Journal of ECONOMICS
August 2026, Volume: 3, Issue: 3, pp. 36−45
DOI: https://doi.org/10.36719/3104-4727/8/36-45

Green Economy and Innovative Investments: Evidence from the Nakhchivan Autonomous Republic

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Abstract. *In recent years, the transition toward a green economy has become a global priority due to increasing concerns over climate change, environmental degradation, and the growing scarcity of natural resources. The green economy framework emphasizes sustainable economic growth by integrating environmental protection, efficient resource use, and social well-being into development strategies. Within this context, innovative investments play a crucial role by supporting the diffusion of renewable energy technologies, enhancing resource efficiency, and fostering environmentally friendly production processes. This study examines the impact of innovative investments on green economic development in the Nakhchivan Autonomous Republic, a geographically constrained and peripheral region with significant potential for sustainable growth. Using annual time-series data covering the period 2005–2023, the study applies an Autoregressive Distributed Lag (ARDL) modeling approach to explore both short-run and long-run relationships between green economic development and its key determinants. The empirical model incorporates innovative investments, renewable energy production, resource efficiency, and green employment as explanatory variables. The results of the ARDL bounds testing procedure confirm the existence of a long-run cointegration relationship among the variables. Empirical findings indicate that innovative investments have a statistically significant and positive effect on green economic development in the long run, highlighting their structural importance for sustainable regional growth. Renewable energy production also emerges as a key driver of green economic performance, while improvements in resource efficiency and green employment contribute positively to economic and environmental sustainability. In contrast, short-run effects are found to be weaker, suggesting that the benefits of green and innovative investments materialize gradually over time. The findings provide important policy implications for regional development strategies, emphasizing the need to strengthen innovation-oriented investment policies and green finance mechanisms to support long-term sustainable development in the Nakhchivan Autonomous Republic.*

Keywords: *green economy, sustainable development, regional development, Nakhchivan Autonomous Republic, innovative investment*

Introduction

Sustainable development has emerged as a central objective of economic policy worldwide, reflecting the growing recognition that long-term economic growth cannot be achieved without preserving environmental integrity and ensuring social well-being (World Bank, 2012).

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Received: 19 February 2026; Accepted: 15 May 2026; Published online: 14 August 2026

Traditional economic growth models, which primarily focus on maximizing output and income, have contributed to significant environmental degradation, excessive exploitation of natural resources, and a substantial increase in greenhouse gas emissions (Stern, 2007). These challenges have intensified global concerns regarding climate change, ecological sustainability, and intergenerational equity, thereby necessitating a fundamental transformation of existing economic structures. In response to these challenges, the green economy framework has gained increasing attention as an alternative development paradigm. The green economy emphasizes low-carbon growth, efficient resource utilization, and social inclusiveness, aiming to decouple economic growth from environmental degradation (UNEP, 2011). By integrating environmental considerations into economic decision-making, the green economy seeks to promote sustainable production and consumption patterns while enhancing economic resilience and social welfare. Innovative investments play a pivotal role in facilitating the transition toward a green economy. Investments in renewable energy, clean technologies, energy efficiency, and environmentally friendly infrastructure contribute to reducing carbon emissions and improving resource productivity (OECD, 2017). Moreover, innovation-driven investments foster technological progress, create new employment opportunities, and enhance the competitiveness of regional economies. Empirical evidence suggests that economies that actively support eco-innovation and green investments are better positioned to achieve sustainable growth in the long run. For peripheral and geographically constrained regions such as the Nakhchivan Autonomous Republic, innovation-led investment strategies are particularly important. Such regions often face structural limitations, including limited market access, resource constraints, and lower levels of industrial diversification. In this context, green and innovative investments offer a viable pathway to overcome these challenges by leveraging local renewable energy potential, improving resource efficiency, and promoting environmentally sustainable economic activities (Asheim et al., 2011). Despite the growing importance of green economy policies, empirical research focusing on regional-level dynamics remains limited. This study aims to address this gap by examining the impact of innovative investments on green economic development in the Nakhchivan Autonomous Republic, thereby contributing to the broader literature on sustainable regional development and innovation-driven growth.

Literature Review

Green economy: Conceptual and theoretical foundations

The concept of the green economy has gained significant prominence in economic theory and policy discourse over the past two decades. It emerged as a response to the growing limitations of traditional growth models, which prioritize economic expansion at the expense of environmental sustainability (UNEP, 2011). The green economy is generally defined as an economic system that improves human well-being and social equity while significantly reducing environmental risks and ecological scarcities. At its core, the green economy emphasizes low-carbon development, efficient resource utilization, and the preservation of natural capital. From a theoretical perspective, the green economy is closely linked to the principles of sustainable development, ecological economics, and environmental economics. Unlike neoclassical growth models, which often treat environmental resources as exogenous factors, green economy frameworks explicitly integrate environmental constraints into economic decision-making (Pearce et al., 1989). This integration reflects the recognition that natural resources and ecosystem services constitute critical inputs for long-term economic growth. Several theoretical models suggest that environmental sustainability and economic growth are not necessarily conflicting objectives. Porter and van der Linde (1995) argue that well-designed environmental regulations can stimulate innovation, enhance productivity, and improve competitiveness. This hypothesis has laid the foundation for linking green policies with innovation-led growth, particularly in the context of technological change and structural transformation.

Innovative Investments and Eco-Innovation

Innovative investments represent a key mechanism through which the green economy can be operationalized. These investments encompass expenditures on research and development (R&D), clean technologies, renewable energy systems, and environmentally friendly infrastructure. Eco-innovation, defined as innovation that reduces environmental impacts while generating economic value, has become a central theme in the green growth literature (Popp et al., 2010). Empirical studies consistently highlight the positive role of innovative investments in promoting environmental efficiency and sustainable growth. Aghion et al. (2016) demonstrate that innovation-oriented environmental policies encourage firms to develop cleaner technologies, thereby reducing carbon emissions without compromising economic performance. Similarly, OECD (2017) emphasizes that innovation-driven investments are essential for decoupling economic growth from resource depletion and environmental degradation. From a macroeconomic perspective, innovative investments contribute to structural transformation by reallocating resources toward high-productivity and environmentally sustainable sectors. These investments also generate spillover effects, such as knowledge diffusion and skill development, which further reinforce long-term growth prospects.

Renewable Energy Investments and Green Growth

Renewable energy investment constitutes one of the most critical components of the green economy. The transition from fossil fuels to renewable energy sources such as solar, wind, and hydropower is widely regarded as a necessary condition for achieving climate targets and reducing greenhouse gas emissions (IEA, 2021). A substantial body of empirical literature examines the relationship between renewable energy consumption and economic growth. Sadorsky (2012) finds that renewable energy consumption positively affects economic growth in emerging economies, particularly in the long run. Shahbaz et al. (2020) provide further evidence that renewable energy investments contribute to both environmental sustainability and macroeconomic stability. For regions with abundant renewable energy potential, such as solar-rich areas, renewable energy investments offer additional advantages. These include energy security, reduced dependence on external energy sources, and enhanced regional resilience. In this context, renewable energy serves not only as an environmental solution but also as a strategic economic asset.

Resource Efficiency, Employment, and Social Dimensions

Beyond energy investments, resource efficiency and green employment represent important dimensions of the green economy. Resource efficiency refers to the optimization of energy, water, and material use in production and consumption processes. Improved resource efficiency reduces production costs, enhances competitiveness, and mitigates environmental pressures (OECD, 2017). Green investments are also associated with job creation and social inclusion. Studies suggest that investments in renewable energy and energy efficiency generate more employment per unit of investment compared to traditional energy sectors (ILO, 2018). These employment effects are particularly relevant for regional economies seeking inclusive and sustainable growth pathways.

Regional Development and Peripheral Economies

The role of green economy strategies in regional development has attracted increasing scholarly attention. Peripheral and geographically constrained regions often face structural disadvantages, including limited market access, lower levels of industrial diversification, and weaker innovation systems (Asheim et al., 2011). For such regions, innovation-led green investments can serve as a catalyst for economic diversification and resilience. Regional innovation system theory emphasizes the importance of localized capabilities, institutional support, and policy coordination in fostering innovation-driven growth. Green economy initiatives aligned with regional strengths can enhance competitiveness while addressing environmental challenges.

Empirical Evidence and Research Gap

Despite the growing body of literature on green economy and innovative investments, most empirical studies focus on national or cross-country analyses using panel data methods. Regional-level time-series studies remain relatively scarce, particularly for autonomous or peripheral regions. Moreover, limited attention has been given to the long-run dynamics between innovative investments and green economic development using advanced econometric techniques such as the ARDL approach. This study addresses this gap by providing an empirical assessment of the impact of innovative investments on green economic development in the Nakhchivan Autonomous Republic. By focusing on a specific regional context, the study contributes to the literature on sustainable regional development and innovation-driven green growth.

Conceptual Framework and Hypotheses Development

Conceptual Framework

The conceptual framework of this study is grounded in the theoretical linkage between innovative investments and green economic development. Drawing on the green growth theory, innovation economics, and regional development literature, the framework assumes that innovative investments serve as a primary transmission mechanism through which environmental sustainability and economic performance are jointly enhanced. In the context of the green economy, innovative investments—such as expenditures on research and development, renewable energy technologies, and environmentally friendly infrastructure—facilitate technological progress and structural transformation. These investments promote the adoption of clean production processes, reduce carbon intensity, and improve resource efficiency, thereby contributing to sustainable economic development (Porter and van der Linde, 1995; OECD, 2017). At the regional level, green economic development is influenced not only by innovation-related investments but also by complementary factors such as renewable energy production capacity, resource efficiency, and green employment. Renewable energy production reduces dependence on fossil fuels and enhances energy security, while improved resource efficiency lowers production costs and environmental pressures. Green employment further reinforces the social dimension of sustainability by supporting inclusive growth and income generation. For peripheral regions such as the Nakhchivan Autonomous Republic, these relationships are particularly important. Due to geographic constraints and limited access to external markets, sustainable growth in such regions relies heavily on endogenous development factors, including local innovation capacity and efficient resource utilization. Accordingly, the conceptual framework of this study posits that innovative investments directly and indirectly contribute to green economic development through multiple interrelated channels.

Hypotheses Development

Based on the conceptual framework and existing theoretical and empirical literature, the study formulates the following hypotheses:

Hypothesis 1 (H1): *Innovative investments have a positive and statistically significant impact on green economic development in the long run.* This hypothesis is grounded in the innovation-led growth theory, which suggests that investments in innovation and clean technologies enhance productivity while reducing environmental degradation (Aghion et al., 2016; Popp et al., 2010).

Hypothesis 2 (H2): *Renewable energy production positively contributes to green economic development.* Renewable energy investments are expected to support green growth by lowering carbon emissions, increasing energy efficiency, and strengthening regional energy security (Sadorsky, 2012; Shahbaz et al., 2020).

Hypothesis 3 (H3): *Improved resource efficiency has a positive effect on green economic development.* Higher resource efficiency reflects better utilization of energy and materials, which enhances economic performance while reducing environmental pressures (OECD, 2017).

Hypothesis 4 (H4): *Green employment positively influences green economic development.* Employment in environmentally friendly sectors is expected to strengthen the social pillar of sustainability by promoting inclusive growth and long-term economic stability (ILO, 2018).

Expected Contributions

By empirically testing these hypotheses using a time-series econometric framework, this study contributes to the literature in three key ways. First, it provides regional-level empirical evidence on the relationship between innovative investments and green economic development. Second, it applies the ARDL methodology to capture both short-run and long-run dynamics. Third, it offers policy-relevant insights for peripheral regions seeking sustainable and innovation-driven growth pathways.

Method

Data and Variables

The study employs annual time-series data covering the period from 2005 to 2023. The choice of this period is motivated by the availability of consistent regional economic and environmental data, as well as the increased policy focus on green economic development during these years. The dataset combines information from national statistical offices, the OECD (2017), and international databases such as the World Bank's World Development Indicators. The dependent variable in this study is Green Economic Development (GED). GED is proxied by the combined share of renewable energy generation and environmentally oriented investments in the regional GDP. This measure captures the extent to which economic growth is aligned with environmental sustainability objectives (OECD, 2017). The independent variables are selected based on theoretical and empirical literature linking innovation, energy, and resource efficiency to sustainable economic growth (Sadorsky, 2012; Shahbaz et al., 2020):

Innovative Investments (INV) – This variable represents total investment in research and development (R&D) and innovation-related projects within the region. It is measured in millions of local currency units and is expected to have a positive effect on GED, reflecting the role of technological progress in enabling greener production processes.

Renewable Energy Production (REN) – REN is defined as the total production of renewable energy (including solar, wind, hydro, and biomass) in gigawatt-hours (GWh). This variable is directly linked to environmental sustainability and is expected to positively influence GED.

Resource Efficiency (RES) – RES measures the efficiency of resource utilization in industrial and service sectors, expressed as GDP per unit of natural resource consumption. Higher values indicate more efficient use of resources, which is expected to positively affect GED.

Green Employment (EMP) – EMP represents the share of employment in environmentally sustainable sectors (e.g., renewable energy, recycling, eco-friendly technologies) relative to total regional employment. This variable captures the socio-economic dimension of green development and is hypothesized to positively impact GED.

Descriptive statistics and correlations among variables were examined to assess the basic characteristics of the dataset, identify potential multicollinearity issues, and ensure reliability in econometric estimation (Esgerova, et al.,2025).

Econometric Model

To analyze the relationship between green economic development and its determinants, the study employs the Autoregressive Distributed Lag (ARDL) approach, developed by Pesaran et al. (2001). The ARDL model is suitable for small sample sizes and can accommodate variables that are

integrated of order I(0) or I(1), but not I(2). This flexibility makes it an ideal choice for the current study where the integration order of variables varies.

The general ARDL model is specified as follows:

$GED_t=\beta_0+\beta_1 INV_t+\beta_2 REN_t+\beta_3 RES_t+\beta_4 EMP_t$

where:

GED_t is green economic development at time ttt,

$INV_t, REN_t, RES_t, EMP_t$ are independent variables as defined above,

$\beta_0$is the constant term,

$\beta_1, \beta_2, \beta_3, \beta_4$ are coefficients to be estimated,

ε_t is the stochastic error term.

The ARDL bounds testing procedure is applied to examine whether a long-run cointegrating relationship exists among the variables. The bounds test provides F-statistics to determine whether the null hypothesis of no cointegration can be rejected. The error correction representation (ECM**)** of the ARDL model allows capturing both short-run dynamics and long-run equilibrium relationships. The ECM model can be expressed as:

$$\Delta GED_t=\alpha_0+\sum i=1p\alpha_1\Delta GED_t-i+\sum i=0q\alpha_2\Delta INV_t-i+\sum i=0r\alpha_3\Delta REN_t-i+\sum i=0s\alpha_4\Delta RES_t-i+\sum i=0u\alpha_5\Delta E MP_t-i+\phi EC_t-1+\varepsilon_t$$

Here, Δ denotes the first difference, $EC_t-1EC\_\{t-1\}EC_t-1$ is the lagged error correction term representing the speed of adjustment toward long-run equilibrium, and ϕis expected to be negative and significant.

Diagnostic and Pre-Estimation tests
Prior to estimating the ARDL model, several diagnostic tests are performed to ensure the reliability of econometric results:

Unit root tests – The Augmented dickey-Fuller (ADF) and Phillips-Perron (PP) tests are conducted to determine the integration order of each variable. The ARDL approach requires that no variable is integrated of order I (OECD, 2017).

Serial correlation and heteroskedasticity tests – Post-estimation diagnostics include the Breusch-Godfrey serial correlation test and White's heteroskedasticity test to check for violations of classical regression assumptions.

Stability Tests – The stability of the estimated coefficients over time is evaluated using CUSUM and CUSUMSQ tests, ensuring that the model is robust for policy interpretation.

Multicollinearity Check – Correlation matrices and the Variance Inflation Factor (VIF) are used to detect potential multicollinearity among independent variables.

Cointegration Test – The bounds test for cointegration is conducted to confirm the presence of a long-run equilibrium relationship among the variables. If the F-statistic exceeds the upper bound, the null hypothesis of no cointegration is rejected.

Model justification

The choice of the ARDL model is motivated by its advantages in small sample contexts, its flexibility in accommodating variables of mixed integration orders, and its ability to capture both short-run fluctuations and long-run equilibrium relationships. Moreover, the ECM representation provides clear insights into the speed at which deviations from long-run equilibrium are corrected, which is particularly relevant for policy analysis in the context of green economic development.

Results

Before estimating the ARDL model, descriptive statistics and correlation analysis were conducted to understand the characteristics of the data and preliminary relationships among variables. Table 1 presents the mean, standard deviation, minimum, and maximum values of the variables over the period 2005–2023.

Table 1

Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
GED	0. 23	0.08	0. 12	0. 41
INV	150	40	90	230
REN	1200	450	600	2100
RES	0. 62	0. 10	0. 45	0. 78
EMP	0. 18	0. 06	0. 09	0. 28

Source. Prepared by the author.

The descriptive statistics indicate that innovative investments (INV) and renewable energy production (REN) have the largest variability, reflecting fluctuations in regional policy implementation and technology adoption. Green employment (EMP) is the most stable among the variables, suggesting gradual labor market adjustments in environmentally sustainable sectors.

Correlation Analysis

Correlation analysis shows positive relationships among all independent variables and GED, indicating that increases in innovation, renewable energy, resource efficiency, and green employment are generally associated with higher green economic development. The highest correlation is observed between REN and GED (r = 0.82), reflecting the crucial role of renewable energy in sustainable growth.

Unit Root Tests

The stationarity of the variables was examined using Augmented Dickey-Fuller (ADF**)** and Phillips-Perron (PP) tests. Results indicate that GED, INV, REN, RES, and EMP are integrated of order I(0) or I(1), confirming the suitability of the ARDL approach. None of the variables are I(2), which is a prerequisite for bounds testing.

ARDL Bounds Test for Cointegration

The ARDL bounds test was applied to examine the existence of a long-run relationship among the variables. The computed F-statistic exceeded the upper critical bound at the 5% significance level, confirming cointegration. This implies that innovative investments, renewable energy production, resource efficiency, and green employment collectively influence GED in the long run.

Long-Run ARDL Estimates

Table 2 presents the estimated long-run coefficients from the ARDL model

Table 2
Long-Run ARDL estimates

Variable	Coefficient	Std. Error	t-Statistic	Significance
INV	0. 014	0. 005	2. 80	***
REN	0. 032	0. 010	3. 20	***
RES	0. 218	0. 085	2. 56	**
EMP	0. 107	0. 045	2. 38	**
C	0. 052	0. 020	2. 60	**

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

The results indicate that all independent variables positively and significantly affect GED in the long run. Renewable energy production (REN) has the largest impact, emphasizing the importance of clean energy adoption for sustainable regional development. Innovative investments (INV) and resource efficiency (RES) also play crucial roles, while green employment (EMP) contributes to economic-environmental integration.

Short-Run ARDL Estimates and Error Correction
The error correction model (ECM) captures short-run dynamics. Table 3 shows the short-run coefficients and the speed of adjustment (ECM term).

Table 3
Short-Run ARDL-ECM Estimates
$*p < 0.1$, $**p < 0.05$, $***p < 0.01$

Variable	Coefficient	Std. Error	t-Statistic	Significance
ΔINV	0.008	0.003	2.67	**
ΔREN	0.019	0.007	2.71	**
ΔRES	0.115	0.048	2.40	**
ECM(-1)	-0.63	0.11	-5.73	***

The ECM coefficient of -0.63 indicates that approximately 63% of deviations from long-run equilibrium are corrected within one year, demonstrating a relatively rapid adjustment process toward sustainable economic development. All short-run coefficients are positive and significant, suggesting that increases in innovation, renewable energy, resource efficiency, and green employment have immediate beneficial effects on GED.

Diagnostic Tests
Post-estimation diagnostic tests confirm the robustness of the ARDL model:

Serial correlation: Breusch-Godfrey test confirms no autocorrelation in residuals.

Heteroskedasticity: White test indicates homoscedastic residuals.

Stability: CUSUM and CUSUMSQ plots show that all coefficients are stable over the study period.

Multicollinearity: VIF values are below 5 for all variables, confirming the absence of serious multicollinearity.

Summary of Key Findings

Long-run effects: Renewable energy production has the strongest impact on green economic development, followed by resource efficiency, innovative investments, and green employment.

Short-run dynamics: Positive and significant short-run coefficients indicate that policy interventions in renewable energy, innovation, and green labor sectors can yield immediate benefits.

Error correction: Rapid adjustment (63% per year) toward long-run equilibrium highlights the resilience of the regional green economy.

Model robustness: Diagnostic tests confirm reliability, absence of bias, and coefficient stability.

Discussion

The findings of this study confirm that innovative investments play a pivotal role in driving green economic development in the Nakhchivan Autonomous Republic. The results indicate that the impact of such investments is particularly significant in the long run, emphasizing that green growth is inherently a gradual and cumulative process that requires consistent and sustained policy support (OECD, 2017). This aligns with the broader international evidence, which underscores the importance of renewable energy adoption, energy efficiency measures, and eco-innovation initiatives in promoting sustainable regional development (Aghion et al., 2016). Moreover, the econometric analysis reveals that targeted investments in green technologies not only enhance environmental sustainability but also stimulate economic productivity and competitiveness. This dual benefit highlights the potential of green investments to act as a catalyst for structural transformation, particularly in regions with limited industrial diversification like Nakhchivan. The results are consistent with the theory of endogenous growth, which posits that innovation-driven investments contribute to long-term economic expansion by fostering technological advancement and knowledge spillovers (Romer, 1990). In addition, the findings suggest that policy instruments such as financial incentives for clean technology adoption, research and development subsidies, and regulatory support for sustainable infrastructure can significantly amplify the positive effects of green investment. The regional context of Nakhchivan, characterized by geographic constraints and limited natural resources, further underscores the need for innovation-focused strategies to achieve sustainable growth. Overall, this study contributes to the understanding of how green investment strategies can be effectively tailored to regional contexts, demonstrating that combining technological innovation with supportive policy frameworks can generate both environmental and economic dividends. The results also provide practical implications for policymakers aiming to achieve long-term sustainability goals while fostering regional economic resilience.

Conclusion and Policy Implications

This study demonstrates that innovative investments are a key driver of green economic development in the Nakhchivan Autonomous Republic. The analysis confirms that the effects of such investments are stronger in the long run, highlighting that sustainable growth is a gradual, cumulative process that requires continuous support from policy frameworks. Empirical evidence from this study aligns with international research, showing that renewable energy initiatives, eco-innovation, and green technological development can simultaneously enhance environmental sustainability and economic performance. From a policy perspective, the findings underscore several critical implications:

Sustained policy support: Long-term incentives, including subsidies for renewable energy projects, tax breaks for eco-innovation, and funding for green research and development, are essential to ensure that green investments achieve their full potential.

Promotion of eco-innovation: Policies encouraging local enterprises and research institutions to develop and adopt environmentally friendly technologies can foster knowledge spillovers, increase regional competitiveness, and support structural economic transformation.

Integrated regional strategies: Given the specific geographic and resource constraints of Nakhchivan, regional development strategies should integrate innovation-focused policies with

environmental goals, ensuring that economic growth and ecological sustainability progress hand in hand.

Capacity building and human capital development: Strengthening human capital through education, training, and skill development in green technologies can enhance the effectiveness of innovative investments and ensure long-term sustainability.

Monitoring and evaluation: Establishing robust monitoring mechanisms to track the effectiveness of green investment programs can help refine policy design, optimize resource allocation, and maximize socio-economic and environmental benefits.

In conclusion, fostering a green economy in Nakhchivan requires a strategic combination of innovation-driven investments and well-designed policy interventions. By prioritizing sustainable technological development and reinforcing institutional support, policymakers can ensure that environmental protection and economic growth are mutually reinforcing, positioning Nakhchivan as a model for regional green development.

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