

## **An Asymmetric Approach to Evaluate Sectoral CO<sub>2</sub> Emissions in Turkey**

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**Abstract:** The increase in population and economic growth are significant factors that contribute to the deterioration of the environment, primarily through the emission of carbon pollutants. Therefore, the overuse of natural resources, degradation of natural ecosystems, and the increasing release of harmful gases threaten our ability to protect the environment for future generations. Although there is a global agreement on the need for clean and carbon-free energy systems to achieve sustainable development, emerging countries persist in giving more priority to economic objectives rather than environmental preservation. This research aimed to explore strategies to mitigate sector-specific emissions and ecological deterioration in Turkey, where enforcing environmental regulations has proven inadequate. This quantitative study analysed symmetric and asymmetric interactions between sectoral emissions and sectoral value added per capita, GDP per capita, and human capital with the nonlinear autoregressive distributed (NARDL) time series method in Turkey. The connections between emissions from different sectors, the value contributed to the economy, the income per person, and the growth of human capital were examined in the research. The study's findings indicated that policies to increase production and develop human capital are effective in the short term for reducing carbon emissions in the services sector. Over time, policies that prioritise raising income levels and building up human capital have been successful. Analyses of strategies to reduce agricultural emissions reveal that implementing short-term investments in human capital and long-term revenue increases are successful policies to reduce emission levels in the industry. Regarding the industry, past levels of emissions in the immediate future exert a constraint on managing the present period's emission levels. Given the asymmetrical impacts, it is evident that people whose quality of life improves through investments in human capital are more likely to prioritise environmental sustainability and adopt practices that reduce

emissions in production. Thus, it is evident that the enhancement of human capital may serve as a significant policy tool across all industries.

**Keywords:** NARDL, Sectoral Analysis, Environmental Economics, Environmental Policy, CO<sub>2</sub> Emissions, Turkey.

## Introduction

A nation's economic success is based on its natural and intellectual assets (Adebayo & Kirikkaleli, 2021). During the first stages of growth, a country's economy relies heavily on natural resources. The utilisation of natural resources plays a significant role in the advancement of nations, but it also poses a threat to their ecological balance (Su et al., 2021). The overexploitation of natural resources has a detrimental impact on the environment, prompting governments to seek alternative energy sources. Governments may refrain from adopting alternative energy sources due to the substantial expenses associated with their deployment, thereby impeding economic progress. At the same time, as manufacturing becomes more automated, the demand for energy has increased, which can be easily met by using fossil fuels. Nevertheless, the utilisation of fossil fuels might result in the inability of the environment to effectively assimilate the waste produced (Agyekum et al., 2021). The degradation of natural ecosystems resulting from a diverse range of human activities and the improper use of natural resources may momentarily enhance GDP but compromise the long-term sustainability (Xue et al., 2022).

The discussions around the depletion of fossil fuels gained momentum with the 1970s oil crisis and the growing environmental awareness in the 1960s. Countries that are just starting to grasp the consequences of human activity on the environment are now introducing taxes to curb pollution and waste. The implementation of recycling and disposal laws in the 1990s was a direct result of the sustainability conversations that were held during that era. During this time, the concept of sustainable development was embraced. It was first established by the Brundtland Commission in 1987 and then elaborated upon by the Earth Summit in 1992, including the economic, ecological, and social aspects of development (Soubbotina, 2013). The 2009 Copenhagen Summit and other environmental discussions brought climate change and other environmental concerns to the forefront of the global agenda. The 2010s marked the beginning of an era characterised by prevalent environmental issues, increased social awareness, and a sustainable perspective. The Sustainable Development Goals (SDGs) were created by the United Nations in response to escalating environmental degradation, with the aim of enhancing global environmental quality. Therefore, there is a global agreement on the need to create energy systems that are free from carbon emissions and environmentally friendly.

Today, the ideas of human-centred sustainable development, ecological hazards, and environmental quality are intertwined with socioeconomic transformation, evidencing the necessity of re-evaluating the concept of sustainable development. Increases in both population and economic activity are widely acknowledged as key contributors to the environmental deterioration (Aguilera et al., 2019). Although the environmental damage caused by economic expansion is largely due to increased CO<sub>2</sub> emissions (Mikayilov et al., 2018) many studies concerning industrialised economies have found that effective management of this process will result in lower emission levels (Acheampong, 2018; Hanif et al., 2019). In the literature, this hypothesis is known as the Environmental Kuznets Curve (EKC) and demonstrates that advanced economies can achieve environmental sustainability (Balado-Naves et al., 2018; Cheikh et al., 2021). However, despite multiple investigations by researchers such as Gill et al. (2017), Katircioğlu and Katircioğlu (2018), and Shahbaz and Sinha (2019), the validity of the hypothesis remains inconclusive.

Reducing reliance on fossil fuels, which is a prerequisite for environmental sustainability, has made renewable energy sources more vital for developed economies. Developing economies prioritise economic aims above environmental quality, leading them to heavily rely on fossil fuels instead of alternative energy sources, despite the worldwide awareness of environmental issues. Despite placing significant emphasis on environmental issues since the 1970s and setting specific goals for environmental protection to meet EU membership requirements, Turkey still struggles with implementing effective environmental regulations. In addition, Turkey's environmental commitments have been evaluated as "inadequate" by the independent organisation Climate Action Tracker due to the country's current economic path posing a threat to the Sustainable Development Goals (SDG) 13 (significant greenhouse gas emissions) SDG 14 (insufficient preservation of the Black Sea ecosystem) and SDG 15 (substandard land quality). Considering Turkey's inadequate performance, it is imperative for the country to implement comprehensive laws that can effectively address the Sustainable Development Goals (SDGs) in the future.

### ***Research Problem***

The need to investigate carbon emissions trends in Turkey's industries is in line with international climate initiatives, facilitating prompt action and policy changes to achieve sustainability targets. The analysis of sectoral emissions, economic indicators, and human capital investments offers benefits like identifying high-emission sectors and supporting sustainable development. This research enriched the knowledge on economic-environmental interplay, providing insights for future studies on sustainable development, environmental economics, and climate policy. While literature at the national level exists on economic indicators and carbon emissions, sectoral emissions in Turkey with value added, income, and human capital need further exploration for nuanced insights. This research can reveal sector-specific emission patterns, effectiveness of human capital investments, and trade-offs between economic growth and environmental sustainability. It can also suggest policy implications for transitioning to a low-carbon economy while promoting inclusive growth and human development.

### ***Research Focus***

In general, this study was centred on investigating the relationships between carbon emissions within specific sectors, sectoral value added, per capita income, and investments in human capital in Turkey. The primary focus of the research lied in comprehending the dynamics of these variables and their mutual effects over varying durations, including short and long terms.

### ***Research Aim and Research Questions***

The purpose of the study was to ascertain the primary sectors that are responsible for carbon emissions in Turkey. Additionally, the study aimed to investigate the relationship between sectoral value added and carbon emissions, with the objective of assessing the environmental efficacy of various economic sectors. In accordance with these goals, the objectives of the study were as follows:

1. To analyse the long-term relationship between sectoral carbon emissions and sectoral value added in Turkey.
2. To assess the short-term dynamics between sectoral carbon emissions and per capita income across various sectors of the Turkish economy.
3. To examine the impact of human capital investments on sectoral carbon emissions in both the short and long term.
4. To identify potential policy interventions for mitigating sectoral carbon emissions while promoting sustainable economic growth and human development in Turkey.

### ***Literature Review***

The concept of the relationship between economic development and pollution was first introduced by Grossman and Krueger in 1991. The EKC hypothesis has since been thoroughly

investigated in numerous scholarly publications (Baloch et al., 2021; Sarkodie & Ozturk, 2020). Over time, it has been seen that the environment has experienced different harmful effects as the methods of production have shifted from agriculture to industry and then to service-oriented economic activity. The reliance on fossil fuel usage for the development of these industrial systems has sparked a discussion on the environmental disadvantages within the framework of ecological modernisation theory. The growth of industries is leading to a rise in environmental deterioration. The theory argues that the negative environmental impacts may be reduced by transitioning the industrial composition towards the services sector (Mol & Spaargaren, 2000). The concept is crucial as it underscores the diversity of energy requirements across different sectors, indicating that these sectors have unique patterns of pollution. Moreover, due to the uneven adoption of green technology and fuels and the promotion of a sustainable environment, it is anticipated that the connection between sectoral output and emissions would vary across different sectors.

The research conducted by Hettige et al. (2019) has shifted the focus of EKC studies towards sectoral indicators, deviating from the usual association between environmental deterioration and productivity. Fujii and Managi (2013) identified an N-shaped pattern in the aggregate CO<sub>2</sub> emissions of nine OECD sectors. They also found that the link between the EKC milestone and sectoral CO<sub>2</sub> emissions differed depending on the kind of fuel used. Moutinho et al. (2020) used the PCSE model and found that three out of the seven sectors of OPEC (agricultural, construction, fishery, forestry, and remaining activities) supported the EKC hypothesis. Ru et al. (2018) specifically examined the worldwide emissions originating from the sectors of power, industry, housing, and transportation. The examination of SO<sub>2</sub> revealed the existence of Environmental Kuznets Curve (EKC) in the industrial and energy sectors, while the EKC for CO<sub>2</sub> was verified in the industrial and residential sectors. Aslan et al. (2018) confirmed the Environmental Kuznets Curve (EKC) theory in the overall, industrial, power, and housing sectors of the United States over the period from 1973 to 2015. However, they could not find evidence supporting the EKC hypothesis in the commerce and transportation sectors. The study conducted by Nguyen et al. (2020) focused on analysing how foreign direct investment (FDI) and trade openness influenced emissions levels in 33 developing countries between 1996 and 2014. The findings from the STIRPAT model indicate a U-shaped correlation between housing and public service connections, whereas manufacturing and production interactions exhibit an inverted U-shaped pattern.

Several researches concern the Environmental Kuznets Curve (EKC) hypothesis by analysing the Gross Value Added (GVA) or Gross Domestic Product (GDP) at a sectoral level (Apergis and Ozturk, 2015; Najafi Alamdarlo, 2016). Moutinho et al. (2017) performed an Environmental Kuznets Curve (EKC) analysis in Portugal and Spain, covering the time period from 1975 to 2012. The econometric analysis revealed variations across sectors in Portugal and Spain. However, Portugal's sectoral value added, and CO<sub>2</sub> emissions exhibit an inverse N-shaped pattern. Based on this analysis, there were 11 economic sectors that exhibited N-shaped and inverted U-shaped patterns. Hamit-Hagggar (2012) conducted a study from 1990 to 2007, focusing on the analysis of Canada's 21 most environmentally harmful companies. The research revealed a correlation between industrial energy usage and greenhouse gas emissions.

The process of structural transformation entails a shift in the economic composition, whereby emissions are expected to rise during the transition from agricultural to industry and then decline during the transition from industry to services. The link between structural change and the environment, which is emphasised here, has also attracted the attention of other researchers. Diakoulaki and Mandaraka (2007) conducted a comparative analysis of the development in 14 EU nations from 1990 to 2003, examining the period before and after the implementation of the Kyoto Protocol. The study acknowledged the benefits of cleaner energy sources in power production. However, it concluded that the Kyoto Protocol failed to accomplish its objectives in the industrial sectors of these nations. Chen et al. (2018) analysed the comprehensive factor productivity in the Chinese

economy, as well as the distribution of factors across different industrial sectors. To address the differing productivity patterns in China's heavy and light sectors, the authors recommended achieving a balanced investment structure, to secure equitable resource access for non-state companies, and build financial institutions for non-state entities. Hocaoglu and Karanfil (2011) used the latent Markov model to demonstrate the correlation between industrial growth and CO<sub>2</sub> emissions in the G7 nations over the period from 1970 to 2008. The model demonstrated a high level of accuracy in quantifying CO<sub>2</sub> emissions. Ahmad et al. (2013) found that the expansion of industries and increase in population were significant factors in the air pollution seen in the SAARC area, specifically in terms of carbon monoxide emissions. Rahman and Kashem (2017) discovered that between 1972 and 2011, the adoption of improved energy efficiency practices and the expansion of industrial operations in Bangladesh resulted in a reduction in both immediate and prolonged carbon emissions. Based on causality studies, the country's surge in industrial activity had an impact on the state of the environment. In their study, Yang et al. (2018) examined the impact of structural changes on CO<sub>2</sub> emissions, highlighting the variations in energy technologies and efficiency across different areas in China. The authors found that the industrial and transportation sectors were the primary contributors to CO<sub>2</sub> emissions. The increase of the energy intensity leads to a reduction in CO<sub>2</sub> emissions. Okamoto (2013) examined the impact of Japan's service sector on the emission of greenhouse gases. Service-intensive industry had a significant decrease in CO<sub>2</sub> emissions from 1995 to 2005. In their study, Musa et al. (2022) investigated the impact of sector-specific emissions on the environmental condition in Nigeria. They found that emissions from transportation and energy sectors had detrimental effects on the ecosystem. Hashmi et al. (2023) examined the influence of uncertainty in climate policy on carbon dioxide emissions in different sectors of the United States, using the environmental Kuznets curve. The results indicated that uncertainty around climate policy led to a rise in carbon dioxide emissions in the residential, commercial, and electric power sectors over both the short and long term. However, it does not have the same effect on industrial emissions. The report proposes implementing legislative measures tailored to individual sectors in order to mitigate carbon dioxide emissions.

In his study, Kumbaroğlu (2011) employed the Laspeyres method to examine the carbon dioxide (CO<sub>2</sub>) emissions in Turkey. The research indicated that electricity generation, industrial activities, and transportation were all significant contributors to pollution. Implementing sustainable production methods reduces agricultural emissions, while participating in energy-intensive agriculture exacerbates them. Pollution is caused by the combined effects of energy production, industrial activities, and transportation. As the energy intensity of agriculture increases, so do its emissions. However, transitioning to clean production methods can effectively reduce emissions within the sector. Cil (2023) examined the influence of Foreign Direct Investment (FDI) on environmental degradation in Turkey from 1970 to 2020. The author used the Fourier methodology to examine the correlation among FDI, economic growth, energy consumption, and CO<sub>2</sub> emissions. The study suggested that the promotion of clean technologies via foreign direct investment (FDI) and the establishment of energy regulations might effectively mitigate pollution in Turkey. Degirmencioglu Aydin and Aydin (2023) used the Environmental Kuznets Curve (EKC) theory to in order to analyse the influence of main economic sectors in Turkey on environmental degradation and the legal obligations of corporations from 1985 to 2017. The research highlighted the imperative need to enforce diverse legislative requirements in order to mitigate pollution, given the detrimental effect of construction enterprises on environmental quality. Ojaghrou et al. (2023) examined the enduring correlation between CO<sub>2</sub> emissions, energy consumption, economic activity, and governance concerns in Turkey from 1980 to 2021, using the STIRPAT theory and the environmental Kuznets curve hypothesis. The investigation revealed a direct association between energy use and CO<sub>2</sub> emissions, indicating a positive relationship. The researchers proposed that energy efficiency might mitigate the rise in CO<sub>2</sub> emissions associated with economic expansion. Ojaghrou and Ugurlu (2023) examined the enduring correlation between CO<sub>2</sub> emissions, urbanisation, and sustainable development in Turkey from 1990 to 2020. They used the STIRPAT hypothesis and the

Environmental Kuznets curve in their analysis. The results demonstrated that the process of urbanisation and economic activities had a direct and favourable impact on the release of CO<sub>2</sub> emissions, leading to environmental damage.

In summary, the comprehensive examination of existing literature underscores the need of investigating sector-specific carbon emissions, value added, per capita income, and investments in human capital within the context of Turkey. The Environmental Kuznets Curve (EKC) hypothesis has played a crucial role in understanding the correlation between economic progress and environmental damage. Nevertheless, previous studies have yielded varying outcomes in different sectors and countries, emphasising the importance of conducting customized analysis to fit the specific circumstances. Despite the existence of several EKC hypotheses and research into sectoral indicators, there are still various gaps that persist. These factors encompass Turkey's insufficient research at the sectoral level, the necessity for comprehensive studies on investing in human capital, and the requirement for nuanced policy recommendations tailored to its socioeconomic and environmental conditions. It is imperative to acknowledge and rectify these deficiencies in order to effectively implement evidence-based policies and practices that effectively mitigate sectoral carbon emissions and foster sustainable economic growth and human development within the context of Turkey. This study aimed to address existing research gaps and offer guidance for future research endeavours by presenting empirical findings on the interconnections among sectoral carbon emissions, economic indicators, and investments in human capital.

### Research Methodology

In this study, symmetric and asymmetric interactions between sectoral emissions and sectoral value added per capita, GDP per capita, and human capital were analysed with the nonlinear autoregressive distributed (NARDL) time series method in Turkey. Shin et al. (2014) introduced the Autoregressive Distributed Lag (ARDL) model as a more favourable alternative to classical cointegration models due to its ability to accurately capture relationships in small samples and accommodate dependent variables with varying levels of stability. In the NARDL model, based on Pesaran et al. (2001) ARDL model, short- and long-term asymmetric effects were added to the standard model. To illustrate the asymmetrical behaviour of the explanatory variables, Shin et al. (2014) developed positive and negative partial sums: Here,  $x_t^+$  and  $x_t^-$  show the positive and negative partial sums of  $x_t$ , respectively. Granger and Yoon (2002) and Schorderet (2001) used the partial total decomposition method to investigate the existence of an asymmetric cointegration relationship. Granger and Yoon (2002) used the partial sum decomposition method to investigate the existence of an asymmetric cointegration relationship by considering both increases and decreases in explanatory variables. Accordingly, the asymmetric ARDL models can be shown in general as follows:

MODEL 1-ARDL

$$LIE_t = \alpha_0 + \alpha_1 LVI_t^+ + \alpha_2 LVI_t^- + \alpha_3 LGDP_t^+ + \alpha_4 LGDP_t^- + \alpha_5 LGHC_t^+ + \alpha_6 LGHC_t^- e_t \quad (1)$$

MODEL 2-ARDL

$$LSE_t = \alpha_0 + \alpha_1 LVS_t^+ + \alpha_2 LVS_t^- + \alpha_3 LGDP_t^+ + \alpha_4 LGDP_t^- + \alpha_5 LGHC_t^+ + \alpha_6 LGHC_t^- e_t \quad (2)$$

MODEL 3-ARDL

$$LAE_t = \alpha_0 + \alpha_1 LVA_t^+ + \alpha_2 LVA_t^- + \alpha_3 LGDP_t^+ + \alpha_4 LGDP_t^- + \alpha_5 LGHC_t^+ + \alpha_6 LGHC_t^- e_t \quad (3)$$

In the model, LIE, LSE, and LAE represent the sectoral emissions of industry, services, and agriculture, respectively. Similarly, LVI (industry) LVS (services) and LVA (agriculture) show the sectoral value added per capita. LGDP is GDP per capita, and LGHC is the growth of the human capital index. These equations show the long-term relationship between sectoral emissions and the variables under question.  $\alpha = (\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6)$  is the vector of long-term parameters estimated.  $LVI_t^+$ ,  $LVI_t^-$

,  $LVS_t^+$ ,  $LVS_t^-$ ,  $LVA_t^+$ , and  $LVA_t^-$  represent the partial sum of positive and negative changes in sectoral value added per capita.  $LGDP_t^+$  and  $LGDP_t^-$  represent the partial sum of positive and negative changes in GDP per capita.  $LGHC_t^+$  and  $LGHC_t^-$  represent the partial sum of positive and negative changes in human capital growth.

The error correction structure of the NARDL model, which consists of separated asymmetric and symmetric variables, is given below:

#### MODEL 1-NARDL

$$LIE_t = \alpha + \beta_0 LIE_{t-1} + \beta_1 LVI_{t-1}^+ + \beta_2 LVI_{t-1}^- + \beta_3 LGDP_{t-1}^+ + \beta_4 LGDP_{t-1}^- + \beta_5 LGHC_{t-1}^+ + \beta_6 LGHC_{t-1}^- + \sum_{i=1}^p \gamma_i \Delta LIE_{t-i} + \sum_{i=1}^q (\delta_{LVIi}^+ \Delta LVI_{t-i}^+ + \delta_{LVIi}^- \Delta LVI_{t-i}^-) + \sum_{i=1}^s (\varphi_{LGDPi}^+ \Delta LGDP_{t-i}^+ + \varphi_{LGDPi}^- \Delta LGDP_{t-i}^-) + \sum_{i=1}^s (\mu_{LGHCi}^+ \Delta LGHC_{t-i}^+ + \mu_{LGHCi}^- \Delta LGHC_{t-i}^-) + \varepsilon_t \quad (4)$$

#### MODEL 2-NARDL

$$LSE_t = \alpha + \beta_0 LSE_{t-1} + \beta_1 LVS_{t-1}^+ + \beta_2 LVS_{t-1}^- + \beta_3 LGDP_{t-1}^+ + \beta_4 LGDP_{t-1}^- + \beta_5 LGHC_{t-1}^+ + \beta_6 LGHC_{t-1}^- + \sum_{i=1}^p \gamma_i \Delta LSE_{t-i} + \sum_{i=1}^q (\delta_{LVSi}^+ \Delta LVS_{t-i}^+ + \delta_{LVSi}^- \Delta LVS_{t-i}^-) + \sum_{i=1}^s (\varphi_{LGDPi}^+ \Delta LGDP_{t-i}^+ + \varphi_{LGDPi}^- \Delta LGDP_{t-i}^-) + \sum_{i=1}^s (\mu_{LGHCi}^+ \Delta LGHC_{t-i}^+ + \mu_{LGHCi}^- \Delta LGHC_{t-i}^-) + \varepsilon_t \quad (5)$$

#### MODEL 3-NARDL

$$LAE_t = \alpha + \beta_0 LAE_{t-1} + \beta_1 LVA_{t-1}^+ + \beta_2 LVA_{t-1}^- + \beta_3 LGDP_{t-1}^+ + \beta_4 LGDP_{t-1}^- + \beta_5 LGHC_{t-1}^+ + \beta_6 LGHC_{t-1}^- + \sum_{i=1}^p \gamma_i \Delta LAE_{t-i} + \sum_{i=1}^q (\delta_{LVAi}^+ \Delta LVA_{t-i}^+ + \delta_{LVAi}^- \Delta LVA_{t-i}^-) + \sum_{i=1}^s (\varphi_{LGDPi}^+ \Delta LGDP_{t-i}^+ + \varphi_{LGDPi}^- \Delta LGDP_{t-i}^-) + \sum_{i=1}^s (\mu_{LGHCi}^+ \Delta LGHC_{t-i}^+ + \mu_{LGHCi}^- \Delta LGHC_{t-i}^-) + \varepsilon_t \quad (6)$$

In the equation,  $p$ ,  $q$  and  $s$  give the lag lengths. While  $\alpha_1 = -\beta_1/\beta_0$ ,  $\alpha_2 = -\beta_2/\beta_0$  showing the long-term effects of increases and decreases in sectoral value added on sectoral emission,  $\alpha_3 = -\beta_3/\beta_0$  and  $\alpha_4 = -\beta_4/\beta_0$  revealing the long-term effects of increases and decreases in gross domestic product per capita on sectoral emissions and  $\alpha_5 = -\beta_5/\beta_0$  and  $\alpha_6 = -\beta_6/\beta_0$  represent the long-term effects of increases and decreases in human capital on sectoral emission.  $\sum_{i=1}^q \delta_{LVIi}^+$ ,  $\sum_{i=1}^q \delta_{LVSi}^+$  and  $\sum_{i=1}^q \delta_{LVAi}^+$  show the short-term effects of the increase in sectoral value added on sectoral emissions, and  $\sum_{i=1}^q \delta_{LVIi}^-$ ,  $\sum_{i=1}^q \delta_{LVSi}^-$  and  $\sum_{i=1}^q \delta_{LVAi}^-$  shows the short-term effects of the decreases in sectoral value added on sectoral emissions. Similarly, while  $\sum_{i=1}^s \varphi_{LGDPi}^+$  indicates the short-term effects of increases in gross domestic product per capita on sectoral emissions,  $\sum_{i=1}^s \varphi_{LGDPi}^-$  measures the short-term effects of decreases in gross domestic product per capita on sectoral emissions. Accordingly, testing the null hypotheses  $H_{LR,LVA}: \alpha_1 = \alpha_2$ ,  $H_{LR, LGDP}: \alpha_3 = \alpha_4$  and  $H_{LR, LGHC}: \alpha_5 = \alpha_6$  using the Wald test will give information about the long-term asymmetry. Similarly, short-term asymmetry will be investigated by testing the null hypotheses  $H_{SR, LVI}: \sum_{i=1}^q \delta_{LVIi}^+ = \sum_{i=1}^q \delta_{LVIi}^-$ ,  $H_{SR, LVS}: \sum_{i=1}^q \delta_{LVSi}^+ = \sum_{i=1}^q \delta_{LVSi}^-$ ,  $H_{SR, LVA}: \sum_{i=1}^q \delta_{LVAi}^+ = \sum_{i=1}^q \delta_{LVAi}^-$ ,  $H_{SR, LGDP}: \sum_{i=1}^s \varphi_{LGDPi}^+ = \sum_{i=1}^s \varphi_{LGDPi}^-$  and  $H_{SR, LGHC}: \sum_{i=1}^s \mu_{LGHCi}^+ = \sum_{i=1}^s \mu_{LGHCi}^-$  using the Wald test. The statistical findings indicate that asymmetry exists if the null hypothesis is rejected.

**Table 1**

#### Variables and Data Sources

Variables	Acronym	Data Source
Sectoral Emission	LIE, LSE, LAE	World Development Indicators, World Bank
Sectoral Value Added	LVI, LVS, LVA	World Development Indicators, World Bank
Gross Domestic Product per capita	GDP	World Development Indicators, World Bank

Growth of Human Capital	GHC	Penn World Table, version 10.0
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Due to the limitations of sectoral carbon emission data, the study covered the years 1960–2014 in the industry and services sectors and 1970–2018 in the agricultural sector. Sectoral carbon emissions, sectoral value added, and gross domestic product per capita data for Turkey are taken from the World Development Indicators Database of the World Bank. In addition, the human capital data were obtained from Feenstra et al. (2015). The variables used in the model and their data sources are given in Table 1.

## Research Results

Before examining the dynamic effects of sectoral value added, per capita gross domestic product, and human capital growth on sectoral emissions, the degrees of stationarity of the series should be determined in order to apply the boundary test approach. Therefore, the unit root test was performed for each series. Table 2 shows the results of the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. The unit root test results show that none of the series is I(2). Therefore, it is possible to use the Nonlinear Autoregressive Distributed Lag (NARDL) model for long- and short-term estimates of the model. The ARDL bound test findings shown in Table 3 indicate that the models will provide statistically significant results at the lag levels specified in the table.

**Table 2**

### Unit Root Tests

Variables	Level		1st Difference		
<b>ADF Test</b>	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Outcome
LIE	-3,35**	-1,86	-7,95***	-9,96***	I(0)/I(1)
LSE	-2,24	-2,79	-6,53***	-6,81***	I(1)
LAE	-0,95	-0,86	-5,36***	-5,31***	I(1)
LGDP	-0,01	-3,62**	-8,55***	-8,39***	I(0)/I(1)
LVI	-0,30	-3,17	-8,59***	-8,49***	I(1)
LVS	-0,26	-2,72	-7,83***	-7,74***	I(1)
LVA	-2,22	-2,35	-7,05***	-7,15***	I(1)
LGHC	-2,23	-2,19	-7,04***	-6,96***	I(1)
<b>PP Test</b>	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Outcome
LIE	-14,62***	-2,03	-7,92***	-11,04***	I(0)/I(1)
LSE	-2,30	-2,79	-6,53***	-6,81***	I(1)
LAE	-1,29	-1,23	-5,39***	-5,35***	I(1)
LGDP	-0,01	-3,94**	-8,55***	-8,39***	I(0)/I(1)
LVI	-0,29	-3,49*	-8,62***	-8,50***	I(1)
LVS	-0,26	-3,08	-7,83***	-7,74***	I(1)
LVA	-2,27	-2,59	-7,07***	-7,15***	I(1)
LGHC	-2,38	-2,35	-7,03***	-6,96***	I(1)

*Note.* ADF Test: Augmented Dickey-Fuller Test, PP Test: Philips-Perron Test LIE: log of industry emissions, LSE: log of services emissions, LAE: log of agriculture emissions, LGDP: log of gross domestic product per capita, LVE: log of industry value added per capita, LVS: log of services value added per capita, LVA: log of agriculture value added per capita, LGHC: log of human capital growth, \* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

**Table 3**

### ARDL Bounds Test Results

	F- statistics	%10		%5		%1	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
MODEL 1- ARDL (4,6,6,5)	7,453***	2,37	3,2	2,79	3,67	3,65	4,66
MODEL 2- ARDL (6,3,6,2)	6,35***	2,37	3,2	2,79	3,67	3,65	4,66
MODEL 3- ARDL (6,5,5,5)	4,55**	2,37	3,2	2,79	3,67	3,65	4,66
MODEL 1-NARDL(6,4,3,4,4,4,3)	6,79***	1,99	2,94	2,27	3,28	2,88	3,99

MODEL 2- NARDL (1,4,4,3,3,2,4)	7,37***	1,99	2,94	2,27	3,28	2,88	3,99
MODEL 3-NARDL(3,4,4,3,4,4,4)	5,45***	2,18	3,25	2,59	3,76	3,54	4,93

\* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

Before analysing the potential impacts of sectoral value added, gross domestic product per capita, and human capital growth on sectoral emissions in both the short and long term, diagnostic tests were conducted to assess the presence of any issues related to normality, serial correlation, heteroskedasticity, and model building errors within the dynamic models. The results are presented in Table 4. All diagnostic tests were done with a 5% significance threshold for model predictions. In addition, Cusum and Cusum square analysis guarantee the validity of regression analyses.

**Table 4**

*ARDL and NARDL Model Diagnostic Tests*

	MODEL 1- ARDL	MODEL 2- ARDL	MODEL 3- ARDL	MODEL 1- NARDL	MODEL 2- NARDL	MODEL 3- NARDL
<b>JB</b>	0,73	0,36	0,13	4,26	5,65	0,79
<b>BG</b>	0,18	1,54	1,61	1,78	1,85	2,20
<b>BP</b>	0,80	0,85	0,70	0,52	1,07	1,20
<b>RR</b>	1,56	2,12	0,54	1,49	0,01	0,81

Note. JB: Jarque-Bera test statistics, BG: Breusch-Godfrey Serial Correlation LM Test, BP: Breusch-Pagan Godfrey, RR: Ramsey Reset Test.

According to Table 4, ARDL and NARDL estimations of the previously defined models have no diagnostic problems. Therefore, the short-run test results are arranged in Table 5 and Table 6.

**Table 5**

*ARDL Short-Run Coefficients*

MODEL 1-ARDL		MODEL 2-ARDL		MODEL 3-ARDL	
Dependent variable: $\Delta LIE_t$		Dependent variable: $\Delta LSE_t$		Dependent variable: $\Delta LAE_t$	
Explanatory variables	coefficient	Explanatory variables	coefficient	Explanatory variables	coefficient
D(LIE(-1))	-0.253**	D(LSE(-1))	0.415605***	D(LAE(-1))	0.125
D(LIE(-2))	-0.579***	D(LSE(-2))	0.0655	D(LAE(-2))	0.189
D(LIE(-3))	-0.325***	D(LSE(-3))	0.165	D(LAE(-3))	0.521***
D(LVI)	0.248**	D(LSE(-4))	0.217*	D(LAE(-4))	0.379**
D(LVI(-1))	0.167	D(LSE(-5))	0.310**	D(LAE(-5))	0.354**
D(LVI(-2))	-0.052	D(LVS)	0.625**	D(LVA)	-0.032
D(LVI(-3))	0.242**	D(LVS(-1))	-1.284***	D(LVA(-1))	-0.173**
D(LVI(-4))	0.025	D(LVS(-2))	-0.750***	D(LVA(-2))	-0.024
D(LVI(-5))	0.507***	D(LGDP)	-0.458*	D(LVA(-3))	0.244***
D(LGDP)	-0.112	D(LGDP(-1))	0.998***	D(LVA(-4))	0.289***
D(LGDP(-1))	0.077	D(LGDP(-2))	0.670***	D(LGDP)	-0.004
D(LGDP(-2))	0.307**	D(LGDP(-3))	-0.040	D(LGDP(-1))	0.042
D(LGDP(-3))	-0.053	D(LGDP(-4))	-0.015	D(LGDP(-2))	-0.067
D(LGDP(-4))	0.129	D(LGDP(-5))	-0.147***	D(LGDP(-3))	-0.336***
D(LGDP(-5))	-0.483***	D(LGHC)	-3.632*	D(LGDP(-4))	-0.377***
D(LGHC)	2.997**	D(LGHC(-1))	5.657***	D(LGHC)	-1.564
D(LGHC(-1))	1.783	CointEq(-1)*	-0.459***	D(LGHC(-1))	-4.196**
D(LGHC(-2))	5.987***			D(LGHC(-2))	-4.888***
D(LGHC(-3))	2.543			D(LGHC(-3))	-3.581**
D(LGHC(-4))	7.600***			D(LGHC(-4))	-3.102**
CointEq(-1)*	-0.379***			CointEq(-1)*	-0.452***
R <sup>2</sup>	0,85	R <sup>2</sup>	0,68	R <sup>2</sup>	0,71

\* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

**Table 6***NARDL Short-Run Coefficients*

<b>MODEL 1-NARDL</b>		<b>MODEL 2-NARDL</b>		<b>MODEL 3-NARDL</b>	
Dependent variable: $\Delta LIE_t$		Dependent variable: $\Delta LSE_t$		Dependent variable: $\Delta LAE_t$	
Explanatory variables	coefficient	Explanatory variables	coefficient	Explanatory variables	Coefficient
LIE(-1)	-0.339***	LVS+	0.202	LAE(-1)	-0.512**
LIE(-2)	-0.501***	LVS+(-1)	-0.992***	LAE(-2)	-0.500**
LIE(-3)	-0.333***	LVS+(-2)	-1.140***	LVA+	-0.119
LIE(-4)	0.424***	LVS+(-3)	-0.117	LVA+(-1)	-0.251**
LIE(-5)	0.270***	LVS-	1.205***	LVA+(-2)	-0.237**
LVI+	0.484***	LVS(-1)	-1.942***	LVA+(-3)	0.094
LVI+(-1)	-0.336**	LVS(-2)	-1.011**	LVA-	0.135
LVI+(-2)	-0.449***	LVS(-3)	0.345***	LVA(-1)	-0.797***
LVI+(-3)	-0.225*	LGDP+	-0.287	LVA(-2)	-0.733***
LVI-	0.183*	LGDP+(-1)	0.709***	LVA(-3)	-0.494***
LVI(-1)	-0.302**	LGDP+(-2)	0.962***	LGDP+	0.214*
LVI(-2)	0.437*	LGDP-	-0.736**	LGDP+(-1)	0.201*
LGDP+	-0.720***	LGDP(-1)	2.329***	LGDP+(-2)	0.372***
LGDP+(-1)	0.253*	LGDP(-2)	1.421***	LGDP-	-0.287**
LGDP+(-2)	0.583***	LGHC+	4.375	LGDP(-1)	1.047***
LGDP+(-3)	0.179	LGHC+(-1)	18.406***	LGDP(-2)	0.770***
LGDP-	0.103	LGHC-	-1.409	LGDP(-3)	0.482**
LGDP(-1)	0.903***	LGHC(-1)	2.466	LGHC+	-5.427**
LGDP(-2)	-0.321	LGHC(-2)	7.852***	LGHC+(-1)	7.784***
LGDP(-3)	0.356***	LGHC(-3)	4.303**	LGHC+(-2)	5.319**
LGHC+	-7.252**	ECM	-0.425***	LGHC+(-3)	5.490***
LGHC+(-1)	4.133*			LGHC-	-5.685**
LGHC+(-2)	4.611**			LGHC(-1)	-6.438***
LGHC+(-3)	-2.796			LGHC(-2)	-8.994***
LGHC-	5.391**			LGHC(-3)	-5.865***
LGHC(-1)	-1.459			ECM	-0.002***
LGHC(-2)	8.512***				
ECM	-0.227***				
R <sup>2</sup>	0,94	R <sup>2</sup>	0,83	R <sup>2</sup>	0,86

\* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

**Table 7***ARDL and NARDL Long-Run Coefficients*

<b>MODEL 1- ARDL</b>	EC = LIE - (0.8464***LVI -1.6794***LGDP + 7.1530*LGHC)
<b>MODEL 2- ARDL</b>	EC = LSE - (1.5289***LVS -1.2412***LGDP -11.1973***LGHC + 9.8593***)
<b>MODEL 3- ARDL</b>	EC = LAE - (0.3148LVA -0.1763**LGDP + 1.1582LGHC + 10.1728***)
<b>MODEL 1-NARDL</b>	EC = LIE-(2.1940**LVI_POS + 3.7039LVI_NEG -2.5334**LGDP_POS -6.4309*LGDP_NEG - 11.0028LGHC_POS +22.9003*LGHC_NEG + 8.9563***)
<b>MODEL 2-NARDL</b>	EC = LSE - (2.3430***LVS_POS + 3.9326***LVS_NEG -2.3453***LGDP_POS - 4.3045***LGDP_NEG -36.3991***LGHC_POS -16.6829***LGHC_NEG + 9.3349***)
<b>MODEL 3-NARDL</b>	EC = LAE - (73.6412LVA_POS + 361.2599LVA_NEG -12.4062*LGDP_POS - 593.2682*LGDP_NEG -5956.3491*LGHC_POS+66.6828*LGHC_NEG)

\* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

**Table 8***Asymmetry Tests*

<b>MODEL 1- NARDL</b>		<b>MODEL 2- NARDL</b>		<b>MODEL 3- NARDL</b>	
$W_{LR,LVI}$	0,84	$W_{LR,LVS}$	1,37	$W_{LR,LVA}$	0,59
$W_{LR,LGDP}$	2,55	$W_{LR,LGDP}$	1,59	$W_{LR,LGDP}$	2,01
$W_{LR,LGHC}$	1,37	$W_{LR,LGHC}$	6,53**	$W_{LR,LGHC}$	0,04
$W_{SR,LVI}$	2,28	$W_{SR,LVS}$	2,35*	$W_{SR,LVA}$	1,92
$W_{SR,LGDP}$	4,42**	$W_{SR,LGDP}$	2,59*	$W_{SR,LGDP}$	0,83

$W_{SR,LGHC}$	2,91*	$W_{SR,LGHC}$	5,07**	$W_{SR,LGHC}$	3,69**
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\* denotes %10 significance level, \*\* denotes %5 significance level and \*\*\* denotes %1 significance level.

## Discussion

Based on the findings from Table 5, the short-term coefficients indicated that the preceding emission levels decreased the current industrial sector emissions, whereas the case was exactly the opposite in both the agriculture and services sectors. As a result of the growth in value added, there was a decrease in emission rates in the services sector, whereas emission rates increased in the industrial and agricultural sectors. The increase in per capita income had a negative impact on emissions in the early stages of a delay but a favourable impact as the delay progresses. Although the development of human capital contributes to a decrease in emissions produced by the service sector within the current period, it ultimately results in an increase in these emissions. It is well known that the significant reduction in emissions in the agriculture sector can be attributed to its investment in human capital. There is a direct correlation between an industry's increase in human capital and its increase in emissions. Given the asymmetric effects shown in Table 6, agricultural and industrial emissions have a positive effect on the current period. Although the improvements in value added contribute to a decrease in sector emission rates, per capita income growth led to an increase in sector emissions. Agriculture is the only industry where a reduction in human capital has positive effects.

Long-term environmental degradation is caused by the increases in the added value of specific sectors, such as industry and services. Conversely, it is widely acknowledged that higher per capita income can effectively lower overall emission levels across industries. The data in Table 7 indicates that enhancing human capital investment leads to a reduction in emissions, particularly within the services sector. Furthermore, asymmetric models offer further support for these findings.

According to the data shown in Table 8, industry sector emissions displayed short-term asymmetries when per capita income and human capital are considered. In the short term, there was an asymmetry between agriculture sector emissions and human capital. On the other hand, emissions from the services sector had both short- and long-term asymmetric effects on human capital. In addition, this verified the existence of a short-term imbalance in terms of added value and per capita income.

It is vital to account for the presence of asymmetric factors to appropriately recognise these traits and choose the most relevant tactics. Therefore, from a sectoral point of view, the most important instrument for reducing emissions in the industrial sector is boosting the level of welfare by generating an increase in per capita income. The rise in the industry's overall emission levels is directly attributable to both the expansion of its production capacity and its human capital. It has been determined that enhancing human capital and promoting welfare are essential steps in mitigating emissions within the services sector. Regarding the agricultural sector, it has been observed that human capital has an uneven effect on emissions in the short term.

The research results highlight the significance of mitigating emissions in the industrial sector because of its manufacturing methods that are high in emissions. This is consistent with previous research that emphasises the role of different sectors in contributing to pollution. The concept of the Environmental Kuznets Curve (EKC) posits a curvilinear association between economic development and pollution, characterised by an inverted U-shaped connection. Notably, the studies conducted by Hettige et al. (2019) and Fujii and Managi (2013) have shown varied patterns within different industries. Although the services sector exhibits more environmentally friendly production practices, suggesting the possibility of reducing emissions through sector-specific interventions, there are clear complications in the dynamics of emissions within each sector. In their study, Moutinho et al. (2017) observed a pattern in Portugal and Spain that exhibited an inverted N-shaped trend, indicating the presence of intricate connections between economic development and emissions. In a study conducted by Kumbaroğlu (2011) in Turkey, it was found that energy generation, industrial activities, and

transportation are major sources of pollution. The study highlighted the significance of conducting industry-specific assessments to gain deeper insights into these variables. Hence, the focus of the presented study on sectoral solutions is consistent with existing scholarly works, underscoring the necessity for customised approaches to address emissions, particularly in sectors characterised by high levels of emissions such as industry.

Consistent with prior research, the study's results confirmed the existence of a short-term relationship between sectoral carbon emissions and per capita income. Consistent with the findings of Ru et al. (2018) and Aslan et al. (2018), short-term increases in per capita income affect all sectors and result in higher levels of consumption and emissions, especially in industries that employ emission-intensive production methods. Nevertheless, although these short-run consequences are detrimental, Ru et al. (2018) propose that in the long run, income-enhancing policies can increase environmental consciousness and decrease emissions, especially in the services industry. Studies by Ru et al. (2018) and Aslan et al. (2018) illustrate that the correlation between economic growth and emissions differs by sector. While certain industries, including transportation and commerce, adhere to the Environmental Kuznets Curve (EKC) hypothesis, this is not the case for others. Furthermore, a study conducted by Cil (2023) in Turkey suggests that energy regulations and Foreign Direct Investment (FDI) have the potential to reduce pollution. This underscores the significance of implementing sector-specific policy interventions. Hence, in conjunction with sector-specific initiatives, it is critical to implement enduring income-enhancing policies to attain sustainable environmental objectives in Turkey.

The results obtained from this research validate the significance of developing human capital as a critical and enduring approach to attaining sustainable environmental objectives in Turkey. Expanding upon the investigations conducted by Ojaghrou et al. (2023) and Ojaghrou and Ugurlu (2023), this research emphasised the significance of human capital investments in addressing carbon emissions in all sectors, as these studies highlight the complex nature of sectoral emissions patterns that are impacted by variables other than economic growth, including energy consumption and governance issues. Although the industrial sector may experience short-term advantages, the long-term positive effects are evident across all sectors. This is consistent with ecological modernization theory's proposition that inequitable adoption of green fuels and technologies requires targeted interventions to effectively promote sustainability. Therefore, in conjunction with broader environmental policies and initiatives, investing in human capital surfaces as an essential pathway to promote sustainable development and mitigate sectoral carbon emissions in Turkey.

The findings underscore the importance of implementing industry-specific strategies to reduce emissions, with a specific focus on industries that create substantial emissions. Transitioning to more ecologically sustainable production methods is critical for long-term emission reduction. Long-term implementation of policies promoting national welfare is necessary to increase environmental consciousness and decrease emissions. Additionally, it is advisable to optimise expenditures on human capital development in Turkey by implementing a balanced investment strategy, through a balanced investment strategy, with a focus on achieving sustainable environmental goals. Consistent with our research outcomes, Hashmi et al. (2023) propose the implementation of sector-specific legislative strategies as an efficient means of reducing carbon dioxide emissions. Their research emphasises the significance of sector-specific legislative interventions in attaining emission reduction objectives, thereby underscoring the need for targeted policies. In the same way, Degirmencioglu Aydin and Aydin (2023) emphasise the necessity of implementing a range of legislative obligations to tackle environmental degradation, with a specific focus on the construction industry. The aforementioned studies provide further support for our conclusions and underscore the importance of sector-specific policies and legislative actions in promoting sustainable development and reducing carbon emissions.

It is important to recognise the restrictions inherent in the examined research, encompassing limitations in data availability, variances in methodology, and the intricate nature of sectoral dynamics.

Furthermore, although the Environmental Kuznets Curve (EKC) hypothesis offers a valuable conceptual framework, its relevance may differ depending on the specific setting and industry, therefore requiring careful consideration when extrapolating the results.

## **Conclusions and Implications**

The rapid rise in emissions is endangering the ability to create a sustainable world for future generations. As a result, the creation and implementation of environmental development policies to reduce emissions has become the most serious issue of the present day. The rise in emissions is due to both the growth of economic activity and increasing consumption patterns. To determine the sectoral measures to be taken in this regard, the emissions resulting from economic activities in Turkey were evaluated using sector-specific models. These emissions are associated with per capita income, human capital, and the value added of each sector for the purposes of the study. The results indicate that sectoral solutions are required to reduce and control emission rates in the country's industrial, services, and agricultural sectors.

High emission levels in the industry sector have prompted the industry to take steps to reduce emissions during the current period. However, in other industries, there was no clear link found between past and present emissions. This may be because the contribution of these sectors to total emissions is not considered to be as significant as that of the industry sector. When considering total sectoral output, it is evident that short-term increases in production create high levels of emission in the industrial and agricultural sectors. Though, in the services sector, production growth was achieved by more eco-friendly methods. Increases in per capita profits, on the other hand, induced demand-side pressure on the sectors and triggered an increase in emission levels. Since the production in the agriculture and services sectors is supported by environmental technologies, emission levels in these sectors have decreased in tandem with the growth of human capital. The development of human capital in the industrial sector resulted in the emergence of production techniques that damage the environment at the expense of increased production. In the long run, production increases in the industry and services sectors have been complemented by high levels of emissions. Individuals whose welfare improves become more concerned about environmental degradation in the long term. As a result, increasing per capita income promotes environmental awareness and reduces sectoral emissions. Furthermore, investing in human capital reduces the emissions generated by the services sector. The asymmetry analysis highlights the requirement of employing more eco-friendly production methods in the industrial sector. Furthermore, the development of human capital has a reducing effect on environmental degradation in all sectors. The asymmetry analysis also confirms that individuals with a high level of welfare attach more importance to a sustainable environment where sectoral emissions are controlled.

According to the general assessment based on the findings to reduce sectoral emissions in Turkey, precautions should be focused primarily on the industrial sector, which utilizes emission-intensive production methods. Unless the industrial sector is equipped with more environmentally friendly technology, increased production will have a significant negative impact on the environment. In the short term, production increases in the service sector do not cause a significant amount of pollution, but they have negative long-term effects. Therefore, it is vital to shift to production processes that reduce emission levels in both the industrial and service sectors in the long run. Short-term increases in per capita income have led to an increase in sectoral consumption and emissions. However, in the long term, income-boosting policies have positive effects by improving environmental awareness. Therefore, in order to achieve a sustainable environmental goal, policies that promote national welfare should be implemented with a long-term perspective. According to the results, the long-term human capital development has a favourable impact on the environment by reducing emission levels in all sectors. Furthermore, the short-term positive human capital-environment relationship could only be confirmed for the industrial sector. Therefore, human capital development plays a crucial role as a long-term policy

tool in fostering a sustainable environment in Turkey. Human capital development, on the other hand, can be accomplished at the expense of other investments. As a result, policies are recommended to optimise human capital development expenditures with a balanced investment strategy.

### **Suggestions for Future Research**

Subsequent investigations might further explore the advancement and implementation of environmentally friendly technology customized for specific industries in Turkey. The examination of the efficacy of these technologies in diminishing emissions across diverse sectors, with a specific focus on industry, has the potential to yield significant knowledge for policymakers and corporations seeking to address environmental deterioration while simultaneously sustaining economic expansion. Further examination of the long-lasting effects of policies that increase the wealth on environmental awareness and emissions specific to certain sectors is required. The inquiry may explore the effects of sustained increases in per capita income on consumption patterns, manufacturing methods, and environmental attitudes over a prolonged timeframe, providing valuable perspectives for developing more sustainable economic strategies.

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