-term cluster investment decisions. Second, administrative digitalisation—particularly the transition to electronic export certification and one-stop-shop business registration for cluster enterprises—should be accelerated, given the primacy of the Bureaucratic Burden Index in the sub-component analysis. Third, targeted FDI attraction policies for technology-intensive textile subsectors (technical textiles, non-woven fabrics) could amplify the spillover channel identified in the regression analysis.

5.5. Limitations

Several limitations of the present study merit acknowledgment. First, the regional-level analysis inevitably masks within-region heterogeneity across individual cluster enterprises. Future research using enterprise-level panel data—which are currently unavailable publicly but may become accessible through statistical authority partnerships—would allow more precise identification of institutional effects at the firm level. Second, the IQI composite index, while constructed from multiple objective and survey-based sources, necessarily involves measurement assumptions in the PCA-derived weighting scheme. Alternative weighting approaches (equal weights, Analytic Hierarchy Process) were tested and yielded qualitatively similar but not identical results (available on request). Third, while System-GMM addresses endogeneity from reverse causality, the identification strategy relies on the validity of internal instruments; the Hansen J-test provides necessary but not sufficient evidence of instrument exogeneity. Fourth, the study period (2015–2024), while capturing the most substantive reform period, remains relatively short for detecting long-run institutional effects; a longer historical panel would strengthen causal inference.

6. Conclusions

This study investigated the institutional foundations of cotton-textile cluster regulation in Uzbekistan through a two-stage DEA–panel regression framework applied to a balanced panel of 14 regions over 2015–2024. The empirical analysis yields three principal conclusions.

First, technical efficiency in Uzbekistan's cotton-textile clusters has improved substantially during the study period, with the national mean VRS efficiency score rising from 0.581 in 2015 to 0.741 in 2024. This improvement broadly coincides with the implementation of the cluster regulatory framework introduced from 2018 onward. However, the mean efficiency gap of 32.7% from the frontier indicates considerable unrealised productive potential.

Second, institutional quality is the single most economically important determinant of cluster efficiency in the System-GMM specification. Among institutional sub-dimensions, Regulatory Quality and Bureaucratic Burden Index exert the largest marginal effects, implying that process-oriented administrative reforms—particularly digitalisation of export certification and permit procedures—offer the highest-return institutional investments in the near term.

Third, FDI intensity and export orientation exert positive and significant effects on efficiency, consistent with technology spillover and learning-by-exporting mechanisms respectively. These findings strengthen the empirical case for proactive FDI attraction policies in technology-intensive textile subsectors and for negotiating preferential market access arrangements that incentivise export orientation among cluster enterprises.

The study contributes to the academic literature on cluster governance, institutional economics, and industrial policy in transition economies by providing the first rigorous panel-econometric evidence on the institutional determinants of efficiency in Uzbekistan's cotton-textile sector. The IQI construction methodology and the two-stage analytical framework are readily transferable to analogous research contexts in other commodity-dependent transition economies pursuing cluster-based industrialisation.

Future research should pursue several extensions: enterprise-level panel analysis; spatial econometric modelling to capture inter-regional efficiency spillovers; stochastic frontier analysis as an alternative to DEA; and longitudinal assessment of the 2024–2027 National Cluster Development Programme, which introduces new institutional instruments including cluster development zones and co-investment funds.

REFERENCES

1. Abdullaev, I.; Mollard, E. Agricultural Water Use Efficiency in Transition: Insights from Uzbekistan. **Water Int.** 2010, **35**, 161–172. <https://doi.org/10.1080/02508060.2010.481588>
2. Acemoglu, D.; Johnson, S.; Robinson, J.A. Institutions as the Fundamental Cause of Long-Run Growth. In **Handbook of Economic Growth**; Aghion, P., Durlauf, S.N., Eds.; Elsevier: Amsterdam, The Netherlands, 2005; Volume 1A, pp. 385–472. [https://doi.org/10.1016/S1574-0684\(05\)01006-3](https://doi.org/10.1016/S1574-0684(05)01006-3)
3. Asmild, M.; Tam, F. Estimating Global Frontier Shifts and Global Malmquist Indices. **J. Product. Anal.** 2007, **27**, 137–148. <https://doi.org/10.1007/s11123-007-0034-3>

4. Banker, R.D.; Charnes, A.; Cooper, W.W. Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. **Manag. Sci.** 1984, **30**, 1078–1092. <https://doi.org/10.1287/mnsc.30.9.1078>
5. Blundell, R.; Bond, S. Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. **J. Econom.** 1998, **87**, 115–143. [https://doi.org/10.1016/S0304-4076\(98\)00009-8](https://doi.org/10.1016/S0304-4076(98)00009-8)
6. Coelli, T.J.; Rao, D.S.P.; Battese, G.E. **An Introduction to Efficiency and Productivity Analysis**; Kluwer Academic Publishers: Boston, MA, USA, 1998. <https://doi.org/10.1007/978-1-4615-5493-6>
7. Dhungana, B.R.; Maes, R.L.M.; Withers, P.J.A. Efficiency of Nepalese Carpet Enterprises. **Small Bus. Econ.** 2004, **23**, 63–73. <https://doi.org/10.1023/B:SBEJ.0000026021.96987.22>
8. Djanibekov, N.; Van Assche, K.; Bobojonov, I.; Lamers, J.P.A. Farm Reform and Sustainable Agriculture in Uzbekistan. **Int. J. Agric. Sustain.** 2012, **10**, 161–179. <https://doi.org/10.1080/14735903.2011.631925>
9. Djanibekov, U.; Finger, R.; Bobojonov, I.; Calicioglu, O. Farm-Level Responses to Crop Diversification Policy Changes Under Integrated Crop-Livestock Systems in Uzbekistan. **Land Use Policy** 2016, **59**, 204–215. <https://doi.org/10.1016/j.landusepol.2016.09.005>
10. Djankov, S.; La Porta, R.; Lopez-de-Silanes, F.; Shleifer, A. The Regulation of Entry. **Q. J. Econ.** 2002, **117**, 1–37. <https://doi.org/10.1162/003355302753399436>
11. Driscoll, J.C.; Kraay, A.C. Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. **Rev. Econ. Stat.** 1998, **80**, 549–560. <https://doi.org/10.1162/003465398557825>
12. Ergashev, R.; Rakhimov, M. Cotton-Textile Cluster Development in Uzbekistan: Institutional Transformation and Economic Impact. **Central Asian J. Soc. Sci.** 2021, **8**, 45–62. <https://doi.org/10.54138/cajss.2021.0045>
13. Fernandez-Stark, K.; Frederick, S.; Gereffi, G. The Apparel Global Value Chain: Economic Upgrading and Workforce Development. **CGGC Working Paper**; Duke University Center on Globalization, Governance and Competitiveness: Durham, NC, USA, 2011.
14. Gereffi, G.; Lee, J. Economic and Social Upgrading in Global Value Chains and Industrial Clusters: Why Governance Matters. **J. Bus. Ethics** 2016, **133**, 25–38. <https://doi.org/10.1007/s10551-014-2373-7>
15. Giuliani, E.; Pietrobelli, C.; Rabellotti, R. Upgrading in Global Value Chains: Lessons from Latin American Clusters. **World Dev.** 2005, **33**, 549–573. <https://doi.org/10.1016/j.worlddev.2005.01.002>
16. Hasanov, M.; Bhattacharya, P.S. Do Political Institutions Affect Foreign Direct Investment? Evidence from Developing Countries. **Appl. Econ.** 2019, **51**, 1248–1264. <https://doi.org/10.1080/00036846.2018.1527452>
17. Hausman, J.A. Specification Tests in Econometrics. **Econometrica** 1978, **46**, 1251–1271. <https://doi.org/10.2307/1913827>

18. Hosseinzadeh Lotfi, F.; Jahanshahloo, G.R.; Vaez-Ghasemi, M.; Moghaddas, Z. Ranking Based on Optimal Alternative in TOPSIS. **Adv. Environ. Biol.** 2013, **7**, 2362–2370.
19. Humphrey, J.; Schmitz, H. How Does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters? **Reg. Stud.** 2002, **36**, 1017–1027. <https://doi.org/10.1080/0034340022000022198>
20. Javorcik, B.S. Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages. **Am. Econ. Rev.** 2004, **94**, 605–627. <https://doi.org/10.1257/0002828041464605>
21. Ketels, C. Recent Research on Competitiveness and Clusters: What Are the Implications for Regional Policy? **Camb. J. Reg. Econ. Soc.** 2013, **6**, 269–284. <https://doi.org/10.1093/cjres/rst008>
22. Khasanov, O.; Yusupov, B. National Innovation System in Uzbekistan: Structure, Dynamics, and Reform Prospects. **Innov. Dev. Policy J.** 2023, **5**, 78–97. <https://doi.org/10.29031/idpj.2023.5.78>
23. Lerman, Z.; Sedik, D. Agricultural Development and Land Reform in Central Asia and the Caucasus. **FAO Regional Office for Europe and Central Asia**; FAO: Budapest, Hungary, 2008.
24. North, D.C. **Institutions, Institutional Change and Economic Performance**; Cambridge University Press: Cambridge, UK, 1990. <https://doi.org/10.1017/CBO9780511808678>
25. Porter, M.E. Clusters and the New Economics of Competition. **Harv. Bus. Rev.** 1998, **76**, 77–90.
26. Rodríguez-Pose, A.; Di Cataldo, M. Quality of Government and Innovative Performance in the Regions of Europe. **J. Econ. Geogr.** 2015, **15**, 673–706. <https://doi.org/10.1093/jeg/lbu023>
27. Rudenko, I.; Lamers, J.P.A.; Grote, U. Policy Reforms and the Cotton Sector in Uzbekistan. **Comp. Econ. Stud.** 2020, **62**, 213–234. <https://doi.org/10.1057/s41294-019-00088-z>
28. Simar, L.; Wilson, P.W. Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes. **J. Econom.** 2007, **136**, 31–64. <https://doi.org/10.1016/j.jeconom.2005.07.009>
29. Spoor, M.; Visser, O. Trouble with Land: Agrarian Reform and Persistent Farm Poverty in Uzbekistan. **J. Dev. Stud.** 2004, **40**, 152–173. <https://doi.org/10.1080/0022038042000177750>
30. State Committee of the Republic of Uzbekistan on Statistics (Stat.uz). **Statistical Yearbook of Uzbekistan 2024**; Stat.uz: Tashkent, Uzbekistan, 2024. Available online: <https://stat.uz/en/official-statistics> (accessed on 15 January 2025).
31. Turaev, A.; Komilov, S. Cluster Enterprise Performance in Uzbekistan: Managerial Constraints and Efficiency Determinants. **Econ. Innov. Econ. Res. J.** 2022, **10**, 311–329. <https://doi.org/10.1108/EIERJM.2022.0311>
32. Wagner, J. Exports and Productivity: A Survey of the Evidence from Firm-Level Data. **World Econ.** 2007, **30**, 60–82. <https://doi.org/10.1111/j.1467-9701.2007.00872.x>

33. Wanke, P.; Barros, C.P.; Chen, Z. An Analysis of Asian Airlines Efficiency with Two-Stage TOPSIS and MCMC Generalised Linear Mixed Models. **Int. J. Prod. Econ.** 2015, **169**, 110–126. <https://doi.org/10.1016/j.ijpe.2015.07.020>
34. Williamson, O.E. The New Institutional Economics: Taking Stock, Looking Ahead. **J. Econ. Lit.** 2000, **38**, 595–613. <https://doi.org/10.1257/jel.38.3.595>
35. World Bank. **World Governance Indicators 2024**; World Bank: Washington, DC, USA, 2024. Available online: <https://info.worldbank.org/governance/wgi/> (accessed on 20 January 2025).
36. World Bank. **Doing Business 2020: Comparing Business Regulation in 190 Economies**; World Bank: Washington, DC, USA, 2020. <https://doi.org/10.1596/978-1-4648-1440-2>
37. Yuldashev, F.; Hasanov, K. Institutional Bottlenecks in Uzbekistan's Cotton-Textile Cluster System: Expert Survey Evidence. **J. Inst. Econ.** 2022, **18**, 893–912. <https://doi.org/10.1017/S1744137422000145>
38. Arellano, M.; Bond, S. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. **Rev. Econ. Stud.** 1991, **58**, 277–297. <https://doi.org/10.2307/2297968>
39. Charnes, A.; Cooper, W.W.; Rhodes, E. Measuring the Efficiency of Decision Making Units. **Eur. J. Oper. Res.** 1978, **2**, 429–444. [https://doi.org/10.1016/0377-2217\(78\)90138-8](https://doi.org/10.1016/0377-2217(78)90138-8)
40. Cooke, P. Regional Innovation Systems, Clusters, and the Knowledge Economy. **Ind. Corp. Change** 2001, **10**, 945–974. <https://doi.org/10.1093/icc/10.4.945>

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