The Nexus between Carbon Emissions and Economic Growth in Türkiye at the 100th Anniversary of the Republic: Rolling Window Causality Analysis with Historical Data

Cumhuriyet'in 100. Yılında Türkiye'de Karbon Emisyonları ve Ekonomik Büyüme Arasındaki İlişki: Tarihsel Veri ile Rolling Window Nedensellik Analizi

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ÖZ

Bu çalışma, 1923-2018 yılları arasındaki Cumhuriyet sonrası dönemde Türkiye'deki karbon emisyonları (CO2) ile iktisadi büyüme arasındaki nedensellik ilişkisini ampirik bir şekilde incelemeyi amaçlamaktadır. Çalışmanın temel amacı, bu dönemdeki dönemsel faktörleri dikkate alarak karbon emisyonları ile iktisadi büyüme arasındaki ilişkiyi analiz ederek, geçmişten günümüze Türkiye'nin sürdürülebilir kalkınma çabalarına ışık tutmayı amaçlamaktadır. Bu sayede, çalışma hem geçmişin deneyimlerinden ders çıkarmayı hem de gelecek politika kararlarını desteklemeyi amaçlamaktadır. Bu amaçla yapılan Hacker ve Hatemi-J (2006) nedensellik testi sonuçlarına göre iki değişken arası çift yönlü nedensellik vardır. Rolling Window Nedensellik Analiz sonuçlarına göre, 1955-1959, 1974-1975, 1987-1989, 1993-1997 ve 2008-2010 alt dönemlerinde CO2 emisyonlarından GSYİH'ye doğru; 1981-1988 alt döneminde ise ekonomik büyüme ile karbon emisyonları arasında doğru bir nedensellik ilişkisi bulunmuş. Bu çalışma, Türkiye Cumhuriyeti'nin gelecek 100 yılının şekillenmesinde çevre ile ekonomi arasındaki karmaşık etkileşimin anlaşılmasına katkı sağlamayı amaçlamaktadır.

Anahtar Kelimeler: Cumhuriyet, Karbon emisyonları, Ekonomik büyüme, Rolling Window nedensellik yaklaşımı

ABSTRACT

This study aims to empirically examine the causality nexus between carbon emissions (CO2) and economic growth in Türkiye in the post-Republican period between 1923-2018. The main objective of the study is to shed light on Türkiye's sustainable development efforts from the past to the present by analyzing the nexus between carbon emissions and economic growth, taking into account the periodic factors in this period. In this way, the study aims both to learn from the experiences of the past and to support future policy decisions. According to the results of the Hacker and Hatemi-J (2006) causality test, there is bidirectional causality between the two variables. According to the results of Rolling Window Causality Analysis, there is a direct causality nexus between CO2 emissions and GDP in the sub-periods 1955-1959, 1974-1975, 1987-1989, 1993-1997 and 2008-2010, and between economic growth and carbon emissions in the sub-period 1981-1988. This study aims to contribute to the understanding of the complex interaction between the environment and the economy in shaping the next 100 years of the Republic of Türkiye.

Keywords: Republic, Carbon emissions, Economic growth, Rolling Window causality approach

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1. Introduction

The proclamation of the Republic, one of the most important turning points in Türkiye's modern history, marked the beginning of a radical change in the country's social, political and economic orientation. This radical change was a move by Türkiye to erase the traces of the past, to create a new national identity and a modern state structure, and to take a step towards a sustainable development goal. The achievements of the Republic not only bear the traces of this historical transformation but have also become a guide for Türkiye's future. On the other hand, the Republic is not only a historical milestone; it is also a clear reflection of Türkiye's first steps towards sustainable development goals.

Sustainable development is a concept that has become increasingly important at the global level in recent years. It aims to achieve a balance between economic growth, social welfare and environmental sustainability. First officially introduced in 1987 with the "Brundtland Report", sustainable development has been adopted and implemented by governments, international organizations and non-governmental organizations around the world. The basic principles of sustainable development guide development efforts. Among the basic principles, i. the principle of environmental sustainability emphasizes the sustainable use of natural resources and the prevention of environmental degradation. Environmental issues such as climate change, water scarcity and loss of biodiversity are focal points of sustainable development. ii. In the Social Justice principle, sustainable development aims to reduce social inequalities and ensure a fair standard of living for all individuals. Social factors such as education, health care and income distribution are part of sustainable development. iii. In the Economic Growth principle, Economic growth is an important component of sustainable development. However, this growth should be achieved through efficient use of resources and without harming future generations. iv. The principle of Long-Term Planning states that sustainable development goes beyond short-term gains. Long-term planning and policies take into account the needs of future generations (Gedik, 2020; McKeown, 2002).

Post-Republican Türkiye's development efforts reflect a complex process that includes economic growth objectives as well as environmental impacts. This process is full of important milestones that reflect the country's efforts to achieve its modernization and development goals. Alongside the gains achieved, environmental impacts have also increased in a way that cannot be ignored.

This process emphasizes the importance of taking environmental factors into account along with the goals of achieving economic growth and increasing social welfare. In particular, Türkiye's industrialization and modernization efforts have resulted in increased energy demand and intensified use of natural resources. The development of industry, increasing population and the need for urbanization have increased the need for energy; as a result, dependence on fossil fuels such as coal and oil has increased. However, the use of these energy resources has brought carbon dioxide (CO_2) emissions and other environmental impacts (Dubey and Narayanan, 2010; Yıldız and Göktürk, 2019; Can and Kılıç, 2022). For example, Türkiye's economic growth efforts since the 1960s led to the growth of the concrete industry with the revival of the construction sector (Bilgin, 2023). Concrete production has led to high EC in stages such as clinker and cement production, which has increased CO_2 emissions (Gülnihal et al., 2018). At the same time, developments in the transportation sector have led to more fossil fuel consumption and air pollution (Bilen et al., 2008; Colvile et al., 2001).

In contrast, the development efforts and strategic steps taken by the Republic of Türkiye during this period also aimed to consider environmental sustainability. For example, steps were taken to develop green energy resources after the 1980s (Özaslan, 2023). Steps such as the construction of hydroelectric power plants and wind energy investments have both enabled the use of energy

resources in more sustainable ways and reduced environmental impacts. Moreover, since the 2000s, more emphasis has been placed on environmental protection and sustainability, international agreements have been harmonized, and significant progress has been made in areas such as waste management (Özaslan, 2023). Especially in the 10th Development Plan for the 2014-2018 period, the concept of green growth came to the fore, and it was stated that steps such as turning to renewable resources in energy production, increasing energy efficiency, and promoting sustainable transportation alternatives have the potential to reduce environmental impacts while supporting economic growth. At the same time, sustainability principles were also mentioned in areas such as the use of cleaner production techniques in industrial production, waste management and protection of water resources (Ministry of Development, 2013).

The development efforts of post-Republican Türkiye reflect a complex process that includes not only economic growth targets but also environmental impacts. This process is full of important milestones that reflect the country's efforts to achieve its modernization and development goals. Infrastructure projects, industrialization moves and economic growth steps in the post-Republican period enabled Türkiye to discover its potential and gain a stronger position in the international arena. Türkiye's sustainable development efforts include important areas such as increasing investments in renewable resources in energy production (Emeksiz and Fındık, 2021), taking important steps in waste management (Tezel, 2020), aiming to use forest resources sustainably (Hakverdi, 2020), and adopting various laws and regulations on environmental protection. It also focuses on national and international efforts such as improving public transportation systems (Çakıcı and Özaslan, 2021), promoting sustainable water management practices in the agricultural sector (Aydın, 2023), addressing social factors as part of sustainable development, and adopting the United Nations' Sustainable Development Goals. The combination of these efforts aims to contribute to Turkey's sustainable development goals. However, in addition to the gains achieved in this period, environmental impacts have also increased in a way that cannot be ignored.

This historical process is also of great importance in terms of future commitments and sustainable development goals. Without jeopardizing the quality of life of future generations, it is necessary to take steps by considering environmental sustainability as well as economic growth. Because increasing carbon emissions and environmental degradation can threaten social welfare in the long run (MAE, 2005; Zeb et al., 2014; Çanakçıoğlu, 2023). Achieving this balance requires not only an approach based on past experiences, but also policymaking that is sensitive to the interests of future generations.

Against this background, this study aims to empirically analyze the nexus between CO2 releases and economic evolution in Türkiye in the post-Republican period between 1923 and 2018. The primary aim of the investigation is to thoroughly investigate the correlation between CO2 releases and economic evolution, while considering the varying factors throughout this timeframe. This analysis aims to help us better understand Türkiye's sustainable development efforts and to provide a more solid basis for future policy decisions. In this way, it aims to learn from our past experiences as well as provide solutions that are appropriate to the needs of future generations. The study proceeds as follows: After the introduction, the second section summarizes the existing empirical literature, while the third section furnishes an elaborate account of the dataset, methodologies employed, and the subsequent findings. The last section, the fourth section, presents conclusions and policy recommendations.

2. **Empirical Literature**

The connection among CO2 emissions and growth poses one of the greatest challenges facing the modern world: The balance between achieving economic progress and preserving environmental

sustainability. The effort to achieve this balance has fuelled a large body of research in the economic literature and has been addressed from different perspectives. The main objective of this chapter is to provide a summary of the findings from different studies in the international literature and to shed light on the complexity of the connection among carbon emissions and growth. The empirical analyses will provide an in-depth assessment of the results of studies conducted in different periods and geographies and discuss how these findings can be used for environmental policymaking and the identification of sustainable development strategies. In this way, an important perspective will be provided to integrate environmental sustainability into economic growth and leave a healthier environment for future generations.

The empirical literature has presented different findings on the nature of the nexus between CO2 releases and economic evolution. While some of the studies show that emissions increase as growth increases, others argue that there is a negative connection among growth and emissions. However, some studies have shown that the rate of increase in emissions is slower than the rate of economic growth and therefore a decoupling between economic growth and emissions is possible.

The nexus between CO2 releases and economic evolution utilizing panel data method are extensively presented in the related literature. Acaravci and Ozturk (2010) examine the nexus between CO2 releases, economic evolution and energy consumption (EC) in 19 European countries. The study shows that there is a long-term connection among carbon releases, EC, real GDP and GDP squared in the panel countries. Muhammad, B. (2019) investigates the interplay among economic growth, EC, and CO2 releases using a panel dataset covering 68 countries. The research focuses on the period from 2001 to 2017, encompassing developed, developing, and Middle East and North Africa (MENA) countries. The analysis employs dynamic models estimated through a range of techniques including seemingly unrelated regression (SUR) and GMM methods. Interestingly, the dynamic between EC and CO2 releases diverges whereas EC decreases as CO2 releases increase in developed and MENA countries, the relationship is inverted in developing nations, where EC increases but CO2 releases decrease. Antonakakis et al. (2017). This study examines the dynamic nexus between EC (and its subcomponents), CO2 releases and real GDP over the period 1971-2011 using a panel data set of 106 countries divided into different income groups. Based on the study's findings, the impacts of distinct forms of EC on economic growth and emissions exhibit variations among different clusters of countries. The interrelation between overall economic growth and EC displays bidirectionality, thereby substantiating the feedback hypothesis. Nonetheless, there exists no statistically substantial substantiation indicating that renewable EC, particularly, fosters economic growth. Balli et al. (2019) examines the repercussions of tourism on both economic growth and CO2 releases, employing panel data methodologies within a selection of Mediterranean nations. The application of cointegration tests brings to light a favorable long-term balance among tourism, CO2 releases, and economic growth. Jebabli et al. (2023) scrutinizes the intricate interplay between CO2 releases and economic growth within the G7 nations. To achieve this objective, they delve into the nuanced distributional asymmetry between emissions and growth. Employing a quantitative vector autoregression framework, the study spans a comprehensive 202-year period spanning from 1820Q1 to 2021Q4. This expansive temporal scope encompasses numerous periods of upheaval, contributing to diverse outcomes in the regression analyses centered around the median. The central findings, however, underscore the broader proposition that the dynamic between environmental degradation and economic growth is inherently asymmetric and subject to temporal shifts. The interconnectedness between CO2 releases and economic growth is discernible through both quantitative asymmetry and the heterogeneous patterns that manifest across the G7 countries. Thus, the research underscores the bidirectional nexus between CO2 releases and economic growth. One of the recent studies examining the nexus between CO2 releases and economic evolution for G7 countries is Khalfaoui et al. (2023). This study aims to examine the simultaneity and antecedent-effect nexus between CO2 releases and economic evolution in G7 countries over two centuries. According to the results, there is a cyclical nexus between CO2 releases and gross domestic product per capita.

In the related literature, the link between CO2 releases and economic evolution has also been comprehensively presented using the time series method. Ahmad and Du (2017) examine the nexus between Iran's energy production, CO2 releases and economic growth. Annual time series data for the period 1971-2011 are used. According to the results, there is a positive nexus between CO2 releases and economic growth. Abbasi et al. (2021) examines the factors affecting economic growth for Pakistan. The study is an analysis covering the period 1972-2018. According to the results obtained with the dynamic ARDL method, EC, CO2 releases positively impact economic growth in Pakistan. There are also studies investigating the nexus between CO2 and growth for Türkiye. One of the pioneering studies in this sense is Ozturk and Acaravci (2010). This study analyzed the nexus between economic evolution, carbon releases, EC, and employment rate in Türkiye. Examinations utilizing data spanning from 1968 to 2005 reveal a sustained interconnectedness among these factors. Granger causality assessments divulge that carbon releases and EC wield no discernible influence upon real GDP per capita. However, it becomes apparent that the short-term trajectory of real GDP per capita is indeed influenced by fluctuations in the employment rate. Another study is Oğuz et al. (2020). This study aims to analyze the nexus between energy use, economic growth and environmental pollution in Türkiye for the period 1968-2016 using ARDL bounds test. The findings show that economic growth and trade openness increase environmental degradation. Similar results were also found in Gövdeli (2019). Using the ARDL bounds test for the period 1970-2014, a cointegration nexus between variables was determined. Long-term coefficients are positive and significant. The outcomes of the VECM Granger causality analysis reveal the existence of causal connections among economic growth, trade openness, tourist arrivals, and CO2 emissions in Türkiye. Raihan and Tuspekova (2022) examined how economic growth, renewable energy use affect CO2 releases in Türkiye. It was analyzed with the Dynamic Mean Least Squares method using data from 1990-2020. The findings illustrate that escalations in economic growth contribute to heightened emissions. Conversely, augmentations in the adoption of renewable energy sources, agricultural efficiency, and forest coverage are associated with reductions in emissions.

A rigorous review of the empirical literature reveals that the nexus between CO2 releases and economic evolution is complex and multifaceted. The fact that these studies have been conducted in a wide range of countries and periods shows that the interaction between the environment and the economy is local and time-varying rather than universal. While many have found a positive nexus between economic growth and carbon releases, some studies have emphasized that this relationship can be reversed by the adoption of environmentally friendly technologies and the effective implementation of environmental policies. Different studies have also examined the effects of factors such as EC, trade openness and tourism on carbon releases and the results have varied. This reflects the complexity and context-independence of environmental sustainability and economic growth objectives. The findings emphasize the importance of considering environmental sustainability goals rather than only aiming for economic growth. Ignoring environmental factors can jeopardize economic stability and social welfare in the long run. Therefore, policymakers and decision-makers should adopt holistic approaches to understand and manage this balanced nexus between economic growth and environmental sustainability.

3. Empirical Analysis

The primary objective of this study is to analyze the causality nexus between carbon releases and growth in Türkiye in the post-Republican period between 1923-2018. To this end, firstly, the data set and methods used for the empirical analysis are presented in detail. Then, the empirical findings obtained from the analysis are presented and evaluated.

CO2 releases, measured in tons based on total accumulated production not including land use changes, are used as an indicator of carbon emissions. This data is based on land-based emissions, which do not account for emissions embedded in traded goods. CO_2 data was obtained from The Global Carbon Budget Office and Our World in Data database. GDP per capita in USD at 2011 prices is

used as an indicator of economic growth. GDP data is obtained from Maddison Project Database 2020 (Bolt and van Zanden, 2020). Scheidel and Friesen (2009), Pamuk and Shatzmiller (2011), Milanovic (2006) and Pamuk (2009) were used to compile historical GDP data for Türkiye. The historical data for Türkiye compiled by Bolt and van Zanden (2020) with the data obtained from these studies are up to 2018. Therefore, the historical data used in the analysis of this study, which focuses on the post-Republican period, covers the period between 1923-2018.

In this study, the Hacker and Hatemi-J (HHJ) (2006) test is utilized to examine the causal link between CO_2 and GDP from a symmetric perspective. The HJ test draws upon the causality testing framework pioneered by Toda and Yamamoto (1995). The critical values calculated for this test are obtained using the bootstrap iteration method developed by Efron (1979). The HHJ test employs the subsequent VAR model to evaluate the causality between two variables:

$$y_t = \emptyset_0 + \emptyset_1 y_{t-1} + \cdots + \emptyset_p y_{p-1} + \varepsilon_t \quad (1)$$

In Equation 1, y_t is the variable vector of size 2x1, $\emptyset$ is the parameter vector. The Wald statistic is utilized to assess the null hypothesis suggesting the absence of a Granger causality relationship among the series.

From another perspective, the HHJ test examines the existence of unidirectional and/or bidirectional causality between variables for the entire sample. However, the causality nexus between variables may change over time and this may be especially important when analyzed between CO_2 and GDP (Destek and Köksel, 2019). Therefore, the Rolling Window (RW) estimation method developed by Balcılar et al. (2010) was used to capture time-varying causality relationships. Based on the methodology of HHJ, Balcılar et al. (2010) constructed the bootstrap causality method for periods defined as t=τ-1+l, τ-1, ..., τ, τ=1,...,T (l: varying sub-period). This approach allows us to examine potential changes in the causal nexus between CO_2 and GDP based on the probability (prop.) values calculated over T-1 sub-periods (Destek and Köksel, 2019).

3. Resault and Discussion

In empirical analysis, determining the stationarity of variables is a fundamental step in econometrics. The purpose of this step is to ensure the reliability of the analysis methods and results. Stationarity of variables means that changes over time are due to random fluctuations, and this allows the analysis to produce more accurate results. However, non-stationarity - i.e., the presence of a unit root - can have serious consequences. In series with unit roots, a possible exogenous intervention or shock can cause a permanent change in the series, which can make the results of the analysis misleading. However, structural breaks are also an important factor to be taken into account in the analysis If the outcomes derived from unit root tests do not account for the presence of structural breaks within the series, they can potentially yield deceptive results. Therefore, it is of great importance to capture the time-varying structural breaks of the series in the analysis.

Within the realm of econometrics literature, unit root tests incorporating considerations for structural breaks have been formulated. Andrews (1993), Lee and Strazicich (2003) and Narayan and Popp (2010) are examples of such tests. However, these tests usually allow for a limited number of structural breaks. The methodology pioneered by Carrion-i-Silvestre et al. (2009) is suitable for handling multiple structural breaks. By allowing up to five endogenously determined structural breaks, this test offers a more flexible approach in the analysis. In this context, Carrion-i-Silvestre et al. (CS) (2009) test is preferred for the determination of stationarity in the analysis. In addition to assessing the stationarity of the series, this test aims to produce more robust results by taking into account possible structural breaks in the series. Thus, the reliability of the analysis is increased, and the results obtained are more meaningful. The results of the unit root test incorporating structural breaks are presented in Table 1:

Table 1. CS Structural Break Unit Root Test Results

Variables	At Level					Break Years
	P_T	MP_T	MZ_α	MSB	MZ_T	
lnCO2	44.192 [9.372]	39.058 [9.372]	-11.143 [-45.076]	0.211 [0.104]	-2.357 [-4.765]	1936, 1949, 1984, 1998, 2008
lnGDP	22.421 [10.220]	32.921 [21.094]	-25.391 [-47.544]	0.138 [0.101]	-3.453 [-4.873]	1945, 1965, 1978, 1998, 2008
	At First Difference					
ΔlnCO2	20.322* [33.542]	15.340* [28.344]	-10.098* [-7.453]	0.109* [0.910]	-4.777* [-1.677]	-
ΔlnGDP	10.043* [13.661]	15.429* [19.031]	-26.604* [-19.003]	0.164* [0.909]	-4.143 [-2.334]	-

Notes: * indicates rejection of the null hypothesis at the 5% significance level. The numbers in square brackets are critical values obtained with 1000 bootstrap iterations. Δ indicates that the first difference of the series is taken.

The results presented in Table 1 clearly reflect the importance of the findings obtained in the case where structural breaks are allowed in terms of stationarity analysis. In the endogenously determined scenario where a maximum of five structural breaks are allowed, the level values of the series are found to contain unit roots. This indicates that the series have an unstable structure over time. In particular, the non-stationarity of the variables is critical for the reliability of the analysis results. On the other hand, in the scenario where structural breaks are allowed, the unit root hypothesis is rejected at 5% significance level when the first differences of the series are taken. This implies that the initial variations within the series attain stationarity as time progresses. These results indicate that the relationships between the variables in the analysis are based on a more robust foundation and the results of the analysis are more reliable.

In the second stage of the study, causality between variables was investigated. HHJ test was employed as a symmetric causality examination. Table 2 shows the causality test results between CO2 and GDP.

Table 2: Causality Test Results

Null Hypothesis	MWALD	VAR $(p+d_{msx})$	Critical Values		
			1%	5%	10%
CO2 ⇏ GDP	6.042*	3	10.656	7.261	5.256
GDP ⇏ CO2	5.997*	3	9.178	6.347	4.994

Notes: *, ** and *** indicate that the null hypothesis is rejected at 10%, 5% and 1% significance levels, respectively. The optimal lag length is defined according to the HJC information criterion. "⇏" indicates the direction of Granger causality and the absence of causality.

First, when the null hypothesis stated as "CO2 ⇏ GDP" is tested with the MWALD statistic, the value of 6.042 is above the critical value of 5.256 at the 10% significance level. This indicates that CO2 emissions have a causality relationship that drives economic growth. Similarly, when the null hypothesis stated as "GDP ⇏ CO2" is tested with the MWALD statistic, the value of 5.997 is above the critical value of 4.994, which is the critical value at the 10% significance level. This indicates that economic growth has a causality relationship that drives CO2 releases. In summation, the outcomes of the causality tests conducted within this analysis bolster the existence of a reciprocal causal nexus between CO2 releases and economic evolution.

Table 3. Parameter Stability Test Results

		Statistics	p-value	Statistics	p-value
		CO2		GDP	
CO2=f(GDP)	Sup-LR	1.464	0.216	3.508	0.163
	Exp-LR	0.280	0.507	0.233	0.898
	Mean-LR	0.522	0.304	0.362	0.344

The results in Table 3 show that the null hypothesis that the parameters are not stable cannot be rejected in all alternative stability tests applied on the model. This indicates that, in general terms, the parameters are unstable and therefore the parameters obtained may not adequately reflect the entire observed period. In this context, the difficulty of determining the causality nexus between CO2 and GDP variables through a single parameter emerges. In light of these findings, in order to obtain more consistent results of the analysis, we propose to consider the period 1923-2018 as a sub-period of 96 years. Under this approach, investigating the causality nexus between CO2 and GDP variables within each sub-period may provide more accurate results. Thanks to this method, the economic, social and environmental dynamics of each sub-period can be analyzed in more detail.

Accordingly, the nexus between CO2 and GDP variables in each sub-period was analyzed using the RW causality analysis method. This analysis allows for a deeper understanding of the potential causal nexus between CO2 releases and growth by taking into account the unique conditions, policies and global factors of each period.

RW causality test results are presented in Chart 1. Chart 1 consists of four panels. Panel (a) of Chart 1 shows the probability (prop.) values of the RW test statistic of the null hypothesis "CO2 is not the Granger cause of GDP" and Panel (b) shows the bootstrap estimation values of the RW coefficient sums measuring the effect of CO2 on GDP. Graph 1 Panel (c) shows the probability (prop.) values of the RW test statistic of the null hypothesis "GDP is not the Granger cause of CO2" and Panel (d) shows the bootstrap estimation values of the RW coefficient sums measuring the effect of GDP on CO2. In the periods below the line representing the 10% significance level of the graph representing the probability values calculated for all sub-periods, the null hypothesis is rejected and it can be determined that there is a Granger causality nexus between the relevant variables.

Graph 1: RW Causality Tetsi Estimation Results
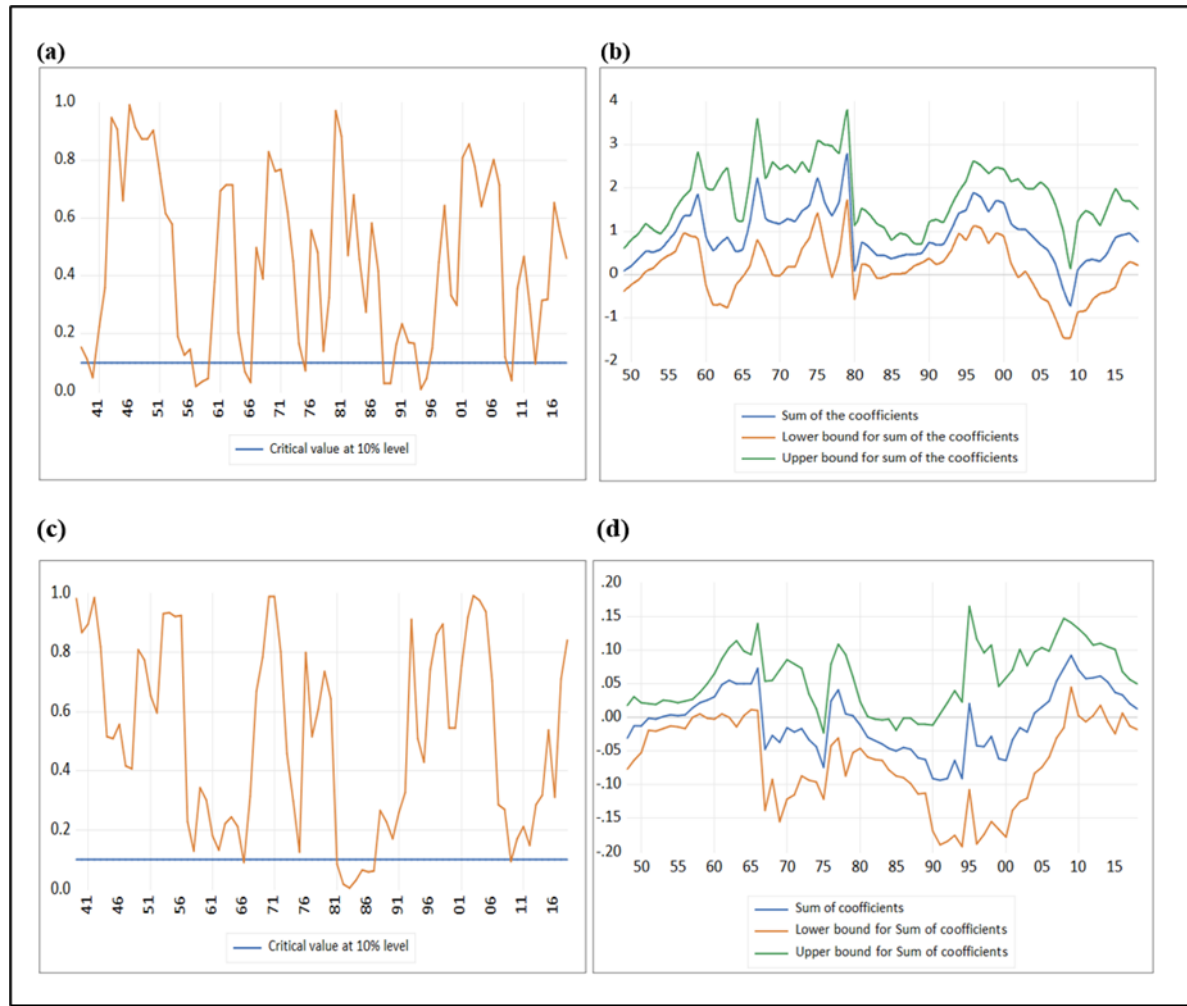
In this sense, the results in Panel (a) of Chart 1 show that the null hypothesis "CO2 is not the Granger cause of GDP" is rejected in the sub-periods 1955-1959, 1974-1975, 1987-1989, 1993-1997 and 2008-2010. This implies that there is a causality from CO2 to GDP in the relevant sub-periods. Panel (b) in Chart 1 indicates that the impact of carbon releases on growth is positive in all sub-periods except the 2008-2010 sub-period. The results in Panel (c) in Chart 1 show that the null hypothesis "GDP is not the Granger cause of CO2" is rejected in the 1981-1988 sub-period. This implies that there is a causality among growth and CO2 releases in the relevant sub-period. Panel (d) in Chart 1 illustrates that within the pertinent sub-period, the effect of economic growth on CO2 releases is observed to be negative.

4. Conclusions and Policy Recommendations

The present study aims to shed light on the nexus between carbon releases and economic growth in Türkiye's post-Republic era between 1923 and 2018. The primary objective of the study is to examine the causality among carbon releases and economic growth by considering the contextual factors during this period, aiming to provide insights into Türkiye's efforts towards sustainable development from the past to the present. As a result, the study not only seeks to learn from historical experiences but also intends to support future policy decisions.

In this context, the findings of the HHJ causality test reveal a bidirectional nexus between CO2 releases and economic evolution. This implies that carbon emissions influence economic growth, and vice versa. Additionally, the results of the Rolling Window Causality Analysis highlight distinct

relationships during different sub-periods. Specifically, during the periods of 1955-1959, 1974-1975, 1987-1989, 1993-1997, and 2008-2010, a causal relationship is observed from carbon emissions to economic growth. Conversely, in the sub-period of 1981-1988, a positive causality is detected from economic growth to carbon emissions.

These findings provide valuable insights for Türkiye's sustainable development efforts. They emphasize the importance of balancing environmental factors and economic growth in shaping future policy decisions. Encouraging eco-friendly technologies, enhancing energy efficiency, and supporting the transition to a green economy are proposed as steps that can both sustain economic growth and preserve environmental quality.

In conclusion, this study evaluates Türkiye's post-Republic era development endeavors in the context of the nexus between environment and economy. It aims to learn from historical experiences and support policy recommendations for the future. This analysis seeks to contribute to understanding the interplay between environment and economy in shaping the next century of the Republic of Türkiye.

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