Latif Zeynalli, PhD
Head of Department / Associate Professor
Center for Analysis of Economic Reforms and Communication (CAERC), Baku, Azerbaijan
Azerbaijan State Oil and Industry University, Baku, Azerbaijan
E-mail: latif.zeynalli@gmail.com
Orcid: https://orcid.org/0000-0001-5887-7946

Ramil Huseyn, DSc
Associate Professor
Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan
Email: ramilzhuseyn@gmail.com
Orcid: https://orcid.org/0000-0001-6689-3823

Agil Asadov, DSc
Head of Department
Center for Analysis of Economic Reforms and Communication (CAERC), Baku, Azerbaijan
E-mail: aqil.asadov@ereforms.gov.az
Orcid: https://orcid.org/0000-0002-8020-8922

Abdulrahim Dadashov, PhD
Deputy Head of Department
Center for Analysis of Economic Reforms and Communication (CAERC), Baku, Azerbaijan
E-mail: abdulrahim.dadashov@ereforms.gov.az
Orcid: https://orcid.org/0000-0002-3174-6521

EXPLORING THE NEXUS BETWEEN EMISSIONS, ECONOMIC GROWTH, AND EMPLOYMENT: EVIDENCE FROM AZERBAIJAN

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Abstract

This paper explores the dynamic relationship between Azerbaijan's green economy and employment by analyzing GDP per capita, CO_2 emissions, and employment rates using the Toda-Yamamoto causality method on annual data from 1990 to 2023. The empirical results reveal two key findings: (1) a statistically significant bidirectional causality between the employment rate and GDP per capita, indicating mutual reinforcement between economic growth and labor market performance; and (2) a statistically significant unidirectional causality from CO_2 emissions per capita to employment at the 1% significance level, underscoring the *role of environmental factors in shaping employment dynamics. Our findings reveal a unidirectional positive relationship between CO_2 emissions and employment, suggesting that increased emissions are associated with rising employment levels. This paper contributes by providing the first time-series evidence from Azerbaijan on the causal links between CO_2 emissions, GDP per capita, and employment, using the Toda-Yamamoto approach.*

Keywords: Azerbaijan, Green Economy, Employment, Economic Growth, Toda-Yamamoto causality test

1. INTRODUCTION

The significance of the green economy is closely linked to the global environmental challenges we face today. Issues such as climate change, the depletion of natural resources, and environmental pollution have cast doubt on the sustainability of traditional economic models. In this context, the green economy offers a new economic development path grounded in ecological sustainability. The growing awareness of environmental concerns and rapid innovation are pushing businesses and governments to adopt more responsible and long-term strategies.

As the host nation for the 29th session of the Conference of the Parties (COP29) to the United Nations Framework Convention on Climate Change, Azerbaijan has expressed its commitment to becoming a “green growth” nation characterized by a clean environment. Azerbaijan is accelerating its transition to a green economy by implementing major initiatives, particularly in the field of renewable energy. These efforts aimed at fostering “green growth” not only contribute to the environmental sustainability of the national economy but also generate new green employment opportunities. For example, Azerbaijan is actively developing large-scale projects to harness the wind energy potential of the Caspian Sea. According to estimates by the World Bank (2022), tapping into this potential could result in the creation of approximately 19.000 jobs under a low-growth scenario and up to 69.000 jobs in a high-growth scenario by 2024.

The study, drawing on time series econometric analysis from 1990 to 2023, investigates the relationship between CO_2 emissions and employment in Azerbaijan, which may indirectly reflect the challenges of green transition, although it does not directly measure the effects of specific green growth initiatives. Using annual data from 1990 to 2023, it explores the interconnections between carbon emissions, employment levels, and economic growth. To ensure the robustness of the findings, the Toda-Yamamoto casuality approach is employed using Ewiews 12 software. The results offer meaningful insights into the ways in which sustainable economic development affects employment dynamics in the context of a transitioning green economy. The structure of the reserach is organised into four main sections. The introduction provides a gemeral overview of the topic and emphasizes the importance of the study. The second section reviews the relevant literature on green economy, employment, and sustainable development. The third section details the methodology and data sources used in the analysis. Finally, the fourth section presents the empirical results and discusses the key findings from both academic and practical perspectives.

2. LITERATURE REVIEW

The green economy is more than just a concept; it is a comprehensive approach that combines economic, environmental, and social aspects. It involves various stakeholders, delivers measurable results, and requires strong governance frameworks. To achieve this essential transformation, we need to implement bold and innovative strategies. Environmentally sustainable development aims to ensure that our methods of resource use, pollution management, and waste control do not compromise the well-being of future generations. Economic growth often leads to increased demand for natural resources, resulting in overexploitation and higher levels of waste production. This situation poses a significant threat to the environment's ability to regenerate. To protect our planet and ensure a sustainable future for generations to come, we must take proactive steps now (Frýdlová & Vostrá, 2011; Kuşat, 2013; Caprotti & Bailey, 2014; Montt et al., 2018; Bogovic & Grdic, 2020).

The “green economy” model, introduced by the United Nations Environment Programme (UNEP) in 2008, provides a transformative framework for economic growth that prioritises ecological sustainability and efficient resource utilisation. This approach aims to tackle the urgent environmental challenges we face today while supporting a prosperous future for both the economy and the planet. Key components of a green economy include initiatives that promote ecological sustainability, such as properly managing hazardous waste, implementing sustainable building practices, restoring ecosystems, transitioning to renewable energy sources, improving energy efficiency, upgrading public transportation systems, and investing in innovative research (Azazi & Uzma, 2022; Karbekova & Karbekova, 2024).

At the macroeconomic level, global warming is acknowledged as a significant market failure with historical implications. It is crucial to transition to a low-carbon economy to avoid severe economic and social repercussions in the future. A primary objective in the battle against climate change is the prompt reduction of global carbon dioxide (CO2) emissions. Understanding the relationship between CO2 emissions and energy consumption, which is vital for international economic activities, is essential. This knowledge is necessary for developing strategies that promote both economic growth and sustainability (Atlama & Özsoy, 2011; Polat, 2022).

The transition to a green economy is a significant challenge, especially in terms of labour conditions, job security, health benefits, and wages. For the creation of highly skilled jobs, these factors are essential. Furthermore, this shift has the potential to improve both the number and the quality of employment opportunities available. The relationship between green economic growth and employment should therefore be examined (Görmüş, 2019).

The development of the green economy provides benefits like resource security, financial stability, and job creation, in addition to environmental protection (Unay-Gailhard & Bojnec, 2019). This approach aims to create new jobs, especially for skilled workers, and stresses the importance of support during the transition from declining sectors. Sustainable development practices promote environmental conservation and contribute to a future-ready workforce.

The employment-to-population ratio is an important indicator of a country's labor force health. It represents the percentage of individuals who actively engage in producing or providing goods and services for financial gain within a given period. Economic growth, which contributes to stability and prosperity in society, is a key indicator of economic stability (Uzar & Eyuboglu, 2019).

There are several ways to assess the significance of the green economy in job creation. These research projects focus on emphasizing the importance of green jobs within the economy, without considering any potential job losses that may result from green policies (Horbach, et al., 2015). The green economy is expected to expand, although there are variations in green job opportunities across different regions. Many countries are introducing promotional programs to encourage employment in green sectors and the adoption of advanced technologies. For the sustainable future and the successful development of the green economy, it is essential to participate in these initiatives.

Fankhaeser et al. (2008) conducted comprehensive research on the impact of environmental policies on the employment sector, highlighting the significance of effectively managing challenges and opportunities over various time frames (Jobs, 2015).

Economic activities that enhance employment while minimizing environmental damage are increasingly demanded. The need for reform is driven by resource shortages and stricter environmental regulations. This is especially important for industrialized countries, which many believe have a moral responsibility for their historical overuse of resources. These countries are also better equipped to adapt to new production methods, thanks to their economic capability and skilled workforce (McEvoy et al., 2000).

Previous studies have shown that Granger causality and Johansen cointegration methods are effective for detecting both short-term effects and long-term relationships between sectoral development and employment dynamics (Pavlić et al., 2013).

The green economy is a way to create jobs and equal opportunities for all people. We can improve the employment situation by expanding the low-carbon economy. However, it is important to acknowledge that while one job in the green sector may emerge, it could replace another in a traditional sector. A more sustainable and equitable future can be achieved by embracing this transition (Ge & Zhi, 2016).

Global warming is considered to be a major market failure of historical significance. Transitioning to a low-carbon economy is necessary to avoid serious economic and social consequences in the future. A primary objective in combating climate change is to reduce global carbon dioxide emissions. The relationship of CO2 emissions and energy consumption is essential to global economic activities. Understanding is necessary to design strategies that support economic growth and sustainability (Atlama & Özsoy, 2011; Polat, 2022).

Countries that are dedicated to building a green workforce understand the essential role of developing key sectors such as low-carbon transportation, renewable energy, and waste management. By investing in these areas, they not only create jobs but also promote a sustainable future (Sakaloğlu, 2019).

Ahmad et al. (2023), analyzed a panel of developing countries using the ARDL approach to investigate the relationship between institutional quality, employment, trade openness, and CO_2 emissions. Their findings indicate that labor market openness exerts a significant effect on CO_2 concentration levels, underscoring the role of accessible employment opportunities as a key channel for promoting environmental sustainability (Ahmad, 2023).

A study examining the relationships between CO2 emissions, economic growth, available energy, and employment in eight Southeastern European countries from 1995 to 2019 provides important insights. In the short term, CO2 emissions and employment influence each other, as do available energy and employment. In the long term, CO2 emissions, GDP, and employment are critical factors that significantly impact system adjustments when deviations from equilibrium occur (Mitić, et al., 2023).

Kopidou et al. (2016), research indicates that EU countries have not established a consistent approach to sustainable and inclusive industrial development. During periods of economic growth, some nations have made progress in reducing emissions while maintaining or increasing employment levels. However, these achievements were often not sustainable in financial downturns. The crisis has led to a significant decline in employment in Greece, due to the absence of industrial development. During the crisis, more resilient economies such as Germany and Austria were able to maintain positive outcomes, reducing emissions while maintaining employment levels.

The research by Güllü and Kartal (2021), applying the Jobs and Economic Development Impact (JEDI) model, examined Turkey's renewable energy sector and found that wind, solar, and hydro sub-sectors were the strongest drivers of job creation. While their study does not directly relate to Azerbaijan, it provides a regional example showing how renewable energy industries can generate employment, thereby offering a useful comparison for Azerbaijan's ongoing green transition.

Huseynli (2022) examined the relationship between energy production and economic growth in Azerbaijan and Turkey from 2005 to 2015 using various statistical tests. The findings showed that renewable energy and economic growth in Azerbaijan are not significantly correlated. However, strong links have been established between traditional energy sources and economic growth in both countries. This research explores the potential benefits of advancing and adopting renewable energy technologies, which could promote economic development and employment rates.

The study conducted by Zhigolli and Fetai (2024) examines the nexus between CO_2 emissions, GDP per capita, and energy consumption in the Western Balkan countries over the period 2011–2022. Utilizing Ordinary Least Squares (OLS), Fixed Effects (FE), Random Effects (RE), and Hausman–Taylor IV estimation methods, the authors identify a negative relationship between CO_2 emissions and GDP per capita and a positive relationship with energy consumption, whereas the effect of industrial production is statistically insignificant. These findings provide robust empirical evidence to inform the development of environmental protection strategies and sustainable development policies in the region.

Cheng et al. (2024) studied the effects of the Paris Agreement on corporate employment levels in China. Their findings show that companies with high carbon emission risks experienced a significant rise in employment levels. The authors suggest that this increase may be explained by firms’ need to comply with new regulatory requirements, expand monitoring and reporting activities, and restructure production processes, all of which demanded additional labor.

Graham and Knittel (2024) introduce the concept of the "employment carbon footprint" to assess how the energy transition affects jobs in the United States. They find that some regions are disproportionately affected, underlining the importance of just transition policies. Although focused on the U.S., their approach is relevant for Azerbaijan, where the shift from oil dependence to renewable energy may also create uneven regional labor market outcomes.

Doksanyedi and Meçik (2024) conducted a comprehensive analysis of Turkey's economic data from 1990 to 2020. Their research uncovered a significant one-directional causal relationship between carbon emissions, employment rates, and gross domestic product (GDP). Using the Toda-Yamamoto causality technique, they revealed a direct link between rising carbon emissions and increased employment in energy-intensive industries. This important finding highlights the urgent need for sustainable practices that not only address environmental challenges but also promote economic growth through job creation.

Musayev (2024) studies the relationship between clean and dirty energy consumption and CO2 emissions in Azerbaijan from 1985 to 2022. The study shows that the use of renewable energy contributes to a reduction in CO2 emissions, whereas natural gas consumption has a one-sided effect on emissions, increasing them. The study recommends several policy measures to address these issues, including promoting investments in renewable energy, reducing subsidies for fossil fuels, and improving energy efficiency.

Suleymanov et al. (2024) examine the relationship between clean and dirty energy consumption and CO2 emissions in Azerbaijan from 1985 to 2022. The study reveals that the use of renewable energy contributes to a reduction in CO2 emissions, while the consumption of natural gas has a one-sided effect on emissions. To address these challenges, the study recommends several policy measures, including promoting investments in renewable energy, reducing subsidies for fossil fuels, and enhancing energy efficiency.

Aliyev et al. (2024) assess the bilateral causal relationship between GDP per capita and renewable energy consumption in Iceland and Azerbaijan, utilizing annual data from 1990 to 2020. They employ a VAR framework along with an adapted Granger causality test for their analysis. The results reveal a significant relationship between the use of renewable energy and economic development.

Huseyn and Abasova's (2024) emphasize that green growth is becoming a key pillar of Azerbaijan's sustainable development strategy. Their study highlights the role of green entrepreneurship, eco-entrepreneurship, and ecotourism in diversifying the non-oil sector, which has received growing state support. These insights are valuable in painting a broader picture of Azerbaijan's current energy consumption and transition challenges, where traditional energy dependence still dominates but new opportunities for sustainable growth are emerging. While the authors also present the views of Generation Z students on the barriers to eco-entrepreneurship, the more relevant takeaway for this paper lies in the broader policy implications for green growth and energy diversification, which connect directly to employment and sustainability.

Gasimli et al. (2024) highlight that prioritizing green energy and fostering greater international collaboration in this sector could bring substantial social benefits to Azerbaijan. Using an Input–Output framework complemented by cost-effectiveness and co-benefit analysis, they examine how the rollout of large-scale renewable energy projects is anticipated to improve unemployment rates and increase income levels within the community.

Srdelić and Barišić (2025) examine sector-specific Environmental Kuznets Curves (EKC) in Croatia, employing ARDL and ECM approaches to highlight how different sectors respond to climate policies. Although not directly focused on Azerbaijan, their study provides a comparative European context that informs how sector-specific frameworks might be relevant for Azerbaijan's transition to a green economy. Placing this discussion earlier in the literature review creates a natural lead-in to the subsequent body of research on Azerbaijan, thereby allowing the review to conclude with the national studies and to articulate more clearly the literature gap this paper addresses.

COP29 has sparked a significant movement toward increased visibility and engagement among enterprises in Azerbaijan focused on initiatives related to the "green economy." The Azerbaijani government is proactively promoting the adoption of electric vehicles and is leading the transformation of urban transport systems to include electric buses. Additionally, there is a growing interest in research related to eco-entrepreneurship within the country. This provides an opportunity to explore how the implementation of "green growth" strategies can positively impact employment across various sectors of the Azerbaijani economy. This paper examines this emerging research area and highlights its potential benefits.

The green economy combines economic, environmental, and social aspects to create jobs while protecting our planet. Developed countries should adopt sustainable practices and use their history to transition towards eco-friendly production methods. This shift can stimulate job growth in renewable energy, sustainable transportation, and waste management, which can improve social equity. Research indicates that reducing CO2 emissions requires a combination of better labour market accessibility and the enforcement of strict environmental regulations. Green technologies can help create jobs and reduce pollution. In order to achieve sustainable development, it is essential to implement targeted policies that balance economic growth with environmental protection.

3. METHODS

This research evaluates GDP per capita, CO2 emissions, and employment statistics for Azerbaijan from 1990 to 2023. A time series analysis method was used to analyze annual data within this period. In this study, economic growth is represented by GDP per capita, with data obtained from the official websites of the State Statistical Committee of the Republic of Azerbaijan (SSC) and the World Bank. To ensure consistency across all variables, logarithmic values were calculated for each. Table 1 provides detailed descriptions of the variables.

Table 1 Variables

Variable	Symbol	Definition	Sources of the data
Employment rate	*LNER*	The percentage of employed persons in relation to the comparable total population (percentage)	The State Statistical Committee of the Republic of Azerbaijan, 2024
GDP	*LNGDP*	Gross domestic product per person (in U.S. dollars)	World Bank Group
Per capita CO_2 emissions	*LNCO2*	The release of carbon dioxide into the atmosphere from human activities such as burning fossil fuels, industrial processes, and deforestation, contributing to climate change (tons)	World Bank, 2024

Source: Prepared by the authors

This research utilizes the Toda-Yamamoto causality test to analyze the relationships between CO2 emissions, employment, and GDP. However, due to certain statistical and methodological constraints, we were unable to include important economic variables such as investment, labor, and human capital in our analysis. Technical challenges that hindered their inclusion in the model include incomplete data for these variables, the lack of appropriate time series or panel data, and instances of multicollinearity among variables. Despite these limitations, the results obtained from the available data still provide valuable insights into the economic relationships that are relevant to the objectives of the study.

One of the main advantages of the Toda-Yamamoto method is that it does not require time series data to be stationary, unlike the traditional Granger causality test. Unlike conventional tests, this method allows non-stationary variables to be analyzed directly, improving the robustness of the results. The testing process involves two primary steps. First, the optimal lag length (k) is determined using a Vector Autoregressive (VAR) model, which effectively captures the dynamic relationships among the variables. In the second step, the maximum order of integration for the variables, known as dmax, is established. This value indicates how much differentiation is required to make the variables stationary. The dmax value is then combined with the lag length (k) to create a new lag structure (k + dmax). This adjustment is crucial for ensuring that the Wald test statistics used to assess causality are valid, even when the variables exhibit different integration orders. By incorporating dmax, the Toda-Yamamoto test reduces potential biases and inaccuracies associated with non-stationary data, making it a robust choice for examining causal relationships. Its flexibility and solid methodology make it particularly suitable for studies exploring macroeconomic and environmental factors with varying time series characteristics. For the paper, we can define the model equations as follows (Toda &Yamamoto, 1995):

$$Yt = \delta 0 + \sum_{i=1}^{k+dmax} \alpha 1i\, Yt - i + \sum_{i=1}^{k+dmax} \beta 1i\, Xt - i + \varepsilon 1t \quad (1)$$

$$Xt = \delta 0 + \sum_{i=1}^{k+dmax} \alpha 2i\, Yt - i + \sum_{i=1}^{k+dmax} \beta 2i\, Xt - i + \varepsilon 2t \quad (2)$$

In this model, determining the lag length k and incorporating the maximum order of integration dmax result in the formation of a VAR [k+dmax] model.

The hypotheses for Equation are as follows:

H0: There is no causal relationship from Y to X.

H1: There is a causal relationship from Y to X.

This research paper will test the hypotheses using the adjusted WALD test statistic. To effectively analyze the critical relationships among carbon emissions, employment rates, and economic growth, we will begin by conducting unit root tests. These tests are essential for determining the stationarity of the time series data, as non-stationary data can lead to spurious regression results, undermining the validity of the analysis. We will employ the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test, both of which are well-regarded for identifying whether a time series contains a unit root, indicating non-stationarity.

The ADF test addresses higher-order autocorrelation by augmenting the Dickey-Fuller equation, while the PP test accounts for heteroscedasticity and serial correlation in the error terms. Together, these tests provide a complementary approach to our analysis. The results from these tests will establish a solid foundation for understanding the dynamic interconnections among the variables being studied. By examining both the original values and their decomposed components, we aim to capture nuanced trends and structural breaks within the data. This detailed approach will help us determine whether the variables are stationary in their original form or become stationary after transformations, such as differencing.

4. RESULTS AND DISCUSSION

Table 2 provides a clear summary of the outcomes from the ADF and PP unit root tests. It offers an overview of the stationarity status for each variable series, including carbon emissions, employment rates, and economic growth, along with their individual components. The table indicates whether the variables are stationary at levels or first differences and presents the optimal lag lengths, test statistics, and the relevant critical values. These insights are crucial for ensuring that subsequent econometric models are based on reliable data, allowing for accurate estimation of the relationships among these key economic and environmental factors.

Table 2 ADF and PP Unit Root Test Results

	ADF Unit root test		**PP Unit root test**	
ADF and PP Unit Root Tests – Level				
Variables	**t-Stat. (Inter.)**	**t-Stat. (Inter. and Trend)**	**t-Stat. (Inter.)**	**t-Stat. (Inter. and Trend)**
LNGDP	-2.594369	-1.138999	-0.743234	-1.909534
	(0.1045)	(0.9061)	(0.8218)	(0.6270)
LNCO2	-4.255737	-2.804305	-4.459662	-2.998963
	(0.0022)	(0.2061)	(0.0013)	(0.1480)
LNER	-2.679816	-2.417319	-2.651179	-2.258835
	(0.0910)	(0.3628)	(0.0961)	(0.4399)
ADF and PP Unit Root Tests - First Difference				
Variables	**t-Stat. (Inter.)**	**t-Stat. (Inter. and Trend)**	**t-Stat. (Inter.)**	**t-Stat. (Inter. and Trend)**
LNGDP	-8.616307	-9.179489	-7.505158	-8.241745
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
LNCO2	-4.459750	-5.709311	-4.557492	-5.720828
	(0.0013)	(0.0003)	(0.0010)	(0.0003)
LNER	-5.171571	-5.334028	-5.172406	-5.514310
	(0.0003)	(0.0012)	(0.0003)	(0.0008)

Source: Authors' calculation

Table 2 presents the results of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for LNGDP. Whether examining only the intercept or both the intercept and trend, the t-statistics indicate that there is insufficient evidence to reject the null hypothesis of a unit root, as the p-values are greater than 0.05. Consequently, LNGDP shows no stationarity when examined at levels. For the ADF test with only the intercept, LNCO2 shows stationarity, as indicated by the t-statistic ($p = 0.0022$), leading to the rejection of the null hypothesis. However, it is non-stationary when assessing the trend ($p = 0.2061$). Similarly, in the case of the PP test, stationarity is evident when only the intercept is considered ($p = 0.0013$), but this is not the case when both the intercept and trend are included. Therefore, LNCO2 yields both positive and negative outcomes depending on the specific context. In contrast, for LNER, the null hypothesis cannot be rejected based on the t-statistics from both ADF and PP tests at levels (p-values > 0.05). Thus, LNER does not maintain stationarity at its initial levels. After differencing the data, all variables show stationarity in both the ADF and PP tests, regardless of whether the intercept or the intercept and trend terms are included. All variables exhibit p-values < 0.05, decisively rejecting the null hypothesis of a unit root. LNGDP is particularly significant after the first difference, with a p-value of 0.0000 in every instance, indicating stationarity post-differencing. LNCO2 also demonstrates consistency with first-order differences, achieving significant p-values of 0.0013 (intercept only) and 0.0003 (intercept and trend) in both tests. LNER records noteworthy p-values ($p < 0.05$) in every case as well. Overall, while the variables LNGDP, LNCO2, and LNER do not exhibit stationarity at their initial levels (except for LNCO2, which presents varying results), they display stationarity after the first differencing.

Table 3 VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	70.08957	NA	4.51e-07	-6.099052	-5.950274	-6.064004
1	118.3131	78.91122	1.29e-08	-9.664827	-9.069713	-9.524636
2	130.8784	17.13444*	9.87e-09	-9.988941	-8.947491	-9.743607
3	146.0892	16.59367	6.50e-09	-10.55357	-9.065780	-10.20309
4	157.4374	9.284877	7.18e-09	-10.76704	-8.832916	-10.31142
5	**183.4004**	**14.16165**	**2.93e-09***	**-12.30913***	**-9.928673***	**-11.74837***

Note: LR Sequential modified LR test statistic (each test at 5% level), the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and the Hannan-Quinn Information Criterion (HQ).

* Indicates lag order selected by the criterion

Source: Study results using the EViews statistical package

The Toda-Yamamoto causality test is a powerful tool that leverages the VAR (Vector Autoregression) framework, enabling effective model estimation with level values, even in the presence of unit roots in the analyzed series. To execute this test successfully, it is essential to first determine the maximum degree of integration (dmax) for the VAR model and establish the optimal lag length (k). Following this, an effective VAR model is estimated with the configuration of (k + dmax). The maximum lag length is rigorously established through ADF and PP unit root tests, confirming that dmax = 1. By applying various criteria to determine the appropriate lag length (k), we can achieve robust results, as detailed in Table 3.

Understanding the dynamics of Azerbaijan's territorial and consumption-based carbon dioxide (CO_2) emissions from 1994 to 2023 is essential for assessing the country's environmental impact and economic growth. Figure 1 illustrates these trends, with consumption-based emissions represented by the orange line and territorial emissions by the blue line.

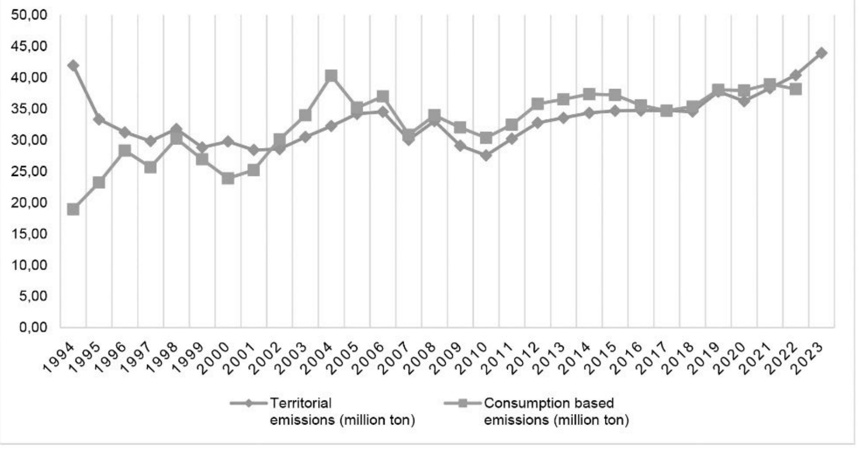

Figure 1 Territorial and Consumption-based CO_2 emissions in Azerbaijan (1994-2023)

Source: Prepared by the author based on Global Carbon Budget (2025) data

Although Azerbaijan's share in global CO_2 emissions is relatively small (0.13%), the urgency of sustainable practices lies in ensuring national resilience and alignment with international commitments. Azerbaijan distinguishes itself in the region by establishing clearly defined long-term climate objectives. Within this ambitious framework, and taking into account the conditions for international support, the country has set itself a target to reduce greenhouse gas emissions by 40% by 2050 compared to 1990 levels. This commitment is underpinned by the implementation of numerous large-scale projects aimed at promoting low-carbon development and enhancing environmental sustainability, reflecting a strategic approach to integrating climate policy within national socio-economic development planning.

This figure illustrates the trends in both territorial and consumption-based CO_2 emissions in Azerbaijan from 1994 to 2023. Between 1994 and 1997, there was a significant decline in territorial emissions, largely due to substantial changes in Azerbaijan's energy and economic sectors following the dissolution of the Soviet Union and the subsequent reorganization of the national economy. During this time, a decrease in industrial production likely played a crucial role in reducing emissions. Since the year 2000, both area-based and consumption-based emissions have been on the rise, reflecting rapid economic growth and increasing energy consumption in Azerbaijan as the country has tapped into its oil and gas resources. This growth period has been characterized by heightened energy demand driven by industrial development, infrastructure projects, and a growing population. From 2009 to 2014, there was a slight decrease in territorial emissions, which can be attributed to enhanced energy efficiency, economic diversification, and the implementation of cleaner technologies in certain industries. Consumption-based emissions in Azerbaijan, representing the emissions embedded in the goods and services consumed, have remained relatively stable. This stability suggests that the country's consumption patterns are still tied to carbon-intensive imports and lifestyles. The most significant change occurred in 2020 when both territorial and consumption-based emissions experienced a notable increase. This rise likely resulted from the economic recovery following the COVID-19 pandemic, as industries resumed higher operational capacities and energy demand surged after the initial economic slowdown.

The ongoing increase in emissions poses a significant challenge for Azerbaijan, which must balance economic development with environmental sustainability. These trends show the urgent need for the country to adopt more sustainable practices in production and consumption to mitigate the environmental impact of its growing economy. This transition involves shifting towards greener energy sources, improving energy efficiency, and integrating sustainability into economic planning and policymaking. As Azerbaijan moves forward, it will be necessary to strike a balance between economic growth and carbon reduction efforts.

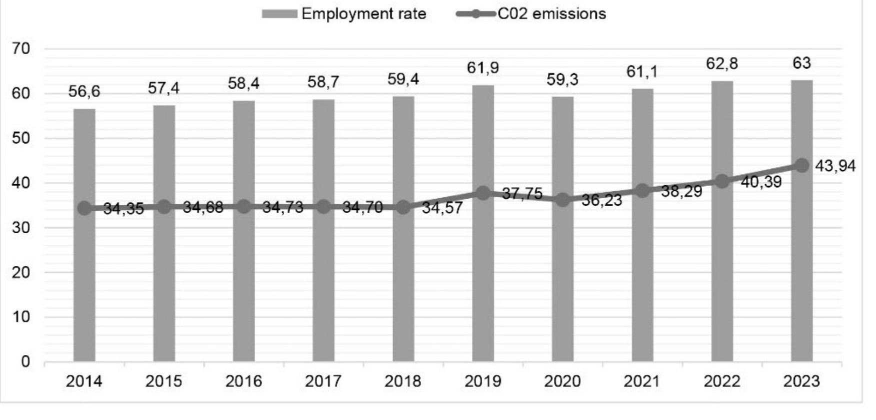

Figure 2 Employment and CO_2 emissions in Azerbaijan (2014-2023)

Source: Prepared by the author based on World Bank (2025) data

Figure 2 illustrates the relationship between the employment rate and carbon dioxide (CO_2) emissions in Azerbaijan from 2014 to 2023. During this period, the employment rate steadily increased from 56.6% in 2014 to 63% in 2023. Initially, the employment rate remained relatively stable from 2014 to 2018, before increasing to 61.9% in 2019. However, in 2020, the rate declined to 59.3%, likely due to the adverse effects of the COVID-19 pandemic on the labor market. Despite this setback, the employment rate began to rise again in 2021, ultimately reaching 63% in 2023. This upward trend can be attributed to Azerbaijan's economic growth, the creation of new job opportunities, and the diversification of various economic sectors. In contrast, CO_2 emissions have consistently increased over the years. In 2014, emissions were recorded at 34.35 million tons, rising to 43.94 million tons by 2023. Between 2014 and 2018, emissions remained relatively stable, fluctuating around 34 to 35 million tons. However, a notable surge in CO_2 emissions occurred starting in 2019, with figures climbing from 37.75 million tons that year to 43.94 million tons in 2023. This increase can primarily be attributed to factors such as industrial growth, increased urbanization, and rising energy consumption. There is a clear correlation between the employment rate and CO_2 emissions; as the employment rate rises, economic activity generally increases, which leads to higher energy demands and consequently to higher CO_2 emissions. It is also important to note that in 2020, the decline in the employment rate due to the pandemic coincided with a temporary decrease in CO_2 emissions. In summary, while the rising employment rate in Azerbaijan indicates economic progress, the corresponding increase in CO_2 emissions raises concerns about environmental sustainability. Therefore, it is essential to implement balanced policies that align economic growth with environmental preservation. Countries with high energy consumption contribute disproportionately to CO_2 emissions, which highlights the need for sustainable energy solutions globally (Sangco, 2024).

In the research, the length of the series delay was determined using VAR analysis. As shown in Table 3, the information criterion with the highest rating indicates that a delay length of 5 is optimal; thus, 5 is selected as the delay length (k). In this study, k = 5 and dmax = 1 were found. Since k > dmax, the equation T-Y could be applied.

$$k+dmax=5+1=6 \tag{3}$$

Table 4 Autocorrelation LM test results

VAR	Lag Length	LM Statistics Values	Probability
LNER LNCO2 LNGDP	1	2.758847	0.1107
	2	0.153985	0.8789
	3	-1.136643	0.2665
	4	-1.122807	0.2722
	5	-0.537405	0.5957
	6	-0.048752	0.9615

Source: Authors' calculation

The Autocorrelation LM test is used to determine whether the time series exhibits autocorrelation issues for the chosen ideal lag length. Table 4 above shows that the p-values in the LM test output are above the 0.05 level, indicating that the series do not contain autocorrelation problems.

Table 5 Normality test results

VAR	Jarqua-Bera	Df	Probability
LNER - LNCO2 - LNGDP	0.58	2	0.75

Source: Authors' calculation

The normality distribution test conducted in the continuation of the analysis employs the Jarque-Bera normality test to examine the hypothesis H_0: the series follows a normal distribution against the alternative hypothesis H_1: the series does not follow a normal distribution. If the results of the Jarque-Bera test are below the 0.05 significance level, the H_0 hypothesis is rejected, indicating that the error terms do not exhibit a normal distribution. Conversely, if the probability values of the series exceed 0.5, it is concluded that the series follows a normal distribution, leading to the rejection of the H_1 hypothesis. The details of the normality test conducted are presented in Table 5 above.

Table 6 Heteroscedasticity test results

VAR	Chi-Square	Df	Probability
LNER - LNCO2 - LNGDP	2.832	66	0.2598

Source: Authors' calculation

The heteroscedasticity test is crucial for assessing whether the error terms maintain a constant variance, which is fundamental for the reliability of the VAR model. A threshold error term level above 0.05 strongly indicates the absence of issues related to changing variance. Thus, the findings presented in Table 6 compellingly demonstrate that the error terms exhibit a stable variance, reinforcing the model's validity and robustness.

Table 7 Toda-Yamamoto Causality Test Results

Variables	Value	Prob.
LNER Causes LNGDP	111.2186	0.0000
LNCO2 Causes LNGDP	53.57955	0.0000
LNGDP Causes LNER	38.17171	0.0000
LNCO2 Causes LNER	19.63255	0.0032
LNGDP Causes LNCO2	11.74890	0.0678
LNER Causes LNCO2	4.217747	0.6472

Source: Authors' calculation

The empirical findings of this study are largely consistent with previous research on the nexus between economic growth, employment and CO_2 emissions. For example, similar to Mitić et al. (2023), our results indicate that in the short run there is mutual influence between employment and CO_2 emissions. Our finding of a bidirectional relationship between GDP per capita and employment corroborates the evidence reported by Huseynli (2022) and Aliyev et al. (2024) regarding the strong link between economic growth and labour market dynamics in Azerbaijan and comparable contexts. Furthermore, the unidirectional impact of CO_2 emissions on employment that we have detected is in line with the conclusions of Doksanyedi and Meçik (2024), Musayev (2024) and Suleymanov et al. (2024), who also emphasize the employment effects of carbon-intensive activities. By comparing our results with these studies, we confirm that our contribution lies in providing the first time-series evidence for Azerbaijan using the Toda–Yamamoto approach, thus extending the existing literature on green economy and employment

The analysis findings, when compared to existing literature, clearly indicate that similar conclusions have been reached regarding the relationship between carbon emissions and employment. This consistency with previous studies underscores the significant impact that strategies and regulations aimed at reducing carbon emissions have on labor markets. Cheng et al. (2024) conducted a comprehensive study on the effects of the Paris Agreement on corporate employment in China. Their findings show a notable increase in employment levels among businesses, especially those in carbon-intensive industries that are exposed to higher risks from emission regulations. This suggests that emission regulations may prompt companies to expand their workforce, likely due to increased compliance requirements or restructuring within carbon-intensive industries. Additionally, this demonstrates that carbon reduction policies not only have environmental implications but also play a crucial role in shaping labor market dynamics.

Graham and Knittel (2024) introduce the concept of the "employment carbon footprint" to evaluate the impact of the energy transition on jobs in the United States. This concept enhances our understanding of the structural changes in the labor market triggered by energy transition activities. Their research shows that certain regions are more adversely affected by this transition, potentially leading to disparities in regional labor markets. Given these findings, the authors stress the importance of implementing just transition policies. They advocate for strategies that protect jobs and mitigate the social consequences of moving from fossil fuel-dependent industries to renewable energy sectors. The research indicates a consistent correlation between carbon emissions and employment across various contexts, highlighting the need for informed decision-making by policymakers and industry leaders. Specifically, companies operating in carbon-intensive industries must adapt their hiring practices to comply with environmental regulations. Furthermore, since the effects of the energy transition can vary significantly by region, it is essential to develop and implement effective just transition policies to ensure a fair and inclusive transformation of the labor market.

5. CONCLUSION

This research paper offers important insights into the complex interactions among economic growth, carbon emissions, and job creation, specifically focusing on Azerbaijan's transition to a green economy. The findings indicate a strong bidirectional causal relationship between GDP per capita and employment, highlighting the critical role that economic growth plays in expanding the labor market. Furthermore, there is a unidirectional impact of CO2 emissions on employment, emphasizing the need for sustainable development strategies to address the environmental challenges linked to Azerbaijan's economic progress. As Azerbaijan advances toward a greener economy, it is crucial to implement policies that strike a balance between economic growth and environmental responsibility. Key strategies should include the integration of renewable energy sources, the expansion of green industries, and the promotion of energy-efficient technologies. These actions are essential for reducing carbon emissions while simultaneously supporting stable job growth. Additionally, investing in green skills and workforce training will be vital in preparing the labor market for the structural changes that accompany sustainable economic policies. The conclusions of the research paper are in line with global trends and illustrate the extensive impact of the transition to a green economy on long-term prosperity. Azerbaijan's commitment to sustainability, particularly in the context of COP29 and its national development strategy, presents a significant opportunity for the country to assume a leadership role in the region. By fostering innovation, promoting green entrepreneurship, and strengthening regulatory frameworks, Azerbaijan can position itself as a leading example of sustainable economic growth. Ultimately, the shift to a green economy is not merely an environmental necessity but also an economic imperative. By adopting a forward-thinking approach that prioritizes sustainability, Azerbaijan can secure a resilient, competitive, and inclusive economic future that will benefit both its workforce and the environment for generations to come.

6. LIMITATIONS AND FUTURE RESEARCH

One major limitation of this study is the use of aggregated national-level data. While this allows us to capture overall trends between CO_2 emissions, GDP per capita, and employment, it does not enable us to distinguish whether changes in employment are driven by the expansion of green sectors or by carbon-intensive “dirty” industries. Future research could overcome this limitation by incorporating sectoral or firm-level employment data, which would allow for a more accurate identification of the sources of employment growth.

Furthemore, it may be possible in future studies to gather more comprehensive and systematic data over a longer period on green economy indicators, such as renewable energy production, carbon emission reduction measures, and ecological investments, along with employment indicators.

Researchers in this field are particularly encouraged to take these methodological and empirical priorities into account in their future research.

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Dr. sc. Latif Zeynalli
Voditelj odjela / Izvanredni profesor
Centar za analizu ekonomskih reformi i komunikacije (CAERC), Baku, Azerbajdžan
Azerbajdžansko državno sveučilište za naftu i industriju, Baku, Azerbajdžan
E-mail: latif.zeynalli@gmail.com
Orcid: https://orcid.org/0000-0001-5887-7946

Dr. sc. Ramil Huseyn
Izvanredni profesor
Azerbajdžansko državno ekonomsko sveučilište (UNEC), Baku, Azerbajdžan
E-mail: ramilzhuseyn@gmail.com
Orcid: https://orcid.org/0000-0001-6689-3823

Dr. sc. Agil Asadov
Voditelj odjela
Centar za analizu ekonomskih reformi i komunikacije (CAERC), Baku, Azerbajdžan
E-mail: aqil.asadov@ereforms.gov.az
Orcid: https://orcid.org/0000-0002-8020-8922

Dr. sc. Abdulrahim Dadashov
Zamjenik voditelja odjela
Centar za analizu ekonomskih reformi i komunikacije (CAERC), Baku, Azerbajdžan
E-mail: abdulrahim.dadashov@ereforms.gov.az
Orcid: https://orcid.org/0000-0002-3174-6521

ISTRAŽIVANJE POVEZANOSTI IZMEĐU EMISIJA, GOSPODARSKOG RASTA I ZAPOSLENOSTI: DOKAZI IZ AZERBAJDŽANA

Sažetak

Ovaj rad istražuje dinamički odnos između zelenoga gospodarstva Azerbajdžana i zaposlenosti analizirajući BDP po glavi stanovnika, emisije CO_2 i stope zaposlenosti primjenom Toda-Yamamotove metode kauzalnosti na godišnjim podacima od 1990. do 2023. godine. Empirijski rezultati otkrivaju dva ključna nalaza: (1) statistički značajnu dvosmjernu kauzalnost između stope zaposlenosti i BDP-a po stanovniku, što ukazuje na uzajamni utjecaj gospodarskog rasta i učinka tržišta rada; (2) statistički značajnu jednosmjernu kauzalnost između emisija CO_2 po stanovniku i zaposlenosti na razini značajnosti od 1%, što naglašava ulogu okolišnih čimbenika u oblikovanju dinamike zaposlenosti. Naši nalazi otkrivaju jednosmjerni pozitivan odnos između emisija CO_2 i zaposlenosti, što sugerira da su povećane emisije povezane s rastućom razinom zaposlenosti. Doprinos ovog rada jest pružanje prvih vremenskih serija dokaza iz Azerbajdžana o uzročno-

posljedičnim vezama između emisija CO_2, BDP-a po glavi stanovnika i zaposlenosti koristeći se Toda-Yamamotovim pristupom.

Ključne riječi: Azerbajdžan, zeleno gospodarstvo, zapošljavanje, gospodarski rast, Toda-Yamamotov test uzročnosti.

JEL klasifikacija: C19, C32, C53, O44, Q54, Q56.