



## **STRUCTURAL TRANSFORMATION AND SCENARIO-BASED FORECASTING OF INDUSTRIAL DEVELOPMENT IN KASHKADARYA REGION, UZBEKISTAN: A SYSTEM GMM APPROACH**

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<b>ABSTRACT</b>	<b>KEYWORDS</b>
<p>This article develops and evaluates three structural transformation scenarios - inertial, reform, and innovation - for Kashkadarya Region's industrial sector over the 2025–2030 horizon, based on System GMM dynamic panel estimates and integrated scenario analysis. The empirical model, estimated on panel data from 148 enterprises (2018–2023), identifies digitalisation investment, export activity, cluster policy participation, and energy efficiency as statistically significant determinants of total factor productivity. The innovation scenario, premised on full implementation of the proposed structural optimisation mechanism, projects industrial output growth from UZS 18,400 billion (2024) to UZS 42,000 billion (2030), a reduction of the Herfindahl–Hirschman Index from 2,840 to 1,450, and an increase in the IT sector share from 2.3% to 8.6%. A KPI monitoring system and risk matrix provide an adaptive governance framework for scenario implementation.</p>	<p>Structural transformation, scenario analysis, System GMM, HHI, KPI monitoring, industrial policy, Kashkadarya Region, Uzbekistan.</p>

### **Introduction**

Structural transformation - the reallocation of economic activity across sectors with differing productivity levels - is a defining feature of economic development and a primary mechanism through which developing economies converge towards higher income levels (Chenery, 1960; Lewis, 1954). In regional contexts, the direction, pace, and sustainability of structural change depend on the interplay of factor endowments, technological capabilities, institutional frameworks, and policy interventions. Understanding this interplay quantitatively is essential for designing effective regional industrial policy.

Kashkadarya Region in south-central Uzbekistan represents a particularly instructive case. The region hosts major industrial enterprises in chemicals, construction materials, food processing, mechanical engineering, and light manufacturing, and has experienced rapid industrial output growth - a 2.7-fold increase from UZS 14.6 to UZS 39.5 trillion - driven primarily by extensive growth rather than

structural diversification. The persistence of high HHI values (2,840 as of 2023–2024) indicates that chemical and petrochemical dominance (31.4% of industrial structure) remains entrenched, creating vulnerabilities to commodity price volatility and impeding transition to higher value-added production. Against this backdrop, the article addresses two research questions: (1) What are the econometrically identified structural determinants of industrial enterprise productivity in Kashkadarya Region? (2) Under what scenario conditions can the region achieve sustainable structural diversification by 2030, and what monitoring and risk governance mechanisms are required?

## 2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

The theoretical foundations of regional structural transformation rest on several complementary frameworks. Classical dual-economy models (Lewis, 1954) and structural change theory (Chenery, 1960) established the macro-level regularities of sectoral reallocation. New economic geography (Krugman, 1991) formalised how scale economies, transport costs, and agglomeration forces shape the spatial distribution and composition of industrial activity. The evolutionary economic geography perspective (Boschma & Frenken, 2006) added a dynamic dimension, demonstrating that new industries tend to emerge from technologically related existing industries, generating path-dependent regional diversification trajectories.

The policy dimension of structural transformation has been extensively theorised in the industrial policy literature (Rodrik, 2016). The OECD's advocacy of place-based industrial policy (OECD, 2024) - tailored to region-specific resource endowments and specialisation patterns - is particularly relevant for Uzbekistan, where regional heterogeneity in industrial capabilities is pronounced. UNCTAD (2024) data indicating a 7% decline in FDI flows to developing countries in 2023 (to USD 867 billion) underscore the importance of domestically driven structural diversification strategies.

In the Uzbek context, the "Uzbekistan–2030" strategy and "Digital Uzbekistan 2030" programme have established an ambitious framework for industrial modernisation. As of April 2025, Uzbekistan hosts 28 special economic zones, 389 small industrial zones, 23 technoparks, and 355 clusters, providing the institutional infrastructure for cluster-based diversification. Processing industry accounted for 83.1% of total industrial output in January 2026 (National Statistics Committee, 2026), confirming the centrality of manufacturing transformation.

## 3. DATA AND EMPIRICAL STRATEGY

The empirical analysis employs balanced panel data on 148 industrial enterprises in Kashkadarya Region from 2018 to 2023. The dependent variable is total factor productivity (TFP), estimated via the Olley–Pakes (1996) semi-parametric production function method using a Cobb–Douglas specification. Independent variables encompass: (1) investment in digitalisation (UZS billions; treated as endogenous); (2) export volume (natural log; endogenous); (3) personnel training expenditure (UZS billions; endogenous); (4) cluster policy participation (binary; treated as exogenous); and (5) energy efficiency index (100 = 2024 base; endogenous). Firm size (log assets), age, leverage, and sector dummies serve as controls.

The core estimator is two-step System GMM (Blundell & Bond, 1998) with Windmeijer (2005) finite-sample corrected standard errors to address potential over-rejection of hypotheses in finite samples. We collapse the instrument matrix to limit instrument proliferation and preserve the informational

content of the Hansen J-test (Roodman, 2009). All variables are winsorised at the 1st and 99th percentiles to mitigate outlier influence.

## 4. RESULTS AND SCENARIO ANALYSIS

### 4.1. System GMM Estimation Results

The two-step System GMM estimates confirm that all five structural determinants positively and significantly predict TFP. Export volume has the largest point estimate ( $\beta = 0.447$ ; SE = 0.096;  $p < 0.001$ ), followed by digitalisation investment ( $\beta = 0.341$ ; SE = 0.142;  $p = 0.016$ ), personnel training ( $\beta = 0.278$ ; SE = 0.118;  $p = 0.019$ ), cluster participation ( $\beta = 0.195$ ; SE = 0.104;  $p = 0.061$ ), and energy efficiency ( $\beta = 0.183$ ; SE = 0.099;  $p = 0.065$ ). The lagged TFP coefficient ( $\beta = 0.612$ ; SE = 0.089;  $p < 0.001$ ) implies substantial productivity persistence, consistent with path-dependent enterprise development dynamics. Specification tests are satisfactory: Hansen J-test  $p = 0.312$ ; AR(1)  $p = 0.012$ ; AR(2)  $p = 0.453$ ; Wald  $\chi^2 = 218.4$  ( $p < 0.001$ ).

### 4.2. Scenario Construction and Projections

Three scenarios are constructed by combining the System GMM coefficients with trend extrapolation and expert elicitation of policy feasibility constraints. The inertial scenario assumes continuation of baseline trends with no active structural policy, yielding annual GDP growth of 3.5–4.0% and industrial output of approximately UZS 28,000 billion by 2030. The reform scenario assumes partial implementation of the proposed structural optimisation mechanism - including selective investment incentives for mechanical engineering and food processing - and projects growth of 5.0–6.5% annually, reaching UZS 35,000 billion by 2030.

The innovation scenario assumes full implementation: digital technology adoption in at least 60% of enterprises; formation of a chemical-technology cluster near Karshi; doubling of SME share in export; establishment of agro-industrial technoparks in Shahrizabz and Kitob; and deep modernisation of mechanical engineering. Under this scenario, industrial output reaches UZS 42,000 billion by 2030 - a 2.3-fold increase from 2024 - while HHI declines from 2,840 to 1,450 and the IT sector share grows from 2.3% to 8.6%.

### 4.3. KPI Monitoring System

Seven KPIs are specified for monitoring structural transformation: (1) industrial output (UZS billion): 18,400 (2024) → 42,000 (2030); (2) new employment: 28,000 cumulative by 2030; (3) share of finished goods in exports: 41% → 68%; (4) energy efficiency index: 100 → 139; (5) share of enterprises with digital technologies: 12% → 62%; (6) innovative product share: 8% → 30%; (7) HHI: 2,840 → 1,450. Monitoring is structured across three governance levels - operational (quarterly), tactical (semi-annual), and strategic (annual) - with designated accountability assigned to regional and ministerial bodies.

## 5. RISK ASSESSMENT AND GOVERNANCE IMPLICATIONS

The risk matrix identifies six principal risks to innovation scenario implementation. Commodity price volatility (risk score 8/10) and investment delays (7/10) represent the highest-severity risks. Personnel shortage (7/10) poses a significant constraint to rapid digitalisation. External demand contraction (5/10)

and inadequate digital infrastructure (6/10) constitute moderate risks. Political and regulatory change (3/10) is assessed as low probability and moderate impact.

Proposed mitigation measures include: diversification of raw material sourcing channels; a state guarantee fund to de-risk private investment; accelerated alignment of university and vocational training curricula with industrial skill demands; export market diversification programmes; and a public-private partnership model for digital infrastructure provision.

The governance architecture for scenario monitoring centres on a proposed Industrial Structure Monitoring Information System (ISMIS), designed to aggregate KPI data in real time and generate automated reports for decision-makers. ISMIS integration with the national Digital Economy System would further strengthen administrative coherence and transparency in structural policy implementation.

## 6. CONCLUSION

This study provides a comprehensive, evidence-based framework for structural transformation governance in Kashkadarya Region. System GMM estimation establishes that digitalisation, export activity, cluster participation, and energy efficiency are causal determinants of enterprise productivity, while strong TFP persistence ( $\beta = 0.612$ ) highlights the importance of sustained, long-run policy commitment over one-off interventions.

The innovation scenario demonstrates that a 2.3-fold increase in industrial output, a near-halving of HHI, and a near-quadrupling of IT sector share are achievable by 2030, subject to consistent policy implementation. The KPI monitoring system and risk matrix provide the adaptive governance infrastructure required to navigate implementation uncertainties while maintaining strategic focus.

Broader lessons for regional industrial policy in transitional economies include: the value of integrating econometric modelling with scenario analysis for policy design; the importance of quantified structural targets (HHI, SSI) alongside output volume targets; and the need for real-time data infrastructure (ISMIS) to enable agile policy adjustment in dynamic industrial environments.

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