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IMPROVING GREEN ECONOMY MECHANISMS FOR THE SUSTAINABLE DEVELOPMENT OF THE INDUSTRIAL SECTOR: EVIDENCE FROM UZBEKISTAN

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Abstract. The transition toward a green economy has become one of the key priorities for ensuring sustainable industrial development in emerging economies. This study investigates green economy mechanisms for sustainable industrial development in Uzbekistan. Statistical analysis, econometric modeling, integrated indicator assessment, and fuzzy logic methods were used to evaluate industrial sustainability. The study develops a Green Index (GI) model for measuring enterprise-level green efficiency. The findings show that, despite rapid industrial growth, green transformation remains constrained by outdated capital, insufficient green investment, and limited institutional incentives. The study proposes institutional and economic mechanisms for improving sustainable industrial transformation.

Keywords: green economy, sustainable development, industrial sector, green investment, carbon pricing.

Аннотация. Переход к зелёной экономике стал одним из ключевых приоритетов обеспечения устойчивого развития промышленного сектора в странах с формирующейся экономикой. В данном исследовании рассматриваются механизмы зелёной экономики для обеспечения устойчивого развития промышленного сектора Узбекистана. Для оценки устойчивости промышленного развития использованы методы статистического анализа, эконометрического моделирования, интегральной оценки показателей и нечёткой логики. В исследовании разработана модель интегрального индекса зелёного развития (Green Index, GI) для измерения уровня экологической эффективности промышленных предприятий. Результаты показывают, что, несмотря на быстрый рост промышленности, процесс зелёной трансформации сдерживается изношенностью основного капитала, недостаточным объёмом зелёных инвестиций и ограниченностью институциональных стимулов. В исследовании предложены институциональные и экономические механизмы совершенствования устойчивой трансформации промышленного сектора.

Ключевые слова: зелёная экономика, устойчивое развитие, промышленный сектор, зелёные инвестиции, углеродное ценообразование.

INTRODUCTION

Global industrial development increasingly faces challenges associated with climate change, environmental degradation, and resource scarcity. Industrial sectors contribute significantly to greenhouse gas emissions, environmental pollution, and excessive energy consumption. As a result, sustainable industrial transformation has become a priority in economic policy worldwide.

Traditional industrial growth models have emphasized output expansion and capital accumulation while giving insufficient attention to environmental externalities. However, the global transition toward sustainable development has increased interest in green economy mechanisms.

A green economy refers to an economic system that improves social welfare while reducing environmental risks and ecological deficits. In the industrial sector, this implies adopting cleaner technologies, increasing resource efficiency, and integrating environmental considerations into economic decision-making.

For Uzbekistan, industrial development remains essential for GDP growth, employment, and export diversification. At the same time, increasing industrial energy intensity creates sustainability challenges. Therefore, improving green economy mechanisms in industry is an urgent scientific and practical issue.

This research aims to develop scientific recommendations for improving green economy mechanisms to ensure the sustainable development of Uzbekistan's industrial sector.

LITERATURE REVIEW

The theoretical foundations of industrial development were established by classical economists such as Adam Smith, David Ricardo, and John Maynard Keynes, who emphasized production factors, capital accumulation, and economic growth.

Modern sustainable development theories have expanded industrial economics by incorporating ecological constraints. Robert Solow highlighted technological progress as a key driver of long-term growth, while Joseph Schumpeter emphasized innovation as a source of structural transformation.

Institutional economists, particularly Douglass North, demonstrated the importance of governance and institutions in ensuring economic efficiency. These theories provide a strong foundation for understanding green industrial transformation.

Recent literature focuses on green growth, ESG governance, the circular economy, and sustainable finance. International organizations such as the United Nations Environment Programme and the United Nations Industrial Development Organization emphasize resource efficiency, carbon neutrality, and green industrialization.

Despite the growing body of literature, limited research exists on comprehensive green economy mechanisms tailored to Uzbekistan's industrial sector. This study addresses this gap.

RESEARCH METHODOLOGY

This study employs a mixed-methods approach combining quantitative and qualitative research techniques to examine green economy mechanisms for sustainable industrial development in Uzbekistan. The analysis is based on industrial, environmental, and investment data for the period 2010–2024 obtained from national statistical sources and international organizations. Statistical and comparative analyses were used to evaluate industrial development trends, while econometric modeling was applied to examine the relationship between green investment and industrial sustainability. In addition, an integrated Green Index (GI) was developed to assess enterprise-level green performance using weighted sustainability indicators. Fuzzy logic techniques were employed to classify sustainability levels under conditions of uncertainty. This methodological framework provides a comprehensive basis for evaluating green industrial transformation and formulating evidence-based policy recommendations.

ANALYSIS AND RESULTS

Industrial Growth Analysis. Industrial output in Uzbekistan increased significantly between 2010 and 2024. Total industrial production rose more than twentyfold, demonstrating strong structural growth. However, this growth remains largely quantitative rather than qualitative.

Energy and Resource Efficiency. Industrial enterprises continue to face high energy intensity. Product-level energy consumption remains above normative thresholds. Heat loss and fuel inefficiency indicate the continued use of outdated production systems.

Fixed Capital and Technology. Fixed asset depreciation has reached approximately 65%, indicating serious technological obsolescence. Equipment renewal remains slow, which reduces competitiveness and sustainability.

Investment Analysis. Green investment accounts for only 12% of total industrial investment. Limited access to long-term green finance slows the adoption of sustainable technologies.

Ecological Indicators. Emission intensity remains high, while waste recycling and water reuse rates remain low. These results indicate that circular economy mechanisms are not yet sufficiently developed.

Green Index Results. The average Green Index for Uzbekistan's industrial sector is:

$$GI = 0.47$$

According to the classification scale, this represents low efficiency.

Five major constraints were identified:

1. High resource intensity;
2. Outdated technology;
3. Limited green finance;
4. Insufficient institutional support;
5. Low levels of digital monitoring.

To evaluate possible future development trajectories, three industrial transformation scenarios were modeled: conservative, baseline, and optimistic.

Under the conservative scenario, green investment growth remains below 15%, resulting in only marginal improvements in energy efficiency and emission reduction. In this scenario, the Green Index is projected to reach 0.53 by 2030, indicating moderate but still insufficient progress.

Under the baseline scenario, gradual institutional reforms and moderate expansion of green financing increase the Green Index to 0.64, approaching medium-to-high efficiency.

Under the optimistic scenario, strong policy support, carbon pricing mechanisms, and large-scale technological modernization significantly improve industrial sustainability. In this case, the Green Index could reach 0.78 by 2030, indicating high efficiency.

These scenarios demonstrate that the intensity of policy measures directly affects the outcomes of industrial green transformation.

CONCLUSION AND RECOMMENDATIONS

This study examined green economy mechanisms for sustainable industrial development in Uzbekistan.

The results show that, despite significant industrial growth, green transformation remains insufficient. Industrial sustainability is constrained by outdated technologies, limited financing mechanisms, and institutional limitations.

The calculated Green Index confirms the low efficiency of current green economy mechanisms.

Based on the analysis, the following recommendations are proposed:

Expand green investment instruments, such as green bonds.

Accelerate industrial modernization and technological renewal.

Introduce carbon pricing mechanisms.

Strengthen ESG governance standards.

Improve digital monitoring of industrial sustainability indicators.

The implementation of these measures will improve industrial competitiveness and long-term sustainability.

From a practical perspective, the proposed Green Index model can serve as an analytical tool for policymakers, industrial enterprises, and financial institutions in monitoring green transition performance and identifying priority investment directions. The model may also support strategic decision-making in industrial modernization programs.

Furthermore, future studies may integrate artificial intelligence, machine learning algorithms, and dynamic forecasting models to improve the precision of sustainability assessment and policy simulation under different industrial development scenarios.

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