Chapter 1

Understanding Economic Growth in Türkiye Through Economic, Social and Environmental Indicators

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Abstract

Economic growth is among the fundamental objectives of a country's policymakers to ensure households live in prosperity. Therefore, certain social, economic, and environmental policies are established to achieve these objectives. To this end, the policies that Türkiye will implement to raise living standards in a sustainable manner are of great importance. According to the World Bank (2025), Türkiye is the 17th largest economy in the world as of 2024. Real GDP growth averaged 5.4% between 2002 and 2022, and per capita income (in real terms) doubled. Therefore, it is crucial to examine the factors affecting growth in Türkiye. This research examines the role of economic, social, and environmental factors affecting economic growth in Türkiye. Considering annual data covering the period 1990 to 2022, the relationships between variables were revealed using the Autoregressive Distributed Lag (ARDL) method. The results indicate that gross fixed capital formation (GFCF), average years of schooling (ASE), and greenhouse gas emissions (GHG) have positive effects on growth. Conversely, life expectancy (LE) was found to have a negative impact, while the labor force (LF) and average air temperature (AAT) were statistically insignificant. These findings suggest that Türkiye's sustainable growth policies must balance production capacity with human and environmental factors.

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1. Introduction

Economic growth is one of the basic dynamics that increases a country's level of prosperity and supports sustainable development. Consequently, economic literature analyzes the dynamics and impacts of economic growth and examines the role of economic, social, and environmental indicators within growth models. Economic growth is not merely an increase in the market value of goods produced during a specific period; it also involves fundamental transformation extending to the entire social and institutional structure of an economy. In the early stages of the development of current economic growth theories, labor, which can replace capital in producing a certain level of output, received significant attention alongside the role of capital (Ara, 1961). Beyond labor and capital accumulation, growth theories have focused on many factors that are fundamental determinants of economic growth including natural resources, technological development, urbanization, energy consumption, foreign trade, health expenditures, and human capital. Moreover, research has been conducted to examine how environmental factors relate to economic growth, as well as how social factors influence economic growth.

School enrollment shows a strong association with economic growth, making it one of the key social indicators influencing development. There is strong evidence that a positive relationship exists between school enrollment and growth (Barro, 1991; Sala-i-Martin, 1997). In cross-country analyses and in economic and environmental modeling, the average school enrollment rate serves as a measure of educational attainment and the stock of human capital (Potančoková et al., 2014). In addition, mixed results have been obtained regarding the nexus between LE and economic growth. Acemoglu and Johnson (2007) reported no evidence that substantial external increases in average LE translated into notable gains in economic growth, whereas Lorentzen et al. (2008) identified a positive link between rising LE and faster economic growth.

In recent years, environmental concerns have been incorporated into policy-making, especially within development and growth strategies (Costantini and Monni, 2008). The nexus between economic growth and environmental indicators is also controversial. Industrialists typically argue that environmental policy harms capital accumulation and growth by increasing abatement costs. Environmentalists, on the other hand, argue that environmental policy is necessary to ensure sustainable growth (Bovenberg and Smulders, 1996).

In recent years, Türkiye has seen significant developments in economic, social, and environmental indicators. The Turkish economy has recorded record growth, rising from 18th to 11th place globally between 2003 and 2021. Türkiye has outperformed its European counterparts in terms of growth rate, with an average annual GDP growth of 5.4% between 2002 and 2022 (Ministry of Industry and Technology, 2025). The average length of education increased by 2 years between 2011 and 2023, reaching 9.3 years for the population aged 25 and over (TURKSTAT, 2023a). LE, which was 68 in 1990, reached 78 in 2022 (World Bank, 2025). Per capita GHG were estimated at 4 tons of CO_2 equivalent in 1990, rising to 6.3 tons in 2020 and 6.7 tons in 2021 (TURKSTAT, 2023b). Türkiye's average autumn temperature for 1991-2020 is 15.3 °C (MGM, 2025). Based on the above information, this study examines the economic, social, and environmental factors that have influenced economic growth in Türkiye from 1990 to 2022.

The study is structured as follows: Section 2 reviews the literature, Section 3 explains the data and empirical strategy, Section 4 presents the findings, and Section 5 concludes with policy recommendations.

2. Literature

The literature on economic, social, and environmental factors affecting economic growth is summarized in this section.

Neoclassical growth theory (Solow, 1956) summarizes how stable economic growth can be achieved through the appropriate use of labor, capital, and technology as its driving forces. Apergis and Payne (2010) found that labor and capital increased economic growth in South America, and Ocal and Aslan (2013) found the same in Türkiye. According to Gibescu (2010), there is a significant association between economic growth and GFCF in Central and Eastern European (CEE) nations. Omri (2013) in MENA countries and Acheampong et al. (2021) in 23 emerging economies found that capital and labor are positively and negatively related to economic growth, respectively. Bhattacharya et al. (2016) in 38 countries demonstrated that capital and labor improve economic growth.

Alongside physical capital, human capital is also among the crucial factors affecting economic growth. Average years of schooling are commonly employed in empirical research as a proxy for human capital. Initial studies in literature produced varying conclusions regarding the link between human capital and economic growth. Results have been obtained indicating that human capital can have a positive (Barro, 1991; Mankiw et al., 1992), negative, or insignificant effect on economic growth (Islam, 1995). Jalil and

Idrees (2013) showed that investments in education in Pakistan can increase economic growth. Self and Grabowski (2004) show that primary education has a strong causal effect on growth, whereas the evidence supporting a similar impact from secondary education is comparatively weaker.

Conversely, there is a close connection between health and economic growth. Economic development is driven by fostering a healthy population, and the life-cycle model illustrates how citizens health, wealth, and consumption patterns shape the income prospects of subsequent generations (Alhassan et al., 2021). Alhassan et al. (2021) showed that LE in Nigeria exerts a significant positive influence on real GDP in both the short- and long-term. Similarly, Ngangue et al. (2015) found that higher average LE enhances economic growth across 141 developing countries. Munir and Shahid (2021) demonstrated that LE has a positive association with economic growth in South Asian nations, while Lawal et al. (2023) confirmed that longer LE contributes positively to economic growth in Nigeria.

Among the first economists to incorporate climate into economic growth models is Nordhaus (1977). Rising carbon emissions from global warming pose serious challenges to human life and economic activity, resulting in reduced productivity, a shrinking labor force, lower economic output, and weakened political stability (Li and Wei, 2021). Azam (2016) demonstrated that environmental pollution hinders economic growth in 11 Asian nations, while Omri (2013) highlighted that CO_2 emissions exert a substantial negative impact on per capita GDP in MENA countries. In contrast, Zhai and Song (2013) estimated that CO2 emissions have a positive impact on per capita GDP in China, and Rehman et al. (2013) found the same in Pakistan.

3. Data and Methodology

In the study, gross domestic product (GDP) per capita calculated using purchasing power parity is used as the dependent variable. The independent variables were labor force (LF), the ratio of gross fixed capital formation to GDP (GFCF), average school enrollment rate (ASE), average life expectancy calculated from life expectancy at birth (LE), Average Air Temperature (AAT), and greenhouse gas emissions (GHG). Due to missing data for some variables in certain years, the study's dataset is limited to the period 1990-2022. "With the exception of GFCF, expressed as a ratio, and AAT, which includes negative values, the natural logarithms of all other variables were applied in the analysis. The variables and their descriptions are given in Table 1.

Table 1: Description of variables

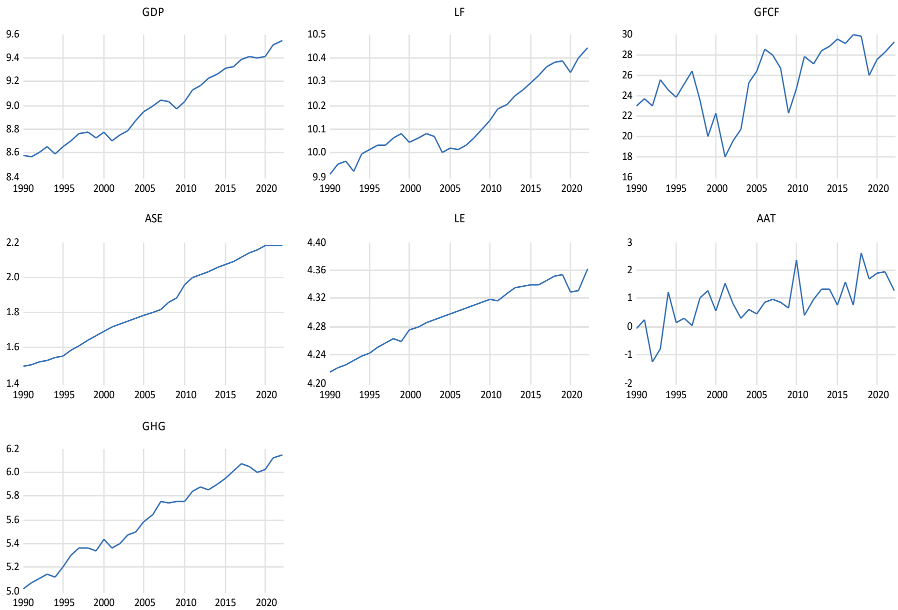
Variable	Description	Sources
GDP	Gross domestic product per capita (at 2015 constant prices, $)	Human Development Reports
Economic indicators		
LF	Total labor force in the country	World Bank
GFCF	Gross fixed capital formation	
Social indicators		
ASE	Average schooling duration per year	Human Development Reports
LE	Life expectancy at birth (average lifespan) by year	
Environmental indicators		
AAT	Annual average air temperature, degrees celsius	World Bank, Climate Change Knowledge Portal,
GHG	Total greenhouse gas emissions (million tons)	TURKSTAT (2023b)

The descriptive statistical information for the series is shown in Table 2. Looking at the descriptive statistics of the series, the standard deviation, which is expressed as volatility in daily life, is highest in GFCF and lowest in LE. The Jarque-Bera test indicates that the series aligns with a normal distribution. The time path graph of the variables is presented in Figure 1.

Table 2: Descriptive statistics

	GDP	LF	GFCF	ASE	LE	AAT	GHG
Mean	8.9867	10.1335	25.4852	1.8365	4.2953	0.8655	5.6121
Median	8.9699	10.0706	25.9776	1.8019	4.3019	0.858	5.6432
Maximum	9.5507	10.4433	29.8571	2.1760	4.3627	2.617	6.1473
Minimum	8.5673	9.9113	17.9503	1.4941	4.2152	-1.237	5.0213
Std. Dev.	0.3089	0.1567	3.2128	0.2320	0.0430	0.8110	0.3480
Skewness	0.2823	0.5650	-0.5583	0.0641	-0.3120	-0.2396	-0.1185
Kurtosis	1.7283	1.9870	2.4578	1.6113	1.9026	3.5360	1.7094
Jarque-Bera	2.6621	3.1665	2.11902	2.6740	2.1914	0.7109	2.3672
Probability	0.2641	0.2052	0.34662	0.2626	0.3342	0.7008	0.3061
Observations	33	33	33	33	33	33	33

Fgure 1: The time path graph of the variables



The study's model was examined through the ARDL bounds testing approach. Initially, a unit root (UR) test was conducted to assess the stationarity of the variables. Subsequently, the ARDL bounds test was employed to evaluate the short-run and long-run coefficients between the explained and explanatory variables. Considering the dependent and independent variables of the study, the model of the study is presented in Equation 1.

$$GDP = \beta + \theta_1 LF_t + \theta_2 GFCF_t + \theta_3 ASE_t + \theta_4 LE_t + \theta_5 AAT_t + \theta_6 GHG_t + \varepsilon_t \quad (1)$$

The stationarity of the variables in Equation (1) was examined using the Augmented Dickey-Fuller (ADF, 1981) and Phillips-Perron (PP, 1988) UR tests, with the null hypothesis assuming the presence of a UR in the series

The ARDL bounds testing approach introduced by Pesaran et al. (2001) contrasts with the cointegration methods of Engle and Granger (1987) and Johansen and Juselius (1990), as it enables the application of cointegration analysis to series with varying degrees of stationarity.

The ARDL method stands out from other methods due to its advantages, such as providing robust and effective results even in small samples, offering the possibility of analyzing long- and short-term dynamics together in an unrestricted error correction model (UECM), and being able to estimate short-term errors (Narayan and Narayan, 2004). Considering the data set, the UECM Equation (2) is used in the study for cointegration.

$$\Delta GDP_t = \alpha_1 + \sum_{t-1}^{m} \varphi_{1i}\Delta GDP_{t-i} + \sum_{i-0}^{m} \varphi_{2i}\Delta LF_{t-i} + \sum_{i-1}^{n} \varphi_{3i}\Delta GFCF_{t-i} + \sum_{i-1}^{p} \varphi_{4i}\Delta ASE_{t-1} + \sum_{i-1}^{q} \varphi_{5i}\Delta LE_{t-1} + \sum_{i-11}^{r} \varphi_{6i}\Delta AAT_{t-1} + \sum_{t-1}^{r} \varphi_{7i}\Delta GHG_{t-1} + \gamma_1 GDP_{t-1} + \gamma_2 LF_{t-1} + \gamma_3 GFCF_{t-1} + \gamma_4 ASE_{t-1} + \gamma_5 LE_{t-1} + \gamma_6 AAT_{t-1} + \gamma_7 GHG + \varepsilon_t \quad (2)$$

Here, Δ is the difference operator. ε_t is the error term. $\varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5, \varphi_6$ and φ_7 represent the short-term relationship, while $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6$, and γ_7 and represent the long-term relationship. The mutual nexus between the variables was examined using the UECM model, as summarized in Equation 2, and including the F-test statistic. The hypotheses developed regarding the F-test statistics are given below.

$$H_0 = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$$

$$H_1 = \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq \gamma_6 \neq \gamma_7 \neq 0$$

The Schwarz Information Criterion (SIC) was employed to identify the optimal lag length, while cointegration among the variables was assessed by analyzing the computed F-test statistics. Cointegration is determined when the F-test statistic exceeds the critical value. When the variables exhibit a long-run relationship, the ARDL model outlined in Equation 3 is applied for estimation.

$$\Delta GDP_t = \alpha_0 + \sum_{i=1}^{m} \theta_{1i}\, \Delta GDP_{t-i} + \sum_{j=0}^{n} \theta_{2i}\, \Delta LF_{t-i} + \sum_{k=0}^{p} \theta_{3i}\, \Delta GFCF_{t-i} + \sum_{l=0}^{q} \theta_{4i}\, \Delta ASE_{t-i} + \sum_{m=0}^{r} \theta\Delta\theta_{5i_{t-i}} + \sum_{n=0}^{s} \theta_{6i} AAT_{t-i} + \sum_{o=0}^{v} \theta_{7i} GHG + \varepsilon_t \quad (3)$$

To identify short-term relationships between variables, an ARDL-based error correction model can be used as specified in equation 4.

$$\Delta GDP_t = \alpha_3 + \sum_{i=1}^{m} \varphi_{1i}\, \Delta GDP_{t-i} + \sum_{j=0}^{n} \varphi_{2i}\, \Delta LF_{t-i} + \sum_{k=0}^{p} \varphi_{3i}\, \Delta GFCF_{t-i} + \sum_{l=0}^{q} \varphi_{4i}\, \Delta ASE_{t-i} + \sum_{m=0}^{r} \varphi\Delta\ \varphi_{5i_{t-i}} + \sum_{n=0}^{s} \varphi_{6i} AAT_{t-i} + \sum_{o=0}^{v} \varphi_{7i} GHG_{t-i} + \phi ECM_{t-i} + \varepsilon_t \quad (4)$$

4. Results

4.1. UR Test Results

The ADF and PP UR test results for the series variables are presented in Table 3. According to the ADF test results, in the fixed model, the LE and AAT variables are stationary at the level, while the other variables do not become stationary at the first difference. According to the results of the PP test, only the AAT is stationary at the level in the fixed model, while the other variables become stationary when the first differences are taken. Since the dependent variable, GDP, can become stationary in the first difference, the model of the study can be analyzed with ADRL.

Table 3: UR test

Variables	ADF		PP	
	C	C+T	C	C+T
GDP	0.63414	-2.46173	1.95829	-2.35782
LF	0.33157	-1.25367	0.33157	-1.24609
GFCF	-1.86428	-2.617326	-1.86428	-2.68591
ASE	-0.22012	-2.14344	-0.25431	-2.03546
LE	-2.93352*	0.85244	-1.65290	-2.67007
AAT	-3.73720***	-6.30811***	-3.72001***	-33.58600***
GHG	-0.74191	-2.88648	-1.22883	-2.89112
ΔGDP	-5.66002***	-5.70730***	-6.38206***	-7.61714***
ΔLF	-5.52351***	-5.66131***	-5.52355***	-5.66131***
ΔGFCF	-5.85439***	-5.76069***	-5.92235***	-5.82129***
ΔASE	-3.29822**	-3.20232	-3.25707**	-3.14366
ΔLE	-6.06079***	-6.03514***	-4.09004***	-3.32949*
ΔAAT	-	-	-	-
ΔGHG	-5.83451***	-5.75963***	-8.27719***	-10.3819***

Note: *****$p < 0.01$*, ***$p < 0.05$*, **$p < 0.1$*. The term Δ denotes the first difference of the variables. C; Constant and C+T; Constant and Trend*

In the model established in the study, the dependent variable GDP is stationary at the I(1) level in the fixed model, allowing the study model to be analyzed using the ARDL method.

Table 4 presents the outcomes of the Zivot–Andrews (Z-A) test (1992), which accounts for structural breaks in the variable series, with GDP serving as the dependent variable. The C Model in Table 3 should be interpreted because the dependent variable exhibits the characteristics of a fixed model. According to Model A, which considers the break in the constant and the trend, the test statistics of the dependent variable are smaller than the critical values at the 1% and 5% significance levels in absolute value, indicating that the constant has a UR. In the Z-A UR tests, structural breaks within the series are found to have no significant impact on the ADF UR results.

Table 4: Z-A UR test

Variables	C (Model A)		C+T (Model C)	
	Minimum t-statistic	Break period	Minimum t-statistic	Break period
GDP	-4.3644	1999	-4.3978	2001

Note: Critical values for Model A: 1%: -5.34 and 5%: -4.93. Critical values for Model C: 1%: -5.57 and 5%: -5.08. C; Constant and C+T; Constant and Trend

4.2. Cointegration and Short- and Long-Term Results

Table 5 presents the estimated outcomes of the ARDL bounds test based on Equation (2). The calculated F statistics are greater than the upper critical value at the 1% significance level. Furthermore, due to the small sample size, the F statistic is higher than the upper critical value at the 1% significance level. Therefore, the hypothesis that there is no cointegration in the model is rejected. SIC and 2 lags were considered in determining the lag lengths in the model.

Table 5: ARDL result

F-statistic	k	
20.115090	6	
Critical value bounds		
Sample Size: n=35	Lower Bound-I(0)	Upper Bound-I(1)
10%	2.254	2.388
5%	2.685	3.960
1%	3.713	5.326

Note: k shows the number of independent variables.

Table 6 shows the short- and long-term forecast results. GDP has a meaningful and positive relationship with its lagged value. In the short term, the GFCF and GHG variables are statistically significant. The GFCF and GHG variables have a significant and positive effect on real GDP in the short term. That is, a one-point increase in GFCF in the short term increases real GDP by 0.01288 points, while a 1% increase in GHG increases GDP by 0.28%.

Here, the negatively signed and statistically significant coefficient (-0.70216) of ECT indicates that 70% of the deviation in period t-1 will be corrected in period t. If there is a short-term shock between the variables, a higher ECT_{t-1} coefficient will lead to a faster return to equilibrium over time.

Long-term results are presented in Table 6. The GFCF coefficient is statistically significant in the long term, coming out at around 0.018. A one-point increase in GFCF increases GDP by 0.018 points. This outcome aligns with Wang and Lee (2022) for China, Okumus et al. (2021) for G7 economies, and Acheampong et al. (2021) for 23 developing nations, all of which confirm the positive impact of GFCF on growth. ASE also shows a significant positive influence on GDP, with a 1% increase in ASE raising GDP by 0.86%, this aligns with the results of Mankiw et al. (1992) and Barro (1997). In contrast, LE exerts a significant negative effect on GDP, as a 1% rise in LE reduces GDP by roughly 2.35%. This finding supports the conclusions of Acemoglu and Johnson (2007) and Ogunleye et al. (2014), who argue that life expectancy does not foster growth. Furthermore, a 1% increase in GHG boosts GDP by nearly 40%, in line with Zhai and Song (2013) and Rehman et al. (2013). This outcome reflects Türkiye's reliance on the growth-then-cleaning model outside of recent periods. Finally, no significant long-term relationship was identified between LF and AAT and GDP.

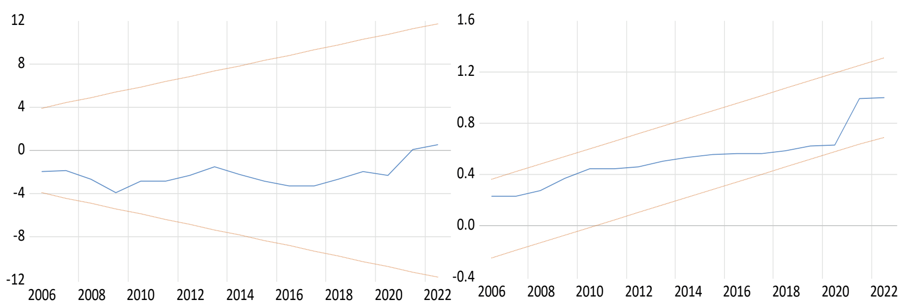
Table 6: ARDL(1,2,0,2,1,1,0) short- and long-run results

Short-run coefficients		
Variables	Coefficient	Std. error
Constant	9.25862***	2.60930
GDP(-1)	0.29783***	0.08599
LF	-0.17885	0.14208
LF(-1)	0.08428	0.15543
LABOR(-2)	0.20666	0.12600
GFCF	0.01288***	0.00180
ASE	0.49206	0.35279
ASE(-1)	-0.78668	0.50239
ASE(-2)	0.89852**	0.32075
LE	0.021319	0.52740
LE(-1)	-1.66982	0.58482
AAT	-0.00275	0.00710
AAT(-1)	0.01975***	0.00673
GHG	0.28087**	0.08809
ECT(-1)	-0.70216***	0.04658
Long-run coefficients		
Variables	Coefficient	Std. error
Constant	13.18579***	4.07806
LF	0.15964	0.14020
GFCF	0.01834***	0.00315
ASE	0.86005***	0.23268
LE	-2.34773***	0.81124
AAT	0.02420	0.01616
GHG	0.40001***	0.10805
R^2	0.9981	
Adj. R^2	0.9967	
F-statistic	721.9333***	
DW	2.10864	
Observations	33	
Diagnostic test statistics		
Test type	Statistic	Prob.value
JB normality test	1.3155	0.518
BG Serial Correlation LM test	2.4344	0.126
BPG Heteroscedasticity Test	1.0092	0.484
Ramsey RESET test	0.1561	0.698

Note: ******$p < 0.01$, **$p < 0.05$, *$p < 0.1$***

Table 6 displays the diagnostic test outcomes. According to the Breusch-Godfrey Serial Correlation LM test statistics, there is no autocorrelation problem. The normality assumption is satisfied according to the Jarque-Bera test statistic, the constant variance assumption is satisfied according to the Breusch–Pagan-Godfrey test statistic, and there is no modeling error according to the Ramsey RESET test statistic. Thus, the reliability and validity of the model are ensured. The CUSUM and CUSUMQ graphs developed by Brown et al. (1975) also reveal the stability of the model. When examining the CUSUM and CUSUMQ graphs, it is seen that the curves obtained from the test statistics related to the error terms are within the critical limits at the 5% significance level (Figure 2). Therefore, it can be stated that the long-term estimates of ARDL are stable.

Figure 2: CUSUM and CUSUMQ



5. Conclusion

This study examines the impact of economic, social, and environmental factors affecting growth dynamics in Türkiye between 1990 and 2022, employing the ARDL approach. The results obtained from the study indicate that, among economic factors, the effect of labor on growth is positive and insignificant, while the effect of GFCF on growth is estimated to be positive and significant. Among social factors, the effect of average years of schooling and life expectancy on growth was found to be positive and negative, respectively. Within the set of environmental factors, average air temperature showed no significant impact on growth, whereas GHG were found to have a positive effect.

According to findings obtained without conducting research, infrastructure investments in Türkiye should be encouraged, as well as public/private sector investments in manufacturing and technology, due to the significant positive impact of fixed capital formation on growth. At this point, tax breaks for the private sector, low-interest loans, and improvements in the investment environment will pave the way for a more effective growth environment.

The contribution of the workforce to growth can be increased to a more meaningful level with the help of policies focused on qualified human resources and productivity, by implementing vocational training programs, technology adaptation, and reforms that will increase labor market flexibility.

Again, considering the positive impact of the average years of schooling on growth, the focus should be on quality education. In this regard, digital literacy training and the use of artificial intelligence that meet the requirements of our age can be widespread. In addition, demographic risks on growth can be reduced by providing more support for services related to health infrastructure.

Environmental policies at national and international levels are becoming increasingly important. Therefore, the implementation of ambitious environmental policies is crucial for growth. The positive impact of greenhouse gas emissions, which represent environmental pollution, on growth could mean dependence on polluting industrialization or energy-intensive sectors in Türkiye. This condition cannot be maintained over the long run. At this point, Türkiye has recently taken important steps towards both increasing growth and improving environmental quality by increasing green energy investments. Drought-resistant agricultural policies, water management, and disaster risk reduction plans should be implemented, taking into account the insignificant micro effects of air temperature.

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