23

Presentation date: January, 2024
Date of acceptance: April , 2024
Publication date: May, 2024

ASSESSMENT OF THE IMPACT OF CONSUMER PRICE INDEX AND RENEWABLE ENERGY CONSUMPTION ON CO2 EMISSIONS IN AZERBAIJAN

EVALUACIÓN DEL IMPACTO DEL ÍNDICE DE PRECIOS AL CONSUMIDOR Y EL CONSUMO DE ENERGÍA RENOVABLE EN LAS EMISIONES DE CO2 EN AZERBAIYÁN

Lachin Vazir Abishli [1*]
E-mail: abishli@bsu.edu.az
ORCID: https://orcid.org/0000-0001-8597-0185
Ikram Ismayil Cebrayilov [1]
E-mail: ikramjabrailov@bsu.edu.az
ORCID: https://orcid.org/0009-0007-9971-0406
Galib Nizami Gafarli [2]
E-mail: qalibqafarli@bsu.edu.az
ORCID: https://orcid.org/0000-0002-2292-2896
Elmar Rahib Dadashov[1]
E-mail: elmardadashov@bsu.edu.az
ORCID: https://orcid.org/0000-0002-3316-332X
Author for correspondence: abishli@bsu.edu.az
[1] Baku State University, Azerbaijan.
[2] Baku State University, Azerbaijan State Agricultural University. Azerbaijan.

Suggested citation (APA, seventh ed.)

Abishli, L. V., Cebrayilov, I. I., Gafarli, G. N., & Dadashov, E. R. (2024). Assessment of the impact of consumer price index and renewable energy consumption on CO2 emissions in Azerbaijan. Universidad y Sociedad, 16(3), 219-231.

ABSTRACT

This study investigates the correlation between carbon dioxide (CO2) emissions, renewable energy consumption (REC), and the consumer price index (CPI) in Azerbaijan between 1995 and 2019. The research employs measurements of CO2 emissions in kilotons, renewable energy consumption as a proportion of total energy consumption, and the consumer price index using real values as of 2010. Various analytical techniques such as Johansen, DOLS, FMOLS, and CCR were applied to analyze the time series data. Additionally, the Granger causality test was employed to establish the causal relationship between the variables. The findings of the empirical analysis indicate that a 1% increase in CPI is associated with an average CO2 increase of 0.14%, whereas a 1% increase in REC is linked to an average CO2 decrease of 0.06%. The research suggests that improving state policies to promote alternative energy sources for energy consumption in Azerbaijan is necessary.

Keywords: Consumer price index, Renewable energy, CO2 emissions, Environmental Kuznets curve, Cointegration.

RESUMEN

Este estudio investiga la correlación entre las emisiones de dióxido de carbono (CO2), el consumo de energía renovable (REC) y el índice de precios al consumidor (IPC) en Azerbaiyán entre 1995 y 2019. La investigación emplea mediciones de las emisiones de CO2 en kilotones, el consumo de energía renovable como proporción del consumo total de energía y el índice de precios al consumidor utilizando valores reales a partir de 2010. Se aplicaron diversas técnicas analíticas como Johansen, DOLS, FMOLS y CCR para analizar los datos de series de tiempo. Además, se empleó la prueba de causalidad de Granger para establecer la relación causal entre las variables. Los hallazgos del análisis empírico indican que un aumento del 1% en el IPC está asociado con un aumento promedio de CO2 del 0,14%, mientras que un aumento del 1% en REC está relacionado con una disminución promedio de CO2 del 0,06%. La investigación sugiere que es necesario mejorar las políticas estatales para promover fuentes de energía alternativas para el consumo de energía en Azerbaiyán.

Palabras clave: Índice de precios al consumo, Energías renovables, Emisiones de CO2, Curva de Kuznets ambiental, Cointegración.

INTRODUCTION

Since the Industrial Revolution, we have witnessed various ecological threats such as global warming, climate change, deforestation, drought, and water scarcity. Industrialization has contributed to environmental pollution along with economic growth. Mechanization has increased the production levels of countries, but it has also increased the levels of greenhouse gas (GHG) emissions and ecological footprints, leading to water pollution, water scarcity, and other negative impacts (Özcan & Öztürk, 2019). Human activities such as burning fossil fuels, emitting excessive smoke from factories, and deforestation contribute to the increase in GHG emissions, mainly carbon dioxide (CO2) concentration (Danish et al., 2017). Therefore, clean energy is the key to combating climate change since energy production accounts for the majority of GHG emissions (Özcan & Öztürk, 2019).

Understanding the causes of global invasion and climate change, which pose threats to all living organisms in recent times, is a crucial concern. Among these factors, the connection between economic growth and environmental pollution stands out as a highly debated subject in economic literature. The Kuznets curve hypothesis is one of the prominent theories that explores this relationship. According to this theory, there exists a reverse-U-shaped association between income growth and environmental degradation. It suggests that initially, as economic growth progresses, environmental pollution also increases. However, beyond a certain turning point, economic growth starts to mitigate environmental pollution (Dinda, 2004).

The Kuznets hypothesis presents a persuasive argument that aligns with fundamental principles governing various phenomena. Specifically, it resonates with the principle of transitioning from quantitative changes to qualitative changes, which is a fundamental concept in dialectical change. This principle is one of the three guiding principles that explain societal transformations (Kolb, 2005). In this context, the hypothesis asserts that as the per capita amount of chemistry surpasses a certain threshold, a qualitative shift occurs, resulting in a reduction of environmental harm. Thus, the hypothesis not only convinces but also conforms to these overarching principles.

By regarding the Consumer Price Index (CPI) as a metric that captures economic dynamics, we can enhance our understanding by incorporating the impact of quality change, represented by technological innovation, as well as the environmental consequences stemming from the utilization of alternative energy sources, specifically the emission of carbon dioxide (CO2). This integration allows for the formulation of a novel interconnected framework comprising these indicators. The expansion of macroeconomic indicators is a fundamental feature of economic advancement (Ullah & Rauf, 2013). Nonetheless, the growth of economic indicators may not necessarily indicate sustainable economic development. If economic growth is achieved through environmentally harmful practices, it may necessitate significant future expenditures or potentially unattainable remediation efforts to mitigate the resultant environmental damage.

Primarily, conventional economic growth metrics such as GDP are imperfect gauges of economic and human well-being since they encompass goods and services that have negative impacts on individuals and society (e.g., environmental remediation, law enforcement, and cancer treatment) and do not consider valuable goods and services that lack market trade but are of significant importance (e.g., household services, ecosystem services, bartering, and sharing). Additionally, correlation does not guarantee causation; some of the benefits in well-being may arise from technological advancements and policies instead of economic growth. Furthermore, economic growth can occur with negligible or no net benefits to laborers or communities. For instance, wages and benefits may be inadequate to fulfill workers' fundamental necessities, and projects that generate economic growth may lead to detrimental consequences for communities (Hammer & Pivo, 2017). Therefore, employing indicators that portray changes in people's well-being and the environment when analyzing and devising economic policies is appropriate.

It is of utmost significance to enforce a policy aimed at augmenting the adoption of renewable energy sources, implementing this policy in the existing economic circumstances, and assessing its effect on carbon dioxide emissions, which are the most frequently emitted gases into the atmosphere by power plants. Resolving worldwide issues triggered by population growth, surging CO2 emissions, and climate change is reliant on the reforms that nations will introduce in their economic policies. Then, our research endeavors to investigate the co-integration relationship between the influence of heightening the usage of renewable energy sources on CO2 emissions and the perceived tendency in the Consumer Price Index (CPI). Through a series of consecutive government policies, Azerbaijan has witnessed an increase in its forest area from 11.6% to 13.6% between 1995 and 2019. This systematic approach, driven by the goal of reducing CO2 emissions and enhancing the ecological environment, forms part of a comprehensive plan of action.

Furthermore, the country has placed significant emphasis on expanding the utilization of alternative energy sources, leading to notable advancements in recent years. For instance, the production of energy from renewable sources such as wind and solar has surged by 25 times between 2014 and 2021 (AR State Statistical Committee, 2021). It is worth noting that the share of energy generated from renewable sources in overall energy production stands at 5.8%. While the current contribution of renewable energy to the total energy output may not be ideal, Azerbaijan possesses substantial potential for viable and economically feasible renewable energy sources. In this context, the estimated potential of renewable energy sources in Azerbaijan amounts to 26,940 MWh, including 3,000 MWh for wind energy, 23,040 MWh for solar energy, 380 MWh for bioenergy, and 520 MWh for mountain river potential (Azerbaijan Renewable Energy Agency, 2022). The presence of such renewable energy potential in Azerbaijan, coupled with the implementation of state policies in this domain, underlines the importance of examining the relationship between CO2 emissions and renewable energy consumption within the Azerbaijani context. Considering the above, the research also aims to assess the necessity for improvement in the country's economic policy based on the identified relationships among the variables included in the model. Furthermore, it seeks to evaluate the significance of the correlation findings from an economic theory perspective.

MATERIALS AND METHODS

The rise in CO2 emissions is closely linked to the increase in greenhouse gas emissions from fossil fuels, with approximately 74% of these emissions being CO2 (Climate Watch, 2019). The concentration of atmospheric CO2 has been rapidly rising since the late 19th century, primarily due to the extensive utilization of fossil fuels following the Industrial Revolution. Notably, the energy, transportation, and industry sectors are the key contributors to fossil fuel consumption. In 2010, these sectors accounted for two-thirds of global carbon dioxide emissions (Le Quéré et al., 2012). Conversely, variations in the consumer price index are influenced by the prevailing conditions in the energy, transportation, and industry sectors. Consequently, one of the main objectives of this research is to establish the relationships among CO2 emissions, the consumer price index, and the consumption of alternative energy sources.

Database

The study investigates the interplay among carbon dioxide emissions, renewable energy consumption, and the consumer price index in the Republic of Azerbaijan between 1995 and 2019. Carbon dioxide emissions were quantified in kilotons, renewable energy consumption was expressed as a percentage of total energy consumption, and the consumer price index was presented in real prices relative to the year 2010. All three annual indicators were derived from statistical data provided by the World Bank. The logarithms of carbon dioxide emissions and the consumer price index variables were utilized, while the renewable energy consumption percentage was included in the model as its original value. This is shown in equation (1) where the terms are: (ln_CO2) - CO2 emissions (kt); CPI (ln_CPI) - consumer price index (2010 = 100); REC - percentage of renewable energy consumption in total energy consumption and εt is an error term.

$$\ln(CO_{2t}) = \beta_0 + \beta_1 \ln(CPI_t) + \beta_2 REC_t + \varepsilon_t \quad (1)$$

Table 1 and Figure 1 show the descriptions and some descriptive statistics of the carbon dioxide emissions, renewable energy consumption, and consumer price index variables included in the model.

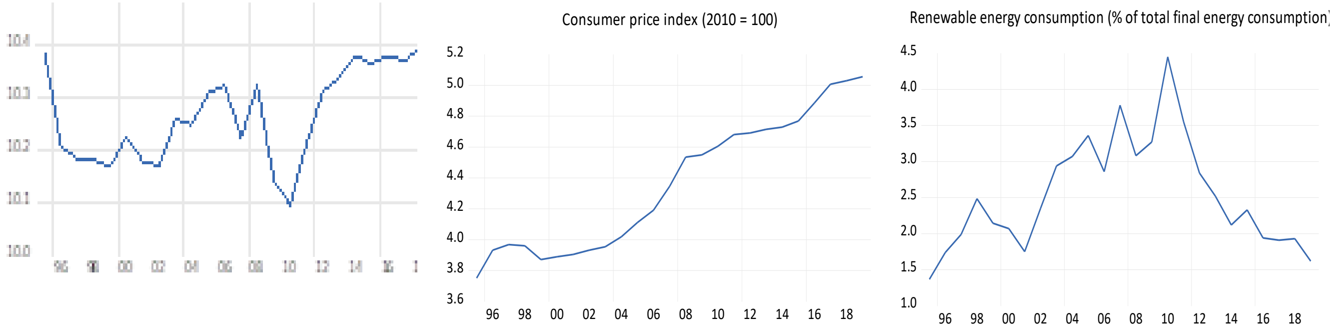
Table 1: Descriptive statistics.

	CO2	CPI	REC
Mean	10.27613	4.363281	2.538556
Median	10.26011	4.345644	2.350000
Maximum	10.47757	5.055555	4.450000
Minimum	10.09864	3.751379	1.366840
Std. Dev.	0.097424	0.432367	0.760867
Skewness	0.118366	0.168277	0.658348
Kurtosis	2.030880	1.517460	2.814616
Jarque-Bera	1.036704	2.407493	1.841727

Probability	0.595501	0.300068	0.398175
Sum	256.9034	109.0820	63.46391
Sum Sq. Dev.	0.227792	4.486583	13.89404
Observations	25	25	25

Source. Author's calculations.

Fig 1: Graphics of the variables.



Source: own elaboration.

Econometric Model and Methodology

In this study, the relationship between carbon dioxide emissions, renewable energy consumption, and the consumer price index was explored through various tests on time series data. To begin with, stationarity tests were conducted using different unit root tests. The results indicated that all three variables exhibit stationarity in their first differences. Since the stationarity levels of all variables were found to be equal, the Johansen test for cointegration was not employed. Subsequently, the Fully Modified Ordinary Least Squares Method (FMOLS), Dynamic Ordinary Least Squares Method (DOLS), and Canonical Cointegration Regression (CCR) tests were applied to determine the long-term impact of the independent variable on the dependent variable. Furthermore, Granger causality analysis was employed to investigate the causal relationship between the variables.

RESULTS AND DISCUSSION

Literature review

The initial observation of an inverted U-shaped association between indicators of environmental degradation and economic growth was made by Grossman and Krueger (1991). Subsequently, this relationship was coined the Environmental Kuznets Curve hypothesis by Panayotou (1993), which led to numerous studies on the subject in subsequent years. To minimize the loss of information caused by missing variables, various explanatory factors have been incorporated into the conducted research. These factors encompass a wide range of variables, including fossil fuel consumption, recovered energy consumption, trade openness, financial development, population density, tourism, globalization, democratization, education, urbanization, and industrialization, in addition to the income variable that varies over time (Efeoğlu, 2022).

conducted a study to examine the influence of industrialization, renewable energy, energy consumption, and financial development on CO2 emissions in E7 countries, considering the Environmental Kuznets Curve hypothesis, covering the period of 1989-2016. The research employed the panel data method and utilized a fixed effects model, which was evaluated using the Parks-Kmenta estimator. The findings of the study indicated that per capita GDP, industrialization, and energy consumption contributed to an increase in CO2 emissions in E7 countries. Conversely, the square of per capita GDP, renewable energy, and financial development were associated with a reduction in CO2 emissions. Based on these results, the study suggests that the Environmental Kuznets Curve hypothesis holds validity within this context. Other research conducted in this field and their results are provided in Table 2.

Table 2: Interesting research conducted about the topic.

Author	Country, period of research	Method	Results
(Sulaiman et al., 2013)	Malaysia / 1980-2009	ARDL	The production of electricity with renewable energy reduces CO2 emissions, and the Environmental Kuznets Curve hypothesis is reliable.
(Ben Jebli et al., 2015)	24 African countries from the Sahara to the south / 1980-2010	Panel cointegration, Granger causality	Renewable energy consumption does not have a significant impact on CO2 emissions and the Environmental Kuznets Curve hypothesis is not reliable.
(Tamazian et al., 2009)	BRIC/1992-2004	Panel data analysis	Financial development reduces CO2 emissions. Energy consumption increases CO2 emissions and the Environmental Kuznets Curve hypothesis is reliable.
(Shahbaz et al., 2013)	SAR / 1965-2008	ARDL	Financial development reduces CO2 emissions and the Environmental Kuznets Curve hypothesis is valid.
(Bhattacharya et al., 2017)	85 developed and developing countries. / 1991-2012	System GMM	While unrenewable energy consumption increases CO2 emissions, renewable energy consumption reduces CO2 emissions.
(Çağlar & Mert, 2017)	Turkey/1960-2013	Cointegration	Recovering energy consumption reduces CO2 emissions.
(Dogan & Ozturk, 2017)	USA/1980-2014	ARDL	An increase in renewable energy consumption reduces CO2 emissions, while an increase in non-renewable energy consumption increases CO2 emissions.
(Dong et al., 2017)	BRIC/1985-2016	Panel cointegration	Renewable energy consumption reduces CO2 emissions.
(Chen et al., 2019)	China/1980-2014	ARDL, Granger causality	While non-renewable energy consumption increases CO2 emissions, renewable energy consumption reduces CO2 emissions, and the Environmental Kuznets Curve (EKC) hypothesis is valid.
(Pata, 2018)	Turkey/1974-2014	ARDL	The impact of renewable energy consumption on CO2 emissions is insignificant.
(Sinha & Shahbaz, 2018)	India/1971-2015	ARDL	Renewable energy production reduces CO2 emissions
(Okumuş, 2019)	Turkey/1968-2014	ARDL	Non-renewable energy consumption increases CO2 emissions, while renewable energy consumption reduces CO2 emissions in the short term, and renewable energy consumption does not have a significant impact on CO2 emissions in the long term. The Environmental Kuznets Curve hypothesis is valid.

Source: own elaboration.

Econometric findings

This section presents the econometric findings obtained during the research, employing a three-stage analysis approach to assess the relationship between carbon dioxide emissions, renewable energy consumption, and the consumer price index. Initially, stationary tests were carried out using unit root tests to examine the stationarity properties of the variables. Subsequently, a cointegration test was conducted to explore the existence of a relationship and determine the long-term dependence coefficients among the variables. Finally, a causality analysis was performed to ascertain the direction of the causal relationship between these variables.

Unit root test results and ADF test

To assess the stationarity of the time series data, unit root tests are employed. Stationarity implies that the mean, variance, and covariance of a series remain constant over time. In this study, the Augmented Dickey-Fuller and Phillips-Perron tests were used to examine the stationarity of variables associated with carbon dioxide emissions, renewable energy consumption, and the consumer price index.

The Augmented Dickey-Fuller (ADF) unit root test examines whether a series possesses a unit root and is non-stationary, as indicated by the null hypothesis (H0). Conversely, the alternative hypothesis (H1) suggests that the series lacks a unit root and is stationary. Table 3 displays the results of the ADF test, revealing that the absolute value of the t-statistic for the level (I(0)) values of the time series is smaller than the critical value. Therefore, the null hypothesis cannot be rejected, indicating that the CO2, CPI, and REC series are non-stationary at a 5% significance level. Consequently, the aforementioned tests were re-applied to the time series after taking their first differences. The subsequent application of the ADF test on the first-differenced series demonstrates that the absolute value of the t-statistic surpasses the critical value. Hence, the null hypothesis is rejected, and the alternative hypothesis is accepted. Consequently, the CO2, CPI, and REC series are deemed stationary at a 5% significance level when considering their first differences.

Table 3: Results of the "Augmented Dickey-Fuller" stationary test.

Variables	T-stat	critical value			Prob.
		1%	5%	10%	
CO2	0.224369	-2.66485	-1.95568	-1.60879	0.7428
∆ CO2	-5.56489	-3.75295	-2.99806	-2.63875	0.0002
CPI	-3.40073	-4.41635	-3.62203	-3.24859	0.0759
∆ CPI	-2.8737	-2.66936	-1.95641	-1.6085	0.0061
REC	-0.40746	-2.66485	-1.95568	-1.60879	0.5259
∆ REC	-5.53965	-2.66936	-1.95641	-1.6085	0.0000

Source: Author's calculations.

Phillips-Perron unit root test results

According to the Phillips-Perron unit root test, the null hypothesis (H0) suggests that the series includes a unit root and is non-stationary. Conversely, the alternative hypothesis (H1) indicates that the series lacks a unit root and is therefore stationary. Table 4 presents the results of the Phillips-Perron test, indicating that for the level (I(0)) values of the time series, the absolute value of the adjusted t-statistic is lower than the critical value. Consequently, the null hypothesis cannot be rejected, affirming that the CO2, CPI, and REC series are non-stationary at a 5% significance level. In light of this, the time series were differenced once, and the aforementioned tests were subsequently conducted. By examining the results of the Phillips-Perron test applied to the differenced series, it is evident that the absolute value of the adjusted t-statistic exceeds the critical value. Hence, the null hypothesis is rejected, and the alternative hypothesis is accepted, signifying that the CO2, CPI, and REC series are stationary at a 5% significance level after undergoing one differencing operation (I(1)).

Table 4: "Phillips-Perron" stationarity test results.

Variables	T-stat	critical value			Prob.
		1%	5%	10%	
CO2	-1.7713	-3.73785	-2.99188	-2.63554	0.3848
∆ CO2	-5.83728	-4.41635	-3.62203	-3.24859	0.0005
CPI	-1.70137	-4.39431	-3.6122	-3.24308	0.7191
∆ CPI	-3.58432	-3.75295	-2.99806	-2.63875	0.0145
REC	-1.48803	-4.39431	-3.6122	-3.24308	0.8054
∆ REC	-5.44762	-3.75295	-2.99806	-2.63875	0.0002

Source: Author's calculations.

After conducting the ADF and Phillips-Perron unit root tests, it can be inferred that the time series data in their original level values are non-stationary, indicating the presence of unit roots. As a result, each series was subjected to first differencing. The unit root tests performed on the differenced data revealed that the variables became stationary in their first difference. In the subsequent stage, an optimal lag length will be determined by constructing a Vector Autoregression Model (VAR), which will be followed by applying the Johansen Cointegration Test.

VAR Model

To conduct the cointegration test on the variables, a VAR model will be constructed using the level values (I(0)) of the variables, and the suitable lag order will be determined. The VAR model, originally proposed by Sims, eliminates the distinction between endogenous and exogenous variables and enhances predictive accuracy by incorporating lagged values of explanatory variables. Concerning the Yt and Xt series, the VAR model is formulated as shown in equations (2) and (3).

$$Y_t = \alpha + \sum_{j=1}^{m} \beta_j Y_{t-j} + \sum_{j=1}^{m} \delta_j X_{t-j} + \varepsilon_{1t} \quad (2)$$

$$X_t = \alpha + \sum_{j=1}^{m} \theta_j Y_{t-j} + \sum_{j=1}^{m} \vartheta_j X_{t-j} + \varepsilon_{2t} \quad (3)$$

After introducing the model, we can determine the optimal lag length. Here, ğ1t and ğ2t are errors, and m represents the optimal lag length. Lagged values of Y affect the X variable, and lagged values of X affect the Y variable. Results are shown in Table 5.

Table 5: Determining the optimal lag length.

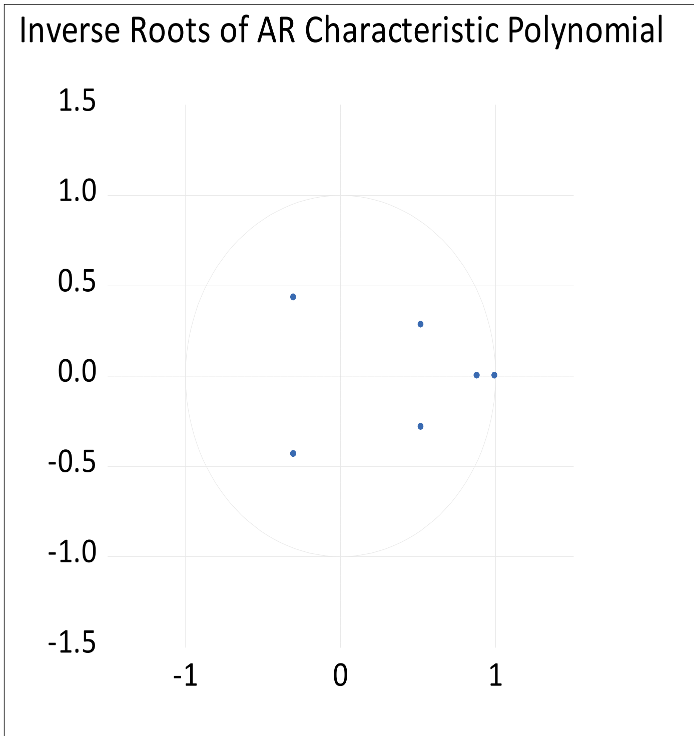
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4.679651	NA	0.000391	0.667796	0.815904	0.705044
1	59.75084	106.4504*	3.19E-06	-4.152247	-3.559815*	-4.003252
2	71.72647	16.66174	2.59e-06*	-4.410997*	-3.374241	-4.150256*

Source: Author's calculations.

As indicated in Table 5, both the modified (LR) Lagrange multiplier test and the Schwartz information criterion (SC) indicate an optimal lag length of 1. On the other hand, the final prediction error (FPE), Akaike Information Criterion (AIC), and Hannan-Quinn information criterion (HQ) suggest an optimal lag length of 2. However, when the lag length of 1 was chosen, issues such as variable variance and non-normal distribution were observed in the model residuals. Therefore, considering the FPE, AIC, and HQ criteria, the optimal lag length was determined as 2. Following this, tests for stability, autocorrelation, heteroskedasticity, and normality were conducted on the model.

To guarantee the stability of the VAR model, the autoregressive (AR) roots must be smaller than 1. As illustrated in Figure 2, it has been observed that all the inverse roots lie within the unit circle. This indicates that the VAR model satisfies the stability criterion.

Fig 2: Stability plot of the VAR model.



Root
Modulus

0.997266
0.997266

0.881534
0.881534

0.521758 - 0.282664i
0.593406

0.521758 + 0.282664i
0.593406

-0.301889 - 0.434296i
0.528914

-0.301889 + 0.434296i
0.528914

No root lies outside the unit circle.

VAR satisfies the stability condition.

Source: Author's calculations.

The Lagrange Multipliers (LM) test was performed to examine the presence of autocorrelation among the residuals of the estimated VAR model. As presented in Table 6, for lag orders up to three, the null hypothesis (H0) of no autocorrelation could not be rejected at the significance levels of 1%, 5%, and 10%. This suggests that there is no evidence of autocorrelation among the residuals.

Table 6: Results of Autocorrelation LM test.

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	7.397749	9	0.5958	0.823474	(9, 26.9)	0.6002
2	13.18266	9	0.1545	1.622441	(9, 26.9)	0.1589
3	6.565778	9	0.6822	0.720562	(9, 26.9)	0.6860

Source: Author's calculations.

Based on the findings presented in Table 7, the null hypothesis, which suggests that the residuals of the model have constant variance (homoscedasticity), cannot be rejected. This indicates that there are no issues with varying variances in the model.

Table 7: Heteroskedasticity (varying variance) test.

Joint test:		
Chi-sq	df	Prob.
73.42771	72	0.4311

Source: Author's calculations.

Based on the results provided in Table 8, the Jarque-Bera test statistic value for the VAR model is computed as 1.409247 (p=0.9653). Since the p-value is greater than 0.05, it can be concluded that the residuals of the model are considered to follow a normal distribution.

Table 8: Jarque-Bera normality test.

Component	Jarque-Bera	df	Prob.
1	0.630045	2	0.7298
2	0.188097	2	0.9102
3	0.591104	2	0.7441
Joint	1.409247	6	0.9653

Source: Author's calculations.

Johansen cointegration test

After performing unit root tests on the variables of carbon dioxide emissions, renewable energy consumption, and the price index in Azerbaijan from 1995 to 2019, it was found that these variables are integrated in the first order (I(1)), indicating they are non-stationary. To explore the long-term relationship between the series, the Johansen cointegration analysis, which can be applied to multiple series over time and is also integrated in the same order, was conducted. The outcome of the Johansen cointegration test is presented in Table 9.

Table 9: Johansen cointegration test.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**	Max-Eigen Statistic	0.05 Critical Value	Prob.**
r = 0	0.735304	51.03728	35.0109	0.0005	29.24183	24.25202	0.0101
r ≤ 1	0.580351	21.79544	18.39771	0.0161	19.10342	17.14769	0.0257
r ≤ 2	0.115174	2.69202	3.841465	0.1008	2.69202	3.841465	0.1008
Trace test indicates 2 cointegrating equation(s) at the 0.05 level Max-eigenvalue test indicates 2 cointegrating equation(s) at the 0.05 level							

Source: Author's calculations.

The results of the Johansen cointegration test indicate that the null hypotheses of no cointegration for r=0, r≤1, and r≤2 can be rejected. This suggests the presence of one or two cointegration relationships among the variables. Upon examining Table 9, it can be observed that the null hypothesis H0 is rejected, as the trace statistic values for r=0 and r≤1 exceed the critical values, and the maximum eigenvalue statistics also surpass the critical values. Hence, the cointegration test results demonstrate the existence of two cointegration relationships among the variables, implying the presence of long-term equilibrium relationships between them.

Analysis of long-term forecast results using FMOLS, DOLS, and CCR methods

After obtaining the results of the cointegration test, several methods were employed in the research to assess the long-term impact of the independent variables on the dependent variable. The Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), and Canonical Cointegration Regression (CCR) methods were utilized for these analyses.

The coefficients of the long-term trend, as hypothesized, exhibit positive values for the CPI variable and negative values for the REC variable, as presented in Table 10. It is worth noting that, except for the CPI coefficient obtained using the DOLS method, all the results are statistically significant. From the analysis, we can infer that holding other variables constant, the impacts of energy consumption and the price index on carbon dioxide emissions are as follows:

- A 1% increase in CPI can increase CO2 emissions by an average of 0.1377-0.14728%.
- A 1% increase in REC can decrease CO2 emissions by an average of 0.05138-0.06973%.

Table 10: Results of the estimation of the long-term relationship.

	FMOLS		DOLS		CCR	
Variable	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**	**Coefficient**	**Prob.**
CPI	0.14728	0.0023*	0.083963	0.1754	0.1377	0.0045*
REC	-0.05138	0.0468**	-0.06973	0.0313**	-0.05213	0.0507***
Note: The dependent variable is CO2. *, **, and *** indicate that the null hypothesis is rejected at the 1%, 5%, and 10% significance level, respectively.						

Source: Author's calculations.

Granger causality test

The Granger causality analysis is employed to identify the causal relationship between variables. This test helps determine whether there is a relationship between variables and, if so, the direction of causality. The findings of the Granger causality test performed in the study are outlined in Table 11, showcasing the results.

Table 11: Granger causality test.

Dependent variable: CO_2

Excluded	Chi-sq	df	Prob.
CPI	5.798764	2	0.0551
REC	4.144235	2	0.1259
All	9.110051	4	0.0584

Dependent variable: REC

Excluded	Chi-sq	df	Prob.
CO_2	5.698667	2	0.0579
CPI	2.711451	2	0.2578
All	8.384054	4	0.0785

Source: Author's calculations.

Based on the results presented in Table 11, it can be observed that the Consumer Price Index (CPI) is identified as a causal factor for carbon dioxide emissions at a significance level of 10% (p=0.0551<0.10). However, renewable energy consumption is not found to be a causal factor for carbon dioxide emissions (p=0.1259). Furthermore, carbon dioxide emissions are found to be a causal factor for the Consumer Price Index at a significance level of 1% (p=0.0027<0.01), while renewable energy consumption is identified as a causal factor for the Consumer Price Index at a significance level of 1% (p=0.0020<0.01). Additionally, carbon dioxide emissions are considered a causal factor for renewable energy consumption at a significance level of 10% (p=0.0579<0.10), whereas the Consumer Price Index is not found to be a causal factor for renewable energy consumption (p=0.2578). A comprehensive summary of all the results is provided in Table 12.

Table 12: Generalized result of the Granger causality test.

CO2	→	REC
CO2	↔	CPI
REC	→	CPI

Source: Author's calculations.

CONCLUSIONS

In this study, the Johansen cointegration test was utilized to examine the effects of renewable energy consumption and the consumer price index on CO2 emissions in Azerbaijan. The test indicated the existence of long-term equilibrium relationships among the variables. Following this, the impacts of renewable energy consumption and the consumer price index on CO2 emissions were analyzed using the FMOLS, DOLS, and CCR cointegration estimation methods. The findings consistently demonstrated that renewable energy consumption harmed CO2 emissions, while the consumer price index had a positive effect.

Moreover, the research uncovered that a 1% increase in renewable energy consumption would lead to an approximate reduction of 0.06% in CO2 emissions. This implies that augmenting renewable energy consumption is of utmost significance in ensuring environmental cleanliness. Consequently, there is a dire need to enhance the government's policy aimed at diversifying energy production in Azerbaijan. Particularly, given the surging energy demand triggered by population growth and economic activities, meeting energy needs through clean, renewable sources rather than conventional means is imperative. It is worth noting that Okumuş (2019) also observed comparable results concerning CO2 emissions and renewable energy consumption in their study, where they proposed an expansion in the use of renewable energy sources as an environmentally friendly policy measure by the government.

Our empirical analysis has revealed that a 1% increase in the consumer price index is associated with an estimated 0.14% increase in CO2 emissions. This finding aligns with the study conducted by Musarat et al., (2021), which investigated the correlation between inflation rates, construction costs, and the value of construction work, along with the identification of interest rate differentials. The study observed a positive relationship among these variables, indicating that a decrease in inflation rates leads to lower material prices and subsequently stimulates increased construction work. Consequently, an increase in construction work directly contributes to higher CO2 emissions. Although the results obtained in the specific context of the construction industry may not directly apply to our research, which is based on the Consumer Price Index encompassing a broader range of goods and services, we can deduce that our study provides more comprehensive insights.

As is known in economic theory, normal inflation stimulates the use of medium- and long-term credit, which in turn promotes economic growth. This is because mild inflation can help promote expenditure and investment, as well as promote price stability and avoid the harmful effects of deflation, thereby stimulating economic growth. In summary, we can consider the results we have obtained to be relevant for normal inflation levels. In other words, under normal inflation conditions, a 1% increase in the inflation rate is associated with a positive impact on economic growth, potentially leading to an estimated 0.14% increase in CO2 emissions.

Considering the above, we believe that the implementation of the following measures can support the government's policy in this area:

Formulate support programs that promote the adoption of renewable energy. Such initiatives will contribute to the reduction of CO2 emissions and facilitate the growth of clean energy consumption.

Take immediate action to implement international standards aimed at reducing reliance on fossil fuels. This will result in a decrease in CO2 emissions and a greater utilization of alternative energy sources.

Develop incentive programs that incentivize both organizations and individuals to decrease their CO2 emissions. This will result in a decrease in overall CO2 emissions and an increase in the adoption of renewable energy sources.

Endorse scientific research and development initiatives associated with renewable energy implementation. Such endeavors are conducive to advancing renewable energy studies and innovative problem-solving approaches.

REFERENCES

AR State Statistical Committee. (2021). ***Production of electricity***. https://www.stat.gov.az/source/balance_fuel/

Azerbaijan Renewable Energy Agency. (2022). ***RE potential***. https://area.gov.az/az/page/yasil-texnologiyalar/boem-potensiali

Ben Jebli, M., Ben Youssef, S., & Ozturk, I. (2015). The Role of Renewable Energy Consumption and Trade: Environmental Kuznets Curve Analysis for Sub-Saharan Africa Countries. ***African Development Review***, ***27***(3), 288–300. https://doi.org/10.1111/1467-8268.12147

Bhattacharya, M., Awaworyi Churchill, S., & Paramati, S. R. (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. ***Renewable Energy***, ***111***, 157–167. https://doi.org/10.1016/j.renene.2017.03.102

Çağlar, A. E., & Mert, M. (2017). Environmental Kuznets hypothesis and the impact of renewable energy consumption on carbon emissions in Turkey: Structural break cointegration approach. ***Management and Economics***, ***24***(1), 21–38.

Chen, Y., Wang, Z., & Zhong, Z. (2019). CO2 emissions, economic growth, renewable and non-renewable energy production, and foreign trade in China. ***Renewable Energy***, ***131***, 208–216. https://doi.org/10.1016/j.renene.2018.07.047

Climate Watch. (2019). ***Greenhouse Gas (GHG) Emissions***. https://www.climatewatchdata.org/ghg-emissions?breakBy=gas&end_year=2019&gases=all-ghg&regions=WORLD&source=Climate%20Watch&start_year=1990

Danish, Zhang, B., Wang, B., & Wang, Z. (2017). Role of renewable energy and non-renewable energy consumption on EKC: Evidence from Pakistan. ***Journal of Cleaner Production***, ***156***, 855–864. https://doi.org/10.1016/j.jclepro.2017.03.203

Dinda, S. (2004). Environmental Kuznets Curve Hypothesis: A Survey. ***Ecological Economics***, ***49***(4), 431–455. https://doi.org/10.1016/j.ecolecon.2004.02.011

Dogan, E., & Ozturk, I. (2017). The influence of renewable and non-renewable energy consumption and real income on CO2 emissions in the USA: Evidence from structural break tests. ***Environmental Science and Pollution Research***, ***24***(11), 10846–10854. https://doi.org/10.1007/s11356-017-8786-y

Dong, K., Sun, R., & Hochman, G. (2017). Do natural gas and renewable energy consumption lead to less CO2 emission? Empirical evidence from a panel of BRICS countries. ***Energy***, ***141***, 1466–1478. https://doi.org/10.1016/j.energy.2017.11.092

Efeoğlu, R. (2022). Çevresel Kuznets Eğrisi Çerçevesinde Sanayileşme, Yenilenebilir Enerji, Enerji Tüketimi ve Finansal Gelişmenin CO2 Salınımı Üzerindeki Etkisi. ***Alanya Akademik Bakış***, ***6***(2). https://doi.org/10.29023/alanyaakademik.1010774

Grossman, G. M., & Krueger, A. B. (1991). ***Environmental Impacts of a North American Free Trade Agreement***. National Bureau of Economic Research. https://doi.org/10.3386/w3914

Hammer, J., & Pivo, G. (2017). The Triple Bottom Line and Sustainable Economic Development Theory and Practice. ***Economic Development Quarterly***, ***31***(1), 25–36. https://doi.org/10.1177/0891242416674808

Kolb, V. M. (2005). On the applicability of the principle of the quantity-to-quality transition to chemical evolution that led to life. ***International Journal of Astrobiology***, ***4***(3–4), 227–232. https://doi.org/10.1017/S1473550405002818

Le Quéré, C., Andres, R. J., Boden, T., Conway, T., Houghton, R. A., House, J. I., Marland, G., Peters, G. P., Van Der Werf, G., Ahlström, A., Andrew, R. M., Bopp, L., Canadell, J. G., Ciais, P., Doney, S. C., Enright, C., Friedlingstein, P., Huntingford, C., Jain, A. K., … Zeng, N. (2012). The global carbon budget 1959–2011. ***Earth System Science Data Discussions***, ***5***(2), 1107–1157. https://doi.org/10.5194/essdd-5-1107-2012

Musarat, M. A., Alaloul, W. S., Liew, M. S., Maqsoom, A., & Qureshi, A. H. (2021). The Effect of Inflation Rate on CO2 Emission: A Framework for Malaysian Construction Industry. ***Sustainability***, ***13***(3), Article 3. https://doi.org/10.3390/su13031562

Okumuş, İ. (2019). Türkiye'de Yenilenebilir Enerji Tüketimi, Tarım ve CO2 Emisyonu İlişkisi. ***Uluslararası Ekonomi ve Yenilik Dergisi***, ***6***(1), Article 1. https://doi.org/10.20979/ueyd.659092

Özcan, B., & Öztürk, I. (2019). Chapter 1—A Historical Perspective on Environmental Kuznets Curve. In B. Özcan & I. Öztürk (Eds.), ***Environmental Kuznets Curve (EKC)*** (pp. 1–7). Academic Press. https://doi.org/10.1016/B978-0-12-816797-7.00001-1

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. ***International Labour Office, Working Paper WP238***.

Pata, U. K. (2018). Renewable energy consumption, urbanization, financial development, income, and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks. ***Journal of Cleaner Production***, ***187***, 770–779. https://doi.org/10.1016/j.jclepro.2018.03.236

Shahbaz, M., Kumar Tiwari, A., & Nasir, M. (2013). The effects of financial development, economic growth, coal consumption, and trade openness on CO2 emissions in South Africa. ***Energy Policy***, ***61***, 1452–1459. https://doi.org/10.1016/j.enpol.2013.07.006

Sinha, A., & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. ***Renewable Energy***, ***119***, 703–711. https://doi.org/10.1016/j.renene.2017.12.058

Sulaiman, J., Azman, A., & Saboori, B. (2013). The Potential of Renewable Energy: Using the Environmental Kuznets Curve Model. ***American Journal of Environmental Sciences***, ***9***(2), 103–112. https://doi.org/10.3844/ajessp.2013.103.112

Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. ***Energy Policy***, ***37***(1), 246–253. https://doi.org/10.1016/j.enpol.2008.08.025

Ullah, F., & Rauf, A. (2013). Impacts of macroeconomic variables on economic growth: A panel data analysis of selected Asian countries. *International Journal of Information, Business and Management*, *5*(2), 4. https://www.academia.edu/download/58930861/UDRXwNaXmVPCgvI_120190417-81133-1nbl7ak.pdf