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HİSTORİCAL CHANGE OF PER CAPİTA CARBON DİOXİDE EMİSSİONS İN AZERBAİJAN

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ABSTRACT

This article provides detailed information on per capita CO2 emissions in Azerbaijan, the factors influencing these levels, and the strategies used to reduce emissions. The aim is to understand various approaches in combating climate change and identify the most effective solutions. Azerbaijan, located at the crossroads of Europe and Asia, has a diverse economy significantly impacted by its abundant oil and gas reserves. The extraction and export of these fossil fuels have been crucial for the country's economic growth. However, this reliance on fossil fuels also presents challenges in terms of CO2 emissions. As Azerbaijan continues to modernize and industrialize, monitoring and managing its per capita CO2 emissions becomes increasingly important. This study aims to provide a thorough analysis of per capita CO2 emissions in Azerbaijan. It will examine historical trends, current levels, and major emission sources. Examples include the rapid growth of the manufacturing industry following the discovery of oil on the Absheron Peninsula in the 1840s, the revolutions in Russia at the beginning of the last century, the crisis caused by the First World War, the rapid industrialization during and after the Second World War, the stagnation following the collapse of the Soviet Empire, and the recent pandemic. Additionally, it is appropriate to analyze this data by dividing it into several periods. For a more detailed analysis of these periods, quarterly data rather than annual data may be more effective.

1. INTRODUCTION

Per capita carbon dioxide emissions is a key indicator in modern ecological and climate change research. This metric reflects the annual CO2 emissions per inhabitant of a country or region, usually measured in tons. CO2 emissions primarily result from the burning of fossil fuels, industrial processes, and agricultural activities. Per capita CO2 emissions, resulting from the burning of fossil fuels, industrial processes, and agricultural activities, are a crucial indicator of a country's economic development, energy consumption patterns, and the lifestyle of its population. The amount of per capita CO2 emissions varies significantly from country to country. Industrialized and high-income countries generally have higher figures, as they consume more energy and have larger industrial activities. However, increasing CO2 emissions are also observed in developing countries, linked to their economic growth and industrialization. Various measures are being implemented globally to reduce per capita CO2 emissions. Expanding renewable energy sources, increasing energy efficiency, electrifying transportation, and deploying carbon capture and storage technologies are just a few of the steps being taken in this direction. International agreements and national policies also play a crucial role in combating climate change.

As the world confronts the urgent issue of climate change, it is essential to understand the patterns and disparities in carbon dioxide (CO_2) emissions. CO_2, a major greenhouse gas, significantly influences global warming and climate instability. While there has been substantial focus on overall national emissions and their role in climate change, examining emissions on a per capita basis offers a more detailed perspective. Analyzing CO_2 emissions per capita provides insights into the emission levels experienced by individuals in different countries, presenting a clearer understanding of each nation's relative contribution to global carbon output. This approach reveals differences between high-income and low-income countries and assesses the effectiveness of various national strategies and technological innovations aimed at reducing carbon footprints.

This article aims to investigate the trends and variations in per capita CO_2 emissions globally. By examining recent data and emerging trends, we seek to identify the factors influencing these variations, such as economic development, energy use, and policy measures. The paper will also explore the implications of these insights for global climate strategies and the development of fair solutions to the climate crisis.

Through an in-depth review of current data and an analysis of contributing factors, this study enhances our understanding of global CO_2 emission patterns and informs better decision-making in climate policy and sustainable development.

This article will provide extensive information on per capita CO2 emissions in Azerbaijan, the factors influencing these indicators, and the strategies employed to reduce emissions. The goal is to understand the different approaches in the fight against climate change and identify the most effective solutions.

2. LİTERATUR REVİEW FOR AZERBAİJAN PER CAPİTA CARBON DİOXİDE EMİSSİONS

The study of per capita CO2 emissions in Azerbaijan is enhanced by a wide range of scholarly research that explores different facets of economic growth, energy consumption, and environmental sustainability. This literature review consolidates key findings from relevant studies to offer a comprehensive understanding of the factors affecting CO2 emissions in Azerbaijan and the potential strategies for their reduction. Hodrick and Prescott's seminal work on business cycles, though not directly related to CO2 emissions, provides a foundational econometric approach that can be useful in analyzing economic fluctuations and their impact on environmental indicators (Hodrick & Prescott, 1997). Their methodology has been widely adopted and adapted in subsequent empirical research, including studies on environmental economics. Mikayilov, Galeotti, and Hasanov (2018) specifically address the relationship between economic growth and CO2 emissions in Azerbaijan. Their findings indicate that economic expansion, driven primarily by the oil and gas sector, has led to increased CO2 emissions. This study underscores the need for sustainable growth strategies that balance economic development with environmental preservation.

Gurbanov (2021) explores the role of natural gas consumption in reducing CO2 emissions. His research suggests that while natural gas is a cleaner alternative to other fossil fuels, its consumption alone is insufficient to achieve significant reductions in CO2 emissions. This highlights the necessity for a diversified energy portfolio that includes renewable energy sources. Huseynli (2024) investigates the relationship between CO2 emissions and research and development (R&D) activities in Azerbaijan. The study reveals that increased investment in R&D can lead to technological advancements that reduce CO2 emissions, emphasizing the importance of innovation and technological progress in environmental sustainability. Hasanov, Mukhtarov, and Suleymanov (2023) provide insights into the role of renewable energy and total factor productivity in reducing CO2 emissions. The study reveals that increased investment in R&D can drive technological advancements that reduce CO2 emissions, highlighting the critical role of innovation in achieving environmental sustainability. Hasanov, Mukhtarov, and Suleymanov (2023) offer insights into the role of renewable energy and total factor productivity in cutting CO2 emissions. Their research introduces a new theoretical framework combining these elements, showing that a shift towards renewable energy and productivity improvements can significantly lower CO2 emissions in Azerbaijan. Dilanchiev, Umair, and Haroon (2024) examine the causal relationship between renewable energy consumption, carbon emissions, and economic growth in the South Caucasus countries, including Azerbaijan. Their findings support the idea that adopting renewable energy can decouple economic growth from CO2 emissions, providing a sustainable development path. Mukhtarov et al. (2022) present evidence on the impact of renewable energy consumption on CO2 emissions in an oil-rich economy like Azerbaijan. Their study confirms that increasing the share of renewables in the energy mix can effectively reduce carbon emissions, reinforcing the advantages of transitioning to cleaner energy sources. Vidadili et al. (2017) discuss the shift to renewable energy and sustainable energy development in Azerbaijan. They argue that a comprehensive policy framework and substantial investments in renewable energy infrastructure are essential for achieving sustainable energy goals and reducing CO2 emissions. Brizga, Feng, and Hubacek (2013) conduct an IPAT (Impact, Population, Affluence, and Technology) analysis of CO2 emissions in the former Soviet Union, including Azerbaijan. Their study identifies key drivers of emissions and provides a comparative perspective on the region's environmental challenges and progress.

This review highlights the complex nature of CO2 emissions in Azerbaijan, shaped by economic activities, energy consumption patterns, and policy measures. The collective insights from these studies emphasize the critical need for integrated approaches that include economic, technological, and policy dimensions to effectively address CO2 emissions challenges and promote sustainable development.

3. THE AMOUNT OF CARBON DİOXİDE PER CAPİTA İN AZERBAİJAN

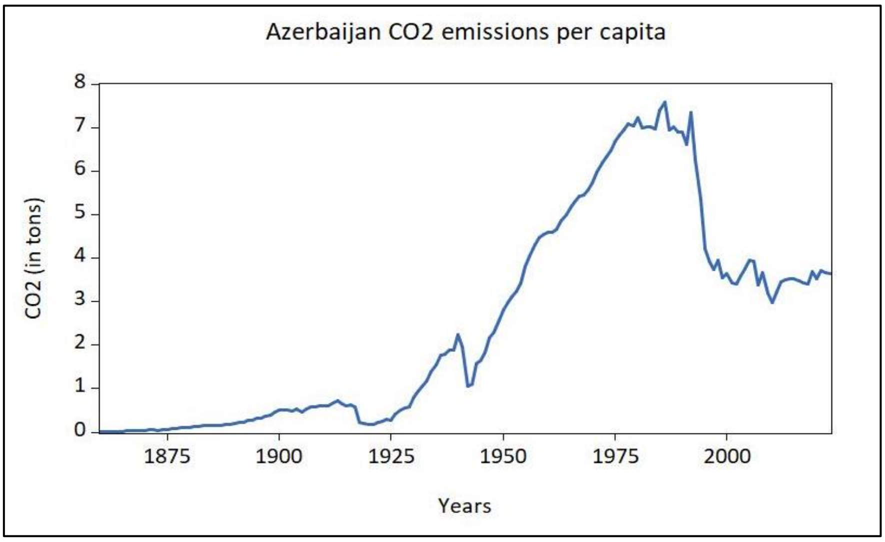
The amount of carbon dioxide (CO2) emissions per capita is a significant metric for assessing the environmental impact of a nation's activities, particularly in the context of climate change and sustainable development. The amount of carbon dioxide (CO2) emissions per capita is a significant metric for assessing the environmental impact of a nation's activities, especially in the context of climate change and sustainable development. In Azerbaijan, a country with a rapidly developing economy and a unique energy landscape, understanding per capita CO2 emissions is crucial for formulating effective environmental policies and strategies. Azerbaijan, located at the crossroads of Europe and Asia, has a diverse economy heavily influenced by its rich oil and gas reserves. The exploitation and export of these fossil fuels have been central to the country's economic growth. However, this dependence on fossil fuels also poses challenges in terms of CO2 emissions. As Azerbaijan continues to modernize and industrialize, monitoring and managing its per capita CO2 emissions becomes increasingly important.

It will explore the historical trends, current levels, and the primary sources of emissions. Additionally, the study will examine the impact of economic activities, energy consumption patterns, and population growth on CO_2 emissions. The findings will offer valuable insights into the effectiveness of existing environmental policies and highlight areas that require further attention and improvement. By understanding the dynamics of per capita CO_2 emissions in Azerbaijan, policymakers, researchers, and stakeholders can better address the challenges of reducing greenhouse gas emissions and advancing towards a more sustainable future. This article contributes to the broader discourse on climate change mitigation and sustainable development by providing a focused examination of Azerbaijan's CO_2 emissions per capita.

4. DATA AND EMPİRİCAL ANALYSİS CARBON DİOXİDE PER CAPİTA (TONS) İN AZERBAİJAN

Data: The amount of carbon dioxide per capita (tons) in Azerbaijan was included in this study for econometric analysis based on data from 1860 to 2023. First, let's analyze the trend graph of the carbon dioxide content over the years:

Figure 1. Azerbaijan carbon-dioxide emissions per capita, 1860-2023



As can be seen from the graph above, although there is an increasing trend every year since 1860, in general, the breaks in several places are drawing attention. The first of them covers the years 1914 and 1918. It is also clear from history that during those times, when Azerbaijan was under the occupation of the Russian Empire, it entered the First World War as part of the empire, although not itself. Also, the well-known revolution and events that engulfed the empire at that time lowered the industrial production that had been increasing in our country since the 1840s. Azerbaijan's declaration of independence in 1918 and fighting for this independence also caused this break. However, the occupation of Azerbaijan by the Soviet Empire in 1920 and the increase of industrialization in the subsequent periods led to an increase in CO_2 emissions again until 1940. Similarly, when looking at the graph, a small decrease is again accompanied by a decrease in industrial production in 1940 and 1944, when a workforce of 640,000 people was involved in World War II. After that, until the late 80s and early 90s, dramatic armor is the most prominent part of the chart. The emission, which was more than 7 tons at the beginning of the years of independence, decreased sharply until the early 2000s and continues with a stability between 3 and 4 tons until today.

The model and analysis: Initially, the database was checked for trend dependence and stationarity. According to the results of the Augmented Dickey-Fuller test (t_statistic = -0.897) even according to the 10% significance level, non-stationarity is not visible in the time series. Also, as can be seen from the equation below, there is no dependence on the trend and the 1st-order lag.

Null Hypothesis: AZ_CO2_PER_CAPITA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.897117	0.9529
Test critical values:	1% level	-4.015700	
	5% level	-3.437801	
	10% level	-3.143138	

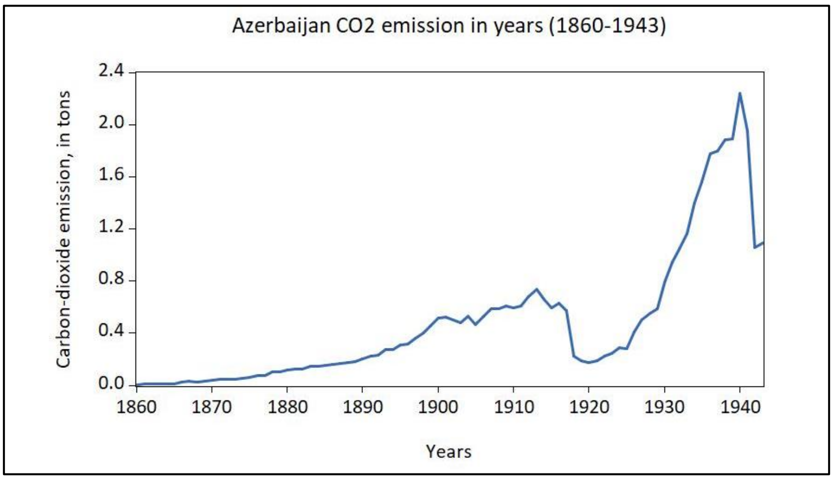
*MacKinnon (1996) one-sided p-values.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AZ_CO2_PER_CAPITA(-1)	-0.011099	0.012372	-0.897117	0.3710
D(AZ_CO2_PER_CAPITA(-1))	0.243425	0.077646	3.135045	0.0020
C	0.027930	0.038140	0.732297	0.4651
@TREND("1860")	0.000207	0.000638	0.323976	0.7464

Similarly, when the stationarity is checked by the Phillips-Perron stationarity test, it is also observed that there is no dependence on the trend and the first order lag in the time series. The KPSS test (Kwiatkowski-Phillips-Schmidt-Shin test statistic), which is different from the two tested tests, checks only the stationarity in the time series, and according to this test, non-stationarity is not visible in the data of carbon dioxide emission per capita even according to the 10% significance level.

Looking again at Figure 1, we see that there is a break between the periods 1860 to 1943 and 1943 to 2023. Taking this into account, if we divide the data into the two periods mentioned above and check its stationarity, we encounter a different picture. So, when we check the stationarity test for the years 1860-1943, which we conventionally divide, we see that there is non-stationarity. There is also a clear trend here.

Figure 2. Azerbaijan CO2 emissions per capita (up to 1943)



		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.144162	0.0003
Test critical values:	1% level	-4.080021	
	5% level	-3.468459	
	10% level	-3.161067	

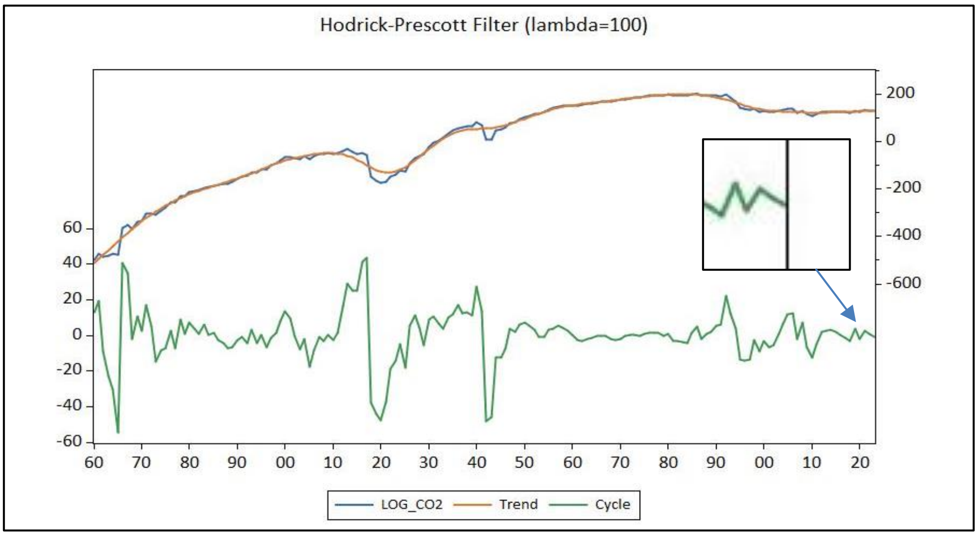
Analyzing the results in the tables, we see that non-stationarity, i.e. dependence on delays, is observed in the trend of the amount of carbon dioxide between 1860 and 1943, even at the 0.1% significance level. It can be seen from the following tables that in this period, although the coefficient indicating the constant is not significant, there is a strong dependence on the trend. Also, the coefficients of the first, third, fourth and fifth lags of the differences between the first lag and the time periods are significant. The coefficient of determination in the table is also a good indicator for this model.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AZ_CO2_PER_CAPITA(-1)	-0.302403	0.058786	-5.144162	0.0000
D(AZ_CO2_PER_CAPITA(-1))	0.402094	0.102689	3.915640	0.0002
D(AZ_CO2_PER_CAPITA(-2))	-0.294605	0.172148	-1.711353	0.0914
D(AZ_CO2_PER_CAPITA(-3))	0.682745	0.188428	3.623373	0.0005
D(AZ_CO2_PER_CAPITA(-4))	0.755824	0.221644	3.410077	0.0011
D(AZ_CO2_PER_CAPITA(-5))	0.505235	0.244451	2.066815	0.0425
C	-0.040827	0.029060	-1.404902	0.1645
@TREND("1860")	0.003560	0.000940	3.787551	0.0003
R-squared	0.457079	Mean dependent var		0.013941
Adjusted R-squared	0.402786	S.D. dependent var		0.136010
S.E. of regression	0.105108	Akaike info criterion		-1.570739
Sum squared resid	0.773341	Schwarz criterion		-1.329025
Log likelihood	69.25883	Hannan-Quinn criter.		-1.473977
F-statistic	8.418869	Durbin-Watson stat		2.067244
Prob(F-statistic)	0.000000			

During the period of the Soviet Empire (1920-1991), an increasing trend in carbon dioxide emissions per capita is observed in Azerbaijan. In this period, dependence is observed both on the trend and on the lag of the first degree. However, the data remains stationary. The stationarity check for all the periods mentioned above, including this period, confirms the historical conjunctures.

To check for cyclicity as a confirmation of stationarity tests, we apply the Hodrick-Prescott Filter [1] to the series as a percentage by multiplying the logarithmic transformation of the time series by 100, and we get the following graph as a result (Figure 3). Looking at the graph, it is observed in what periods there is cyclicality in the amount of carbon dioxide per capita in Azerbaijan. It appears first in 1866, then in 1918-1920, 1940-1942, 1992-1996 and 2008-2010 respectively. All these periods can be interpreted mainly as a result of the economic downturn. But the most recent, albeit small, decrease per capita coincides with the period of the Covid-19 pandemic, i.e. 2019-2021.

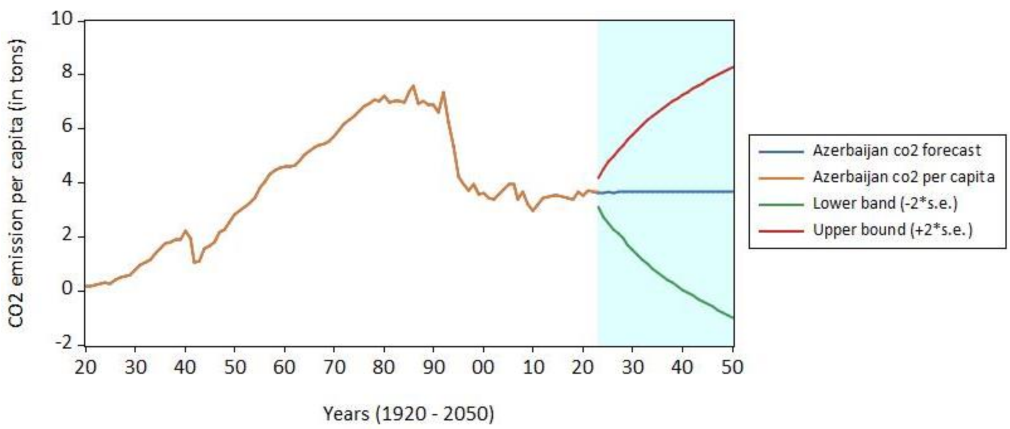
Figure 3. Hodrick-Presscott filter



Finally, after the above tests, it is determined that our fitting model for a stationary time series is more significant than the model you would create with autoregression from degree 1 and moving average from degree 6. The prediction equation and regression result for this model are as follows:

D(CO2 emissions) = [AR(1)=0.261, MA(6)=0.244, uncond, estsmpl="1920 2023"] (1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.260721	0.054803	4.757399	0.0000
MA(6)	0.244179	0.104405	2.338756	0.0213
SIGMASQ	0.072754	0.006261	11.62068	0.0000
R-squared	0.116468	Mean dependent var		0.033253
Adjusted R-squared	0.098972	S.D. dependent var		0.288347
S.E. of regression	0.273706	Akaike info criterion		0.279120
Sum squared resid	7.566396	Schwarz criterion		0.355401
Log likelihood	-11.51426	Hannan-Quinn criter.		0.310024
Durbin-Watson stat	2.046203			



The forecast equation was calculated in Eviews software and an interval of up to 2 standard deviations around the forecast until 2050 was added to the model.

5. CONCLUSION

Although a fairly long period of time was considered in the study, the presence of such a secular period here creates various problems for the database. The most important of them is that the conjuncture has changed several times in the secular period. Examples of these are the rapid development of the manufacturing industry after the discovery of oil on the Absheron Peninsula in the 1840s, the revolutions in Tsarist Russia at the beginning of the last century and the crisis caused by the First World War, the rapid industrialization in the Second World War and its aftermath, and the collapse of the Soviet Empire. stagnation and finally the well-known pandemic can be shown. In addition to these, it is appropriate to analyze these data by dividing them into several periods. But for a more detailed analysis of these periods, instead of annual data, at least quarterly data may be more effective.

As can be seen from the forecast graph, although the forecast line shows a stable trend, the upper and lower limits of up to 2 standard deviations deviate from reality in the long run. This is the result of changes in the conjuncture and various political decisions in the long term. This review underscores the multifaceted nature of CO_2 emissions in Azerbaijan, shaped by economic activities, energy consumption patterns, and policy measures. The collective insights emphasize the critical need for integrated approaches encompassing economic, technological, and policy dimensions to effectively address CO_2 emissions challenges and foster sustainable development. The amount of carbon dioxide (CO_2) emissions per capita is a crucial metric for evaluating the environmental impact of a nation's activities, particularly concerning climate change and sustainable development. In Azerbaijan, a rapidly developing economy with a unique energy landscape, understanding per capita CO_2 emissions is vital for formulating effective environmental policies and strategies. Located at the crossroads of Europe and Asia, Azerbaijan has a diverse economy significantly influenced by its abundant oil and gas reserves. The extraction and export of these fossil fuels have been central to the country's economic growth, but this dependence also presents challenges regarding CO_2 emissions. As Azerbaijan continues to modernize and industrialize, it becomes increasingly important to monitor and manage its per capita CO_2 emissions.

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