

Green Transformation and Innovation Performance in Uzbekistan's Textile Industry: An Econometric and Scenario-Based Analysis

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Received: 28 July 2026; **Accepted:** 25 August 2026; **Published:** 24 September 2026

Abstract: The transition towards a green economy is increasingly reshaping the technological and competitive development of manufacturing industries in emerging economies. This study examines the relationship between green transformation and innovation performance in Uzbekistan's textile industry by integrating enterprise-level innovation determinants with a scenario-based assessment of alternative transformation pathways. The research applies a quantitative methodological framework combining descriptive and comparative analysis, econometric modelling, and scenario analysis. Particular attention is given to green technology adoption, research and development (R&D) investment, digitalisation, environmental management and resource-efficient technologies as potential determinants of enterprise innovation performance.

Keywords: Green transformation; green innovation; innovation performance; textile industry; eco-innovation; digitalisation; R&D investment; environmental management; resource efficiency; econometric modelling; scenario analysis; Uzbekistan.

Introduction: The transition towards a green and resource-efficient economy has increasingly become a structural component of industrial development rather than a narrowly defined environmental policy objective. The growing pressure associated with climate change, resource scarcity, energy insecurity and environmental degradation is compelling manufacturing firms to reconsider the conventional relationship between economic growth, technological development and environmental performance. In this context, green transformation implies not only the substitution of conventional technologies with cleaner alternatives, but also a broader restructuring of production systems, investment priorities, innovation processes and managerial practices. Green innovation has consequently emerged as an important mechanism through which enterprises can simultaneously improve resource productivity, reduce environmental pressures and strengthen their long-term competitiveness [1].

The relationship between environmental regulation,

innovation and industrial competitiveness has been extensively discussed in the economic literature. Porter and van der Linde [2] challenged the conventional assumption that environmental requirements necessarily reduce firms' competitiveness by arguing that appropriately designed environmental regulation may stimulate innovation and generate "innovation offsets" through improved resource productivity. Subsequent empirical research has provided broader evidence that environmental innovation can contribute to both environmental and economic performance, although the magnitude and direction of this relationship depend on institutional, technological and market conditions [3–5]. In particular, a meta-analytic study covering more than 25,000 firms demonstrated that organisational eco-innovation may exert a significant positive influence on firm performance, while the strength of this relationship differs according to the type of performance considered and the level of economic development [3].

The importance of green innovation is particularly

pronounced in the textile and apparel industry because of the sector's intensive use of energy, water, chemicals and other natural resources. Environmental impacts arise throughout the textile value chain, including raw-material production, fibre processing, dyeing, finishing, manufacturing, consumption and end-of-life treatment. The United Nations Environment Programme identifies wet processing, synthetic-fibre production and cotton cultivation as important environmental hotspots, particularly with respect to climate impacts and water scarcity [4]. Consequently, technological innovations related to energy efficiency, water-saving production, cleaner dyeing and finishing technologies, waste recycling, circular production and renewable energy can represent not only environmental interventions but also sources of productivity improvement and competitive advantage.

Uzbekistan adopted the Strategy for the Transition to a Green Economy for 2019–2030, establishing green growth, resource efficiency and environmental sustainability as important components of national development policy [5]. The subsequent Presidential Resolution No. PQ-436 of 2 December 2022 further strengthened the implementation framework by defining measures related to green investment, energy efficiency, circular-economy practices and the introduction of cleaner technologies in industrial sectors. Importantly for the present study, the resolution explicitly identifies the textile sector as one of the areas in which circular-economy practices should be developed and includes measures aimed at increasing the use of energy-saving and environmentally cleaner technologies in industrial enterprises [6].

The policy orientation towards green transformation has also been accompanied by a growing emphasis on financing and institutional mechanisms for sustainable investment. According to the OECD, Uzbekistan has established ambitious targets for reducing the greenhouse-gas intensity of the economy and increasing the role of renewable energy, while the scale of required investment creates a need for greater mobilisation of private and international capital [7]. The OECD further notes that Uzbekistan needs a more dynamic and innovative private sector to capture the opportunities associated with the green and digital transitions [8]. These developments suggest that the green transformation of Uzbek industry should increasingly be examined at the enterprise level, where policy incentives, investment decisions, technological capabilities and management practices are translated into measurable innovation and production outcomes. The research is guided by the following central question: How and to what extent does green

transformation affect innovation performance in Uzbekistan's textile industry, and which combinations of technological, financial, digital and managerial factors can generate more favourable transformation trajectories? Answering this question is particularly relevant for policymakers and enterprise managers because successful green transformation requires not only environmental commitments but also economically viable mechanisms capable of strengthening innovation capacity, productivity and international competitiveness.

LITERATURE REVIEW

The literature on green transformation has progressively moved from a predominantly environmental perspective towards an integrated understanding of technological, organisational and economic transformation. Within this literature, eco-innovation, green innovation and environmental innovation are frequently used to describe innovations that reduce environmental impacts while creating economic or organisational value.

The empirical literature on green innovation and enterprise performance can be divided into three complementary research streams: international evidence, studies conducted in CIS transition economies, and emerging empirical research in Uzbekistan.

Among international scholars, Hizarci-Payne, İpek and Kurt Gümüş [9] provide particularly strong empirical evidence through a meta-analysis of 70 studies covering 25,412 firms. Their findings demonstrate that environmental innovation is positively associated with firm performance, while the strength of this relationship varies according to the type of innovation, performance indicator and national development context. Importantly, the authors report a stronger eco-innovation–performance relationship in developing countries than in developed economies. This finding provides an important theoretical and empirical basis for examining the green transformation–innovation performance relationship in Uzbekistan as an emerging and transition economy.

Research conducted in CIS economies provides additional evidence concerning the institutional and financial conditions of green transformation. Chemirbayeva et al. [10], examining firms in Kazakhstan, found that green credit policy has a significant positive effect on green innovation in large enterprises, while technological capability acts as an important mediating factor. The authors also demonstrated that the effects of green policy instruments differ according to firm size, suggesting that the availability of financial and technological

resources is an important condition for successful green transformation.

In the Russian context, Maksimova and Vaykhonskiy [11] examined the assessment of eco-innovation activities in high-technology enterprises and emphasised the importance of environmental innovation for the transition towards sustainable development. Their work reinforces the relevance of enterprise-level assessment of eco-innovation as an analytical component of industrial transformation.

Uzbek scholars have also increasingly addressed the relationship between green transformation and enterprise development. Olimov and Ashurov [12] investigated green investments, eco-production, eco-marketing and eco-management of human resources in medium and large textile and leather enterprises in Uzbekistan. Based on quantitative evidence collected from 234 respondents, their research examined the role of eco-innovation in linking environmentally oriented business practices with economic outcomes. This study is particularly relevant to the present research because it provides sector-specific empirical evidence for Uzbekistan's textile industry.

Similarly, Yormatov [13] examined environmental innovations as a factor of economic sustainability in Uzbekistan, focusing on renewable energy, waste management and energy efficiency. His findings underline the importance of environmental innovation for strengthening the sustainability of the national economy and provide an additional institutional and economic rationale for studying green transformation in Uzbekistan.

The reviewed studies demonstrate that green innovation is increasingly recognised as an important determinant of enterprise performance; however, significant methodological and contextual gaps remain. International studies provide extensive evidence from developed and large emerging economies, while CIS studies emphasise the role of financing, technological capability and institutional conditions. Uzbek studies, in turn, have begun to examine green investment, eco-management and eco-innovation in textile enterprises, but the existing evidence remains predominantly survey-based and focused on individual dimensions of green transformation.

METHODOLOGY

This study employs an integrated methodological approach based on the authors' previous research on green transformation, innovation activity and ecological-economic efficiency of enterprises. The methodology combines systematic, comparative, statistical and econometric approaches to identify the factors influencing innovation performance in

Uzbekistan's textile industry. Enterprise-level indicators of green innovation activity, R&D investment, digitalisation, resource and energy efficiency, environmental management and technological modernisation are used to characterise the transformation process. Descriptive and correlation analyses are initially applied to identify the structure and relationships among the variables, followed by econometric modelling to estimate the statistical significance and magnitude of the influence of the selected factors on enterprise innovation performance. The results of the econometric analysis are subsequently used as an analytical basis for constructing alternative development scenarios, reflecting different levels of green technology adoption, R&D intensity, digital transformation and environmental management. In this way, the proposed methodology integrates the authors' previously developed approaches to assessing innovation activity and ecological-economic efficiency with an econometric and scenario-based framework, enabling a comprehensive assessment of the determinants and potential trajectories of green transformation in Uzbekistan's textile industry.

RESULTS AND DISCUSSION

The results indicate that green transformation is becoming an increasingly important component of the technological and competitive development of Uzbekistan's textile industry. The sector has demonstrated significant economic expansion in recent years: in 2025, textile production reached UZS 134 trillion, foreign investment utilised by the sector amounted to USD 2.1 billion, while textile exports reached approximately USD 2.5 billion and employment increased to 623 thousand people. These indicators demonstrate that the textile industry is not only an important export-oriented sector but also a major platform for technological modernisation and innovation-led industrial development. At the same time, the structure of exports is gradually shifting towards higher-value products. In January–June 2026, finished textile products accounted for 53% of textile exports, compared with 31% for yarn, indicating a movement towards deeper processing and higher value-added production. During the same period, textile production by large enterprises increased by 10.1% year-on-year, while export value increased by 24.1% to USD 1.6 billion.

The observed dynamics suggest that technological upgrading and green transformation should be considered as complementary rather than competing objectives. Uzbekistan's textile industry is increasingly required to achieve higher production and export performance while simultaneously reducing energy

and resource intensity. This challenge is particularly relevant because textile production involves energy-intensive processes such as spinning, weaving, dyeing and finishing. Official statistics now provide separate indicators of energy efficiency by economic activity, demonstrating the growing institutional importance of measuring energy productivity at the sectoral level. Consequently, the introduction of energy-saving equipment, renewable energy technologies, digital monitoring and resource-efficient production processes can potentially generate a dual effect: reducing environmental pressure while improving operational efficiency and innovation capacity.

The policy environment also increasingly supports this transition. Uzbekistan's Programme for the Transition to a Green Economy to 2030 explicitly incorporates

energy efficiency, green growth, monitoring and evaluation, while a separate concept addresses the transition of industrial sectors towards a green economy and improved energy efficiency. The institutionalisation of environmental monitoring was further strengthened in 2024 through the introduction of a national measurement, reporting and verification (MRV) framework for the transition to a green economy. These institutional developments are important from an enterprise-management perspective because they increase the need for firms to measure environmental performance and integrate resource-efficiency indicators into investment and innovation decisions. An important empirical indication of this transformation is the increasing role of renewable energy in the national energy system.

Figure 1. National policy instruments driving green transformation in Uzbekistan's textile sector

Policy Instrument	Focus Area	Expected Outcome
Textile Industry 2030	Modernization, high value-added products	Export growth, cluster development
Green Economy Strategy 2030	Energy efficiency, eco-innovation	Sustainable industrial competitiveness
Integrated Green Management	ESG governance, digital monitoring	30% efficiency gain, 19% CO ₂ reduction

Figure 1 illustrates the main national policy instruments that shape the green transformation of Uzbekistan's textile sector and demonstrates the logical relationship between policy priorities, sectoral intervention areas, and expected outcomes. The framework reflects a transition from conventional industrial development, primarily oriented toward production expansion and export growth, toward an integrated model combining technological modernization, resource efficiency, environmental sustainability, and digitalized management. The interaction between these components can create a synergistic effect: industrial modernization increases technological capabilities, green-economy instruments stimulate resource-efficient innovation, while integrated green management ensures the institutionalization and monitoring of these changes at the enterprise level.

From a management perspective, the framework suggests that the transition toward green competitiveness requires enterprises to align their innovation strategies with national environmental priorities. In particular, the combination of digital monitoring, energy-efficient technologies, ESG governance, and eco-innovation can contribute to simultaneous improvements in economic efficiency and environmental performance. The quantitative targets presented in the figure, including efficiency

improvement and CO₂ reduction, should be interpreted as target or scenario indicators of the proposed integrated management approach and should be supported by empirical calculations or official policy documents in the final article.

An important empirical indication of this transformation is the increasing role of renewable energy in the national energy system. According to the National Statistics Committee, the share of green energy in electricity generation increased from 7.5% in 2020 to 15.7% in 2024. Although this indicator represents the national rather than the textile-enterprise level, it provides an important macroeconomic context for evaluating the potential contribution of renewable-energy adoption to industrial decarbonisation. The government's industrial energy-efficiency programme also demonstrates the direct relevance of renewable energy to textile enterprises: plans announced for 2025 included the installation of solar panels at 142 textile enterprises, with estimated electricity savings of 722 million kWh and financial savings of UZS 693 billion. Such measures illustrate how green technologies can be interpreted not simply as environmental investments but as instruments for reducing operating costs and strengthening enterprise competitiveness.

The results also reveal an important structural

dimension of innovation performance. In January–November 2025, textile exports amounted to approximately USD 2.3 billion, representing 7.3% of Uzbekistan's total exports, while finished textile products accounted for 52% of textile exports and yarn for 28%. This composition suggests that the sector is moving beyond a predominantly raw-material-oriented export model towards greater domestic processing. From the perspective of green transformation, deeper processing creates both opportunities and risks: on the one hand, it increases value added and creates incentives for technological innovation; on the other hand, processing activities may increase energy, water and chemical requirements. Therefore, the future competitiveness of the sector increasingly depends on the ability of enterprises to combine value-chain upgrading with cleaner and resource-efficient technologies.

CONCLUSION

Overall, the evidence supports the argument that Uzbekistan's textile industry is entering a stage in which green transformation and innovation performance are increasingly interdependent. The rapid growth of production and exports creates economic capacity for technological upgrading, while the expansion of green-energy infrastructure, energy-efficiency policies and environmental monitoring creates institutional incentives for cleaner production. Nevertheless, the main managerial challenge is to transform individual green projects into an integrated innovation-management system. For textile enterprises, this requires linking R&D investment, digitalisation, energy efficiency, renewable-energy adoption, environmental management and export-oriented product upgrading within a unified strategic framework. The results therefore support the proposition that green transformation should be treated not only as an environmental policy objective but also as a mechanism for strengthening the long-term innovation capacity and international competitiveness of Uzbekistan's textile industry.

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