The role of governance in ensuring economic growth and reducing emissions: a case study of Bulgaria

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Abstract. In most instances, economic growth is accompanied by heightened emissions. Nevertheless, effective governmental governance can potentially ameliorate the adverse environmental ramifications of economic growth. In this vein, utilizing a case study of Bulgaria, this article seeks to investigate the links between GDP levels, emission levels, and the quality of governmental administration. This study utilizes annual data for Bulgaria spanning from 1996 to 2022. To derive the outcomes, the following methodologies were employed: correlation analysis; logarithmic transformation; Dickey-Fuller test calculation; determination of the first differences of logarithms for non-stationary time series; correlogram construction; Granger causality test calculation; and graphical analysis. The study revealed causal links from RL to CC and from METH to GE in the short term. Moreover, connections were identified from GDP to CC, from RL to CC, and from METH to GE. In the long term, causal links were observed from GE to VA, from PV to CO2E, from PV to METH, from RL to CO2E, from RL to VA, from VA to GE, from VA to GDP, and from CO2E to GE. In all cases, the links were unidirectional. No direct correlation was detected between GDP and emission levels, as well as between GDP and the quality of government regulation in the case of Bulgaria. All computations were conducted using the EViews 12 software.

1 Introduction

One of the primary indicators of economic development in any country is its Gross Domestic Product (GDP). Typically, GDP growth is directly linked to resource consumption. As a natural outcome of production processes and energy and raw material consumption, emissions into the atmosphere and water sources occur, leading to environmental pollution. In most cases, countries with higher levels of GDP production have more developed industries, which often coincide with higher levels of greenhouse gas emissions and other pollutants. However, such a dependency is not absolute.

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For instance, contemporary economic trends increasingly focus on environmental efficiency and transitioning to clean energy sources. This may lead to a situation where economically developed countries commence reducing their emissions by employing innovative technologies and implementing policies that promote environmental sustainability. This entails investments in infrastructure upgrades and the advancement of resource-conserving technologies. Conversely, failure to do so may result in elevated pollution levels, adversely impacting public health and ecosystems. Consequently, this could escalate healthcare expenditures and environmental remediation efforts, thereby impeding economic growth. Furthermore, negative ecological externalities may exacerbate social and political tensions within society.

It should be noted that government management plays a pivotal role in mitigating the negative impact of economic growth on the environment. Governments can establish regulations and standards to monitor emissions, impose fines for exceeding them, and incentivize companies to adopt clean technologies. Effective government management has the potential to create incentives for economic development based on sustainable resource utilization and environmental protection. Relevant government agencies can provide financial incentives or penalize enterprises depending on their compliance or violation of environmental standards. This can serve as a powerful incentive for companies to reduce emissions and implement cleaner production technologies.

As a member of the European Union, Bulgaria is obliged to adhere to all EU environmental norms and standards. Adherence to stringent environmental standards often increases costs and reduces the competitiveness of goods in global markets [1]. Therefore, it is important for the country to strike a balance between implementing environmental principles and methods of production development, which may manifest in adhering to the concept of sustainable development [2, 3], implementing principles of circular economy [4-6], and so forth. To develop effective tools for implementing environmentally oriented state policies, it is important to understand the mechanism by which economic development affects the environment and the opportunities for state regulation to reduce emissions of harmful substances. In this context, the aim of this article is to examine the characteristics of the relationship between GDP levels, emission levels, and the quality of government management using Bulgaria as a case study.

2 Theory

Research on the link between Gross Domestic Product (GDP) and emissions of harmful substances is a crucial topic in contemporary economic science. The level of economic development of a country influences the volume of emissions into the atmosphere, as the production of goods and services often involves the release of harmful substances. Studies indicate a direct correlation between GDP levels and emission volumes. Chopra et al. [7] determined a positive link between GDP and carbon footprint in China, the USA, India, and Japan. Sushchenko, Prokopishyna & Kozubova [8] emphasized the existence of a link between GDP growth and waste making. Han [9], focusing on China, India, Pakistan, and Kazakhstan, concluded that GDP has a nonlinear impact on CO_2 emissions, while the link between political stability and CO_2 emissions is statistically significant and negative.

Often, developed countries exhibit higher emission levels due to the extensive resource requirements and reliance on hydrocarbon fuels for energy production and consumption. For instance, Mehmood et al. [10], in their study of G-11 countries, found that GDP growth adversely affects environmental quality in both the short and long term. They argue that governments should focus efforts on reducing CO_2 emissions.

However, with technological advancements and the transition to cleaner energy sources, this trend is beginning to change. As noted by Cui et al. [11], in some cases, economic development can be compatible with low carbon emissions.

There are methods to reduce harmful substance emissions while GDP grows, such as implementing clean technologies, improving environmental standards, and incentivizing environmentally responsible production. For instance, in a study examining the link between CO2 emissions and GDP, the influence of GDP on CO2 emissions was found to be insignificant for 37 OECD countries [12]. Espoir, Sunge & Bannor [13] concluded that economic growth does not have a significant impact on CO2 emissions in 47 African countries in the short term.

The interest in research on the link between GDP and emissions of harmful substances underscores the necessity of finding a balance between economic development and environmental protection to ensure sustainable societal progress. It is worth noting that countries with more transparent governance typically have more effective strategies for reducing emissions and implementing environmental protection measures. For instance, Ronaghi, Reed & Saghaian [14] identified a direct correlation between carbon dioxide emissions and GDP, and an inverse relationship with the governance index using OPEC countries as a case study.

Researchers highlight the crucial role of governments in regulating greenhouse gas emissions reduction efforts. Similarly, Szetela et al. [15] noted that countries with better governance indicators experience a faster reduction in CO2 emissions. Jain & Kaur [16] determined a negative link between democracy and environmental quality while observing a positive correlation between economic growth and carbon dioxide emissions in Asian countries. In MENA countries, GDP, control of corruption, political stability, rule of law, voice and accountability, as well as government effectiveness, contribute to increased CO2 emissions, while regulatory quality does not affect CO2 emissions [17].

The quality of governance positively influences environmental performance indicators (EPI), and EPI, in turn, have a positive impact on environmental quality for 107 developing countries and 39 Belt and Road Initiative (BRI) countries [18]. Similarly, Huang et al. [19] reached similar conclusions, indicating that institutional quality positively affects the environment in 47 BRI countries by promoting the adoption of environmentally sustainable industrialization methods. GDP growth significantly increases carbon emissions, while institutional quality contributes to improving environmental quality [20].

3 Material and methods

This study utilizes World Bank [21] data for Bulgaria spanning from 1996 to 2022 (with a sample size of 27 observations). As an indicator of economic development, the study employs GDP per capita. The effectiveness of government management is assessed using The Worldwide Governance Indicators [22]. Emissions data are sourced from Climate Watch Historical GHG Emissions [23]. The indicators, logarithms of indicators, first differences of logarithms, as well as their respective symbols, are presented in Table 1.

Place the figure as close as possible after the point where it is first referenced in the text. If there is many figures and tables, it might be necessary to place some before their text citation.

To obtain the final results, the study employs the following methods: correlation analysis; logarithm transformation; Dickey-Fuller test calculation; determination of the first differences of logarithms for non-stationary time series; construction of correlograms; Granger causality test calculation; graphical method.

Table 1. Indicators and their symbols.

Indicator	Symbol	Logarithm	First differences
GDP per capita (current US$)	GDP	lgGDP	DlgGDP
Control of Corruption	CC	lgCC	DlgCC
Government Effectiveness	GE	lgGE	DlgGE
Political Stability and Absence of Violence/Terrorism	PV	lgPV	DlgPV
Regulatory Quality	RQ	lgRQ	DlgRQ
Rule of Law	RL	lgRL	DlgRL
Voice and Accountability	VA	lgVA	DlgVA
CO2 emissions (metric tons per capita)	CO2E	lgCO2E	DlgCO2E
Methane emissions (metric tons of CO2 equivalent per capita)	METH	lgMETH	DlgMETH
Nitrous oxide emissions (metric tons of CO2 equivalent per capita)	NOXE	lgNOXE	DlgNOXE

4 Research results

The realization of the research objective entails the acceptance or refutation of the following hypotheses:

H1 – There exists a correlation between GDP and the quality of governance;

H2 – There exists a correlation between GDP and emission levels;

H3 – There exists a correlation between the quality of governance and emission levels.

To assess the presence of linear dependencies between the indicators, an analysis was conducted, resulting in the construction of a correlation matrix (Table 2).

Table 2. The correlation matrix of the analyzed indicators.

	GDP	CC	GE	PV	RQ	RL	VA	CO2E	METH	NOXE
GDP	1,00									
CC	-0,36	1,00								
GE	-0,12	0,45	1,00							
PV	0,06	0,08	0,01	1,00						
RQ	0,60	0,28	0,13	0,00	1,00					
RL	0,46	0,27	0,28	0,40	0,75	1,00				
VA	-0,41	0,52	0,02	-0,02	0,29	0,23	1,00			
CO2E	-0,11	0,03	-0,26	-0,28	0,07	-0,25	0,58	1,00		
METH	-0,93	0,18	-0,07	-0,08	-0,77	-0,66	0,27	0,19	1,00	
NOXE	0,60	-0,09	0,32	-0,28	0,37	0,15	-0,38	-0,09	-0,53	1,00

Note: The noted correlations are significant at the level p <,05000

Source: Author's calculations were performed using Eviews 12 software.

Table 2 shows that the strongest correlation is observed between GDP and the indicators RQ and NOXE, while the correlation with METH is strongly negative.

Additionally, there is a high statistically significant negative correlation between METH and RQ, as well as METH and RL. The indicators CO2E and VA demonstrate a moderate correlation. It is worth noting that the correlation analysis provides general insights into the existence of relationships between the analyzed indicators.

For a clearer representation of the links between the analyzed indicators, all the time series were transformed into logarithmic form during the research process. Unlike the initial data, which had different units of measurement, logarithmic series are presented within a unified range, allowing for more accurate comparisons. Additionally, since the indicators of governance management quality range from -2.5 to 2.5, before the logarithmic transformation, their values were adjusted to a positive scale by adding 2.5 to each indicator value (resulting in a scale of indicators ranging from 0 to 5). On Figure 1, the dynamics of the logarithms of the analyzed indicators are presented.

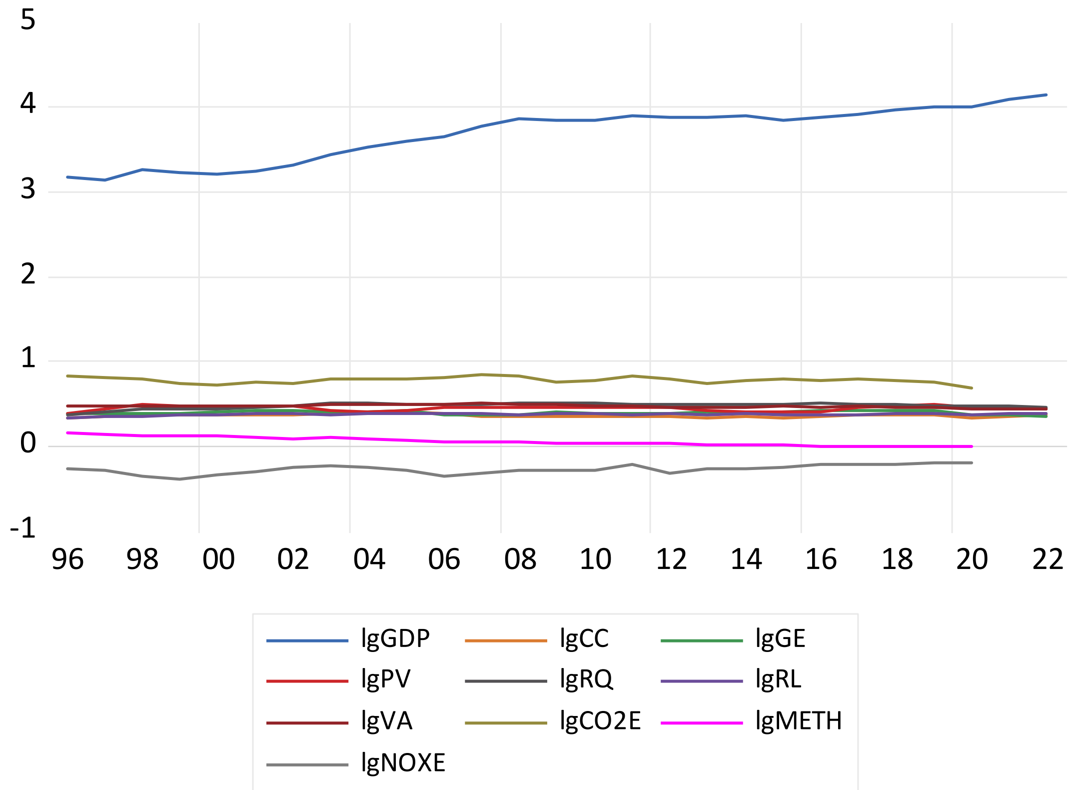


Fig. 1. The dynamics of the logarithms of the analyzed indicators.
Source: Author's calculations were performed using Eviews 12 software.

Figure 1 demonstrates that the time series plots of the indicators exhibit trend components. Therefore, to remove the trends, the study further employs the first differences of the logarithms of the indicators (Figure 2).

The first differences of logarithms approximate the rates of change of the variables. Figure 2 demonstrates that in the dynamics of the first differences of the logarithms of the analyzed indicators, the presence of trend components is no longer evident. Next, it is necessary to test the time series for stationarity. To do this, the authors of the study employ the Augmented Dickey-Fuller (ADF) Unit Root Test. The ADF test is conducted for each time series separately.

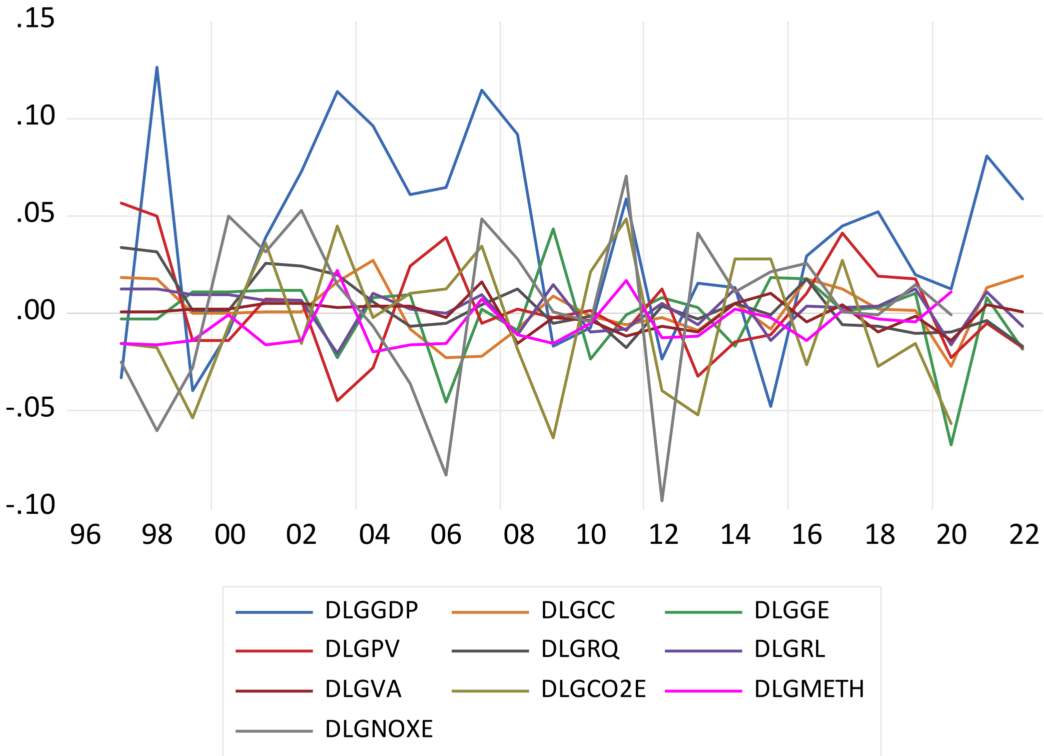


Fig. 2. The dynamics of the first differences of the logarithms of the indicators.
Source: Author's calculations were performed using Eviews 12 software.

The results of the Dickey-Fuller test for the logarithms of the indicators and their first differences are presented in Table 3.

Table 3. The results of the Dickey-Fuller test.

Indicator	The p-value for the logarithm of the indicator (lg)	The p-value for the first difference of the logarithm of the indicator (Dlg)
GDP	0.8112	0.0021
CC	0.0885	0.0015
GE	0.1168	0.0000
PV	0.0011	0.0066
RQ	0.2046	0.0421
RL	0.0028	0.0007
VA	0.8473	0.0003
CO2E	0.2198	0.0017
METH	0.0737	0.0004
NOXE	0.3371	0.0005

Source: Author's calculations were performed using Eviews 12 software.

The result of the Dickey-Fuller test is the obtained test statistic value and the critical values of the MacKinnon τ-statistic. If the Dickey-Fuller test statistic is greater than the critical value at the 1%, 5%, and 10% significance levels, the time series is considered non-stationary. The results of the calculations (Table 3) indicate that the majority of the time series of the logarithms of the indicators (except lgPV and lgRL) are non-stationary. Therefore, for further analysis, the study utilizes the first differences of the logarithms of the indicators. The calculation of the Dickey-Fuller test for the time series in the scale of the first differences of the logarithms showed that the transformed series are stationary (Table 3).

The next stage of the study involves constructing plots of the autocorrelation (correlogram) and partial autocorrelation functions for the logarithmic time series and their first differences (Figures 3-12).

Sample: 1996 2022
Included observations: 27

	AC	PAC	Q-
1	0.890	0.890	23.
2	0.767	-0.123	42.
3	0.670	0.059	56.
4	0.550	-0.184	67.
5	0.417	-0.111	73.
6	0.288	-0.098	76.
7	0.173	-0.025	77.
8	0.085	0.036	77.
9	0.005	-0.039	77.
10	-0.067	-0.031	78.
11	-0.132	-0.082	79.
12	-0.182	-0.018	80.

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

	AC	PAC	Q-
1	0.126	0.126	0.4
2	0.062	0.047	0.5
3	0.160	0.150	1.3
4	0.048	0.010	1.4
5	0.041	0.021	1.5
6	-0.173	-0.215	2.6
7	-0.336	-0.331	6.9
8	-0.333	-0.341	11.
9	-0.139	-0.075	12.
10	0.020	0.223	12.
11	-0.220	-0.014	14.
12	-0.195	-0.150	16.

Fig. 3. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable GDP.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

	AC	PAC	Q-
1	0.685	0.685	14.
2	0.315	-0.291	17.
3	0.122	0.088	17.
4	0.049	-0.012	17.
5	0.080	0.118	18.
6	-0.022	-0.288	18.
7	-0.217	-0.152	19.
8	-0.410	-0.266	26.
9	-0.466	-0.018	36.
10	-0.384	-0.098	43.
11	-0.249	0.067	46.
12	-0.079	0.140	46.

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

	AC	PAC	Q-
1	0.258	0.258	1.9
2	-0.199	-0.284	3.1
3	-0.293	-0.180	5.8
4	-0.196	-0.135	7.1
5	0.261	0.298	9.4
6	0.212	-0.062	11.
7	0.142	0.180	11.
8	-0.099	-0.118	12.
9	-0.290	-0.079	15.
10	-0.258	-0.286	18.
11	-0.215	-0.236	21.
12	0.119	-0.026	21.

Fig. 4. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable CC.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

	AC	PAC	Q-
1	0.387	0.387	4.5
2	0.135	-0.017	5.0
3	-0.220	-0.313	6.6
4	-0.242	-0.065	8.6
5	-0.321	-0.187	12.
6	-0.199	-0.077	13.
7	-0.046	0.034	13.
8	0.007	-0.122	13.
9	-0.087	-0.236	14.
10	-0.025	0.000	14.
11	-0.107	-0.198	14.
12	0.026	0.007	14.

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

	AC	PAC	Q-
1	-0.281	-0.281	2.2
2	0.065	-0.015	2.4
3	-0.051	-0.040	2.5
4	0.020	-0.005	2.5
5	-0.201	-0.212	3.9
6	-0.035	-0.171	3.9
7	0.020	-0.041	3.9
8	0.069	0.059	4.1
9	-0.085	-0.075	4.4
10	0.115	0.017	5.0
11	-0.239	-0.279	7.8
12	0.076	-0.104	8.1

Fig. 5. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable GE.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	0.484	0.484	7.0
		2	-0.079	-0.408	7.2
		3	-0.284	-0.051	9.8
		4	-0.321	-0.217	13.
		5	-0.417	-0.372	19.
		6	-0.342	-0.153	23.
		7	-0.013	0.001	23.
		8	0.189	-0.176	25.
		9	0.198	-0.082	27.
		10	0.180	-0.043	28.
		11	0.228	0.068	31.
		12	0.102	-0.077	31.

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	0.286	0.286	2.3
		2	-0.234	-0.344	4.0
		3	-0.255	-0.083	6.1
		4	0.004	0.057	6.1
		5	-0.190	-0.384	7.3
		6	-0.296	-0.178	10.
		7	-0.027	0.033	10.
		8	0.124	-0.203	11.
		9	0.132	0.064	11.
		10	0.086	0.036	12.
		11	0.183	0.060	13.
		12	0.081	0.029	14.

Fig. 6. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable PV.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	0.733	0.733	16.
		2	0.515	-0.047	24.
		3	0.375	0.031	29.
		4	0.234	-0.087	30.
		5	0.057	-0.175	31.
		6	-0.070	-0.061	31.
		7	-0.144	-0.033	32.
		8	-0.168	0.025	33.
		9	-0.156	0.038	34.
		10	-0.163	-0.068	35.
		11	-0.184	-0.093	37.
		12	-0.210	-0.106	39.

lgRQ

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	0.437	0.437	5.5
		2	0.152	-0.048	6.2
		3	0.033	-0.020	6.2
		4	0.257	0.318	8.4
		5	0.227	-0.006	10.
		6	0.172	0.044	11.
		7	0.008	-0.066	11.
		8	-0.121	-0.205	11.
		9	-0.061	0.046	12.
		10	-0.023	-0.073	12.
		11	0.073	0.108	12.
		12	-0.057	-0.064	12.

DlgRQ

Fig. 7. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable RQ.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	0.485	0.485	7.0
		2	0.306	0.093	10.
		3	0.077	-0.135	10.
		4	-0.094	-0.148	10.
		5	-0.017	0.141	10.
		6	-0.144	-0.162	11.
		7	0.125	0.307	11.
		8	-0.046	-0.289	11.
		9	-0.077	-0.028	12.
		10	-0.088	-0.049	12.
		11	-0.203	-0.037	14.
		12	-0.011	0.091	14.

lgRL

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-S
		1	-0.398	-0.398	4.6
		2	0.274	0.137	6.9
		3	0.006	0.188	6.9
		4	-0.251	-0.287	8.9
		5	0.436	0.299	15.
		6	-0.548	-0.326	26.
		7	0.386	0.083	32.
		8	-0.110	0.163	32.
		9	0.008	0.069	32.
		10	0.152	-0.151	33.
		11	-0.356	-0.069	39.
		12	0.337	0.003	45.

DlgRL

Fig. 8. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable RL.

Source: Author's calculations were performed using Eviews 12 software.

Sample: 1996 2022
Included observations: 27

	AC	PAC	Q-S
1	0.841	0.841	21.
2	0.696	-0.038	36.
3	0.472	-0.354	43.
4	0.311	0.056	47.
5	0.182	0.081	48.
6	0.097	-0.037	48.
7	0.039	-0.032	48.
8	-0.013	-0.057	48.
9	-0.136	-0.353	49.
10	-0.256	-0.123	52.
11	-0.365	0.079	58.
12	-0.403	0.079	67.

lgVA

Sample (adjusted): 1997 2022
Included observations: 26 after adjustments

	AC	PAC	Q-S
1	-0.082	-0.082	0.1
2	0.282	0.277	2.6
3	-0.028	0.012	2.6
4	-0.128	-0.225	3.1
5	-0.023	-0.045	3.1
6	-0.201	-0.114	4.6
7	0.045	0.047	4.7
8	0.135	0.248	5.4
9	-0.118	-0.163	6.0
10	0.101	-0.108	6.5
11	-0.183	-0.120	8.1
12	0.122	0.159	8.9

DlgVA

Fig. 9. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable VA.

Source: Author's calculations were performed using Eviews 12 software.

Sample (adjusted): 1996 2020
Included observations: 25 after adjustments

	AC	PAC	Q-S
1	0.406	0.406	4.6
2	0.014	-0.181	4.6
3	-0.034	0.040	4.6
4	0.035	0.047	4.7
5	-0.169	-0.263	5.6
6	-0.184	0.013	6.8
7	-0.068	-0.002	7.0
8	-0.226	-0.330	9.0
9	-0.171	0.132	10.
10	0.085	0.123	10.
11	0.053	-0.253	10.
12	-0.204	-0.118	12.

lgCO2E

Sample (adjusted): 1997 2020
Included observations: 24 after adjustments

	AC	PAC	Q-S
1	-0.035	-0.035	0.0
2	-0.323	-0.325	2.9
3	0.048	0.024	3.0
4	0.244	0.159	4.9
5	-0.186	-0.169	6.0
6	-0.219	-0.134	7.7
7	0.138	0.026	8.4
8	-0.081	-0.236	8.6
9	-0.121	-0.030	9.2
10	0.142	0.118	10.
11	0.108	-0.018	10.
12	-0.096	0.018	11.

DlgCO2E

Fig. 10. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable CO2E.

Source: Author's calculations were performed using Eviews 12 software.

Sample (adjusted): 1996 2020
Included observations: 25 after adjustments

	AC	PAC	Q-S
1	0.852	0.852	20.
2	0.714	-0.045	35.
3	0.609	0.042	46.
4	0.508	-0.046	55.
5	0.376	-0.171	59.
6	0.285	0.061	62.
7	0.219	0.006	64.
8	0.092	-0.268	64.
9	-0.014	-0.003	64.
10	-0.085	-0.019	65.
11	-0.146	-0.054	66.
12	-0.233	-0.103	69.

lgMETH

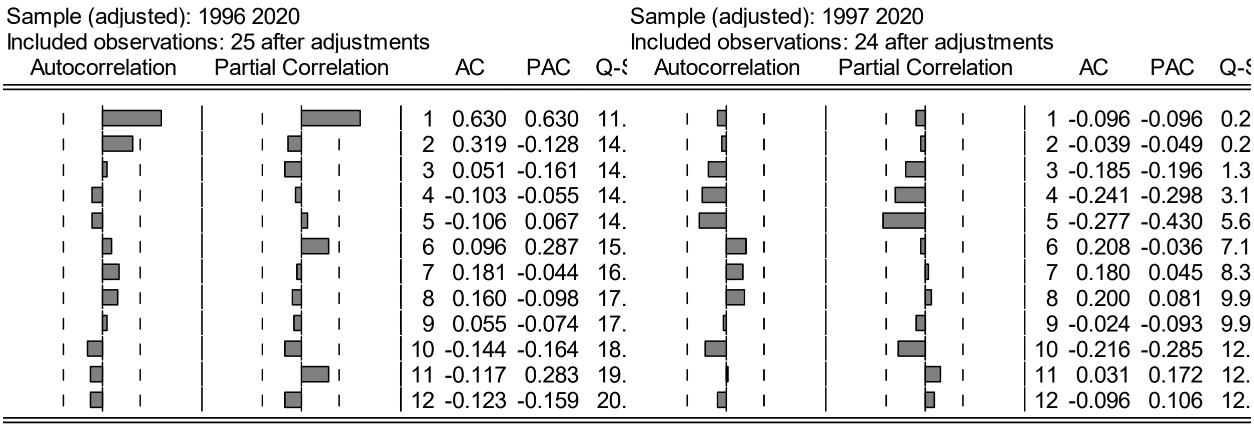
Sample (adjusted): 1997 2020
Included observations: 24 after adjustments

	AC	PAC	Q-S
1	-0.170	-0.170	0.7
2	-0.316	-0.355	3.6
3	0.175	0.049	4.5
4	0.336	0.322	8.0
5	-0.235	-0.033	9.8
6	-0.180	-0.104	10.
7	0.155	-0.077	11.
8	0.275	0.226	14.
9	-0.086	0.227	15.
10	-0.115	0.075	15.
11	0.143	-0.017	16.
12	-0.027	-0.279	16.

DlgMETH

Fig. 11. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable METH.

Source: Author's calculations were performed using Eviews 12 software.



lgNOXE DlgNOXE

Fig. 12. The autocorrelation (ACF) and partial autocorrelation (PACF) functions for the logarithm and the first difference of the logarithm of the variable NOXE.

Source: Author's calculations were performed using Eviews 12 software.

From Figures 3-12, it can be observed that the analyzed time series of logarithms of the variables are non-stationary (except for lgPV and lgRL), while the series in the first differences of the logarithms of variables are stationary. Additionally, the dynamics of the transformed time series are characterized by constant fluctuations around zero, indicating their stationarity. The correlogram and partial autocorrelation function plots also decay with increasing *t(2*) after several initial values. Thus, the majority of the analyzed time series are non-stationary in logarithmic terms but demonstrate stationarity when converted into the first differences of the logarithms of variables.

The next stage of the study involves determining causal links between the examined indicators of time series in the first differences of logarithms. Causal analysis, unlike correlation analysis, allows for the identification of the direction of causality between the analyzed variables. To achieve this goal, the Granger causality test was employed in the study.

The Granger causality test is sensitive to the number of lags, denoted as 'm'. Therefore, the tests were conducted for lags m = 2; 3; 4; 5; 6. The maximum number of lags, m = 6, was chosen because the minimum sample size for some indicators is 24 values, and the number of lags for analysis should not exceed the number of observations divided by 4.

To determine the presence of causal relationships between the analyzed indicators, the values of the F-statistic and the corresponding probability (p-value) are considered. To reject the null hypothesis 'A is not the cause of changes in B' at the 5% significance level, the p-value for the corresponding pair of indicators should be less than 0.05.

Table 4 provides a visual representation of the direction of causality between the analyzed indicators in the first difference of logarithms.

As shown in Table 4, in the short term, there is a one-way causal relationship from RL to CC and from METH to GE. With an increase in the number of lags, a relationship is observed from GDP to CC, from RL to CC, and from METH to GE. In the long term, there is a causal relationship from GE to VA, from PV to CO2E, from PV to METH, from RL to CO2E, from RL to VA, from VA to GE, from VA to GDP, and from CO2E to GE. In all cases, the relationship is one-way. Analysis of the relationship's characteristics shows that among all indicators of government quality, Political Stability and Absence of Violence/Terrorism has a causal influence on emissions in Bulgaria in the long term.

Table 4. The interpretation of the Granger causality test for the causal link between variables in the first differences of logarithms.

Lag / Iindicator	m=2	m=3	m=4	m=5	m=6
GDP			GDP → CC		
CC					
GE					GE → VA
PV				PV → CO2E PV → METH	PV → CO2E PV → METH
RQ					
RL	RL → CC	RL → CC	RL → CC	RL → CO2E	RL → VA
VA				VA → GE	VA → GDP
CO2E				CO2E → GE	
METH		METH → GE	METH → GE		
NOXE					

Additionally, the Rule of Law affects carbon emissions levels, while carbon emissions levels affect Government Effectiveness. It is worth noting that no direct relationship was found between GDP and emissions levels, as well as between GDP and the quality of government regulation in the case of Bulgaria.

5 Discussion

On one hand, the pursuit of economic growth and prosperity leads to increased production and consumption, which in turn increases emissions and environmental pollution. On the other hand, government policies aimed at reducing emissions and protecting the environment may restrict economic growth and the competitiveness of companies. Thus, there is a dilemma between the need to ensure economic development and the protection of the environment. To address this issue, a comprehensive approach is required, which includes the development of effective environmental standards, incentivizing innovation and the use of new technologies, as well as improving the system of government management, including industrial ownership [24]. The example of Germany and China demonstrates that as economies grow, emissions can both increase and decrease [25]. Since in Bulgaria, the growth of real GDP per capita was accompanied by an increase in carbon emissions up to a threshold value of 5.8%, followed by a decrease in emissions, Todorov & Angelova [26] suggest that the country needs to achieve a minimum real economic growth per capita of 5.8% to achieve a reduction in carbon emissions.

An important role in balancing economic growth and reducing emissions is played by government management. For example, Khan Q.R. [27] a notes that the development of political mechanisms is crucial, as effective governance has a significant positive impact on reducing CO2 emissions in the APEC region. One of the important mechanisms available to the government is the introduction of economic instruments aimed at stimulating environmentally friendly technologies and processes. In addition, the government also takes a series of regulatory measures aimed at controlling and reducing emissions of harmful substances into the atmosphere, water, and soil. Regulation of production activities, implementation of quality standards and environmental norms, as well as environmental monitoring, all contribute to limiting the negative impact of economic growth on the environment.

6 Conclusion

High-quality government management can contribute to sustainable GDP growth, increased income levels, and improved quality of life for the population, as well as the implementation of effective environmental policies. Reliable institutions and efficient rules create a favourable environment for business, investment, and innovation in the country.

At the same time, corruption and ineffective legislation can create uncertainty for businesses and investors, hindering economic development. Additionally, government management plays a crucial role in controlling emissions and protecting the environment. Its effectiveness depends on a variety of factors, including the strictness of standards, transparency of processes, and efforts to combat corruption. Therefore, studying the interplay between the quality of government management, its impact on GDP, and environmental indicators is highly relevant.

The study revealed significant disparities in Bulgaria between GDP, indicators of government management quality, and emission levels, both in the direction of their relationship and in its strength, with some cases even showing a complete absence of correlation.

When testing hypothesis H1 regarding the link between GDP per capita and the quality of government management, a statistically significant positive correlation was found between GDP and Regulatory Quality, along with a moderate negative correlation from GDP to Voice and Accountability. Additionally, calculations revealed a causal link from GDP to Control of Corruption, indicating that economic growth influences corruption in Bulgaria. However, the correlation between GDP and indicators of government management quality was not observed in all cases, suggesting insufficient utilization of governmental mechanisms to stimulate economic growth.

Testing hypothesis H2 regarding the potential link between GDP and emissions levels revealed a strong negative correlation between GDP and Methane emissions, as well as a significant positive correlation between GDP and Nitrous oxide emissions. This suggests that economic growth in Bulgaria is accompanied by an increase in Nitrous oxide emissions. Therefore, the government of the country should develop effective tools to reduce this type of emissions. However, Granger causality analysis did not reveal a causal relationship between GDP and emissions levels in Bulgaria.

Testing hypothesis H3 regarding the potential link between indicators of government quality and emissions levels was confirmed through correlation coefficient calculations for pairs of indicators, such as: VA and CO2E (significant positive correlation); RQ and METH (significant negative correlation); RL and METH (significant negative correlation). Additionally, Granger causality analysis revealed a causal relationship from PV to METH and CO2E; from RL to CO2E; and from CO2E and METH to GE. This confirms that measures of government quality influence emissions levels, and emissions levels ultimately impact Government Effectiveness.

Thus, the study confirms that good quality of government regulation can contribute to reducing emissions and improving environmental quality, while also positively impacting the pace of economic growth in Bulgaria. In this context, the development of policy instruments by the Bulgarian government aimed at ensuring sustainable economic growth while considering environmental goals represents a promising direction for further scientific research.

References

1. Petrova, M., Nikolova, M., & Pavlov, P. (2023). An Innovative Organic Agriculture Model for Sustainable Development of Rural Areas in Bulgaria. IOP Conference Series. Earth and Environmental Science. 1126 012034. https://doi.org/10.1088/1755-1315/1126/1/012034

1. Abuseridze, G., Paliani-Dittrich, I., Shalikashvili, M., & Zahars, V. (2022). Challenges and economic adjustment policies in the EU. Access to science, business, innovation in digital economy. https://doi.org/10.46656/access.2022.3.2(4)
2. Lazarova, E., Pavlov, P., Petrova, M., Shalbayeva, S. (2023). Analysis and Assessment of Infrastructural Potential in Rural Territories. Economics. Ecology. Socium, Vol. 7, pp.1-14. https://doi.org/10.31520/2616-7107/2023.7.1-1
3. Iliev, N., Marinov, M., Milinov, V., Petrova, M. (2023). Is Investment Portfolio Construction Sustainable in the Circular Economy Paradigm - The Case of ESG Investment?. In: Koval, V., Kazancoglu, Y., Lakatos, ES. (eds) Circular Business Management in Sustainability. ISCMEE 2022. Lecture Notes in Management and Industrial Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-23463-7_2, ISBN 978-3-031-23462-0, ISBN 978-3-031-23463-7 (eBook), pp. 15 -42.
4. Petrova, M., Popova, P., Popov, V., Shishmanov, K., Marinova, K. (2022). Digital Ecosystem: Nature, Types and Opportunities for Value Creation. In: Innovations in Digital Economy. SPBPU IDE 2021. Communications in Computer and Information Science, vol 1619. Springer, Cham. https://doi.org/10.1007/978-3-031-14985-6_5
5. Jarmusevica, V., Ilisko, D., Badjanova, J., Jukss, V., Petrova, M. (2019). SMART governance of implementing the strategy of corporate societal responsibility for a sustainable regional development. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM 19(5.3), pp. 645-652, DOI: 10.5593/sgem2019/5.3/S21.081
6. Nikolova-Alexieva, V., Alexieva, I., Valeva, K., Petrova, M. (2022). Model of the Factors Affecting the Eco-Innovation Activity of Bulgarian Industrial Enterprises. Risks, 10(9), 178. https://doi.org/10.3390/risks10090178, 23p.
7. Chopra, R., Rehman, M.A., Yadav, A., & Bhardwaj, S. (2024). Revisiting the EKC framework concerning COP-28 carbon neutrality management: Evidence from Top-5 carbon embittering countries. Journal of Environmental Management, 356, 120690. https://doi.org/10.1016/j.jenvman.2024.120690
8. Sushchenko, O., Prokopishyna, O., & Kozubova, N. (2018). Eco-Friendly Behavior of Local Population, Tourists and Companies as a Factor of Sustainable Tourism Development. International Journal of Engineering & Technology, 7(4.3), 514-518. https://doi.org/10.14419/ijet.v7i4.3.19926
9. Han, Y., Bao, M., Niu, Y., & Rehman, J.U. (2024). Driving towards net zero emissions: The role of natural resources, government debt and political stability. Resources Policy, 88, 104479. https://doi.org/10.1016/j.resourpol.2023.104479
10. Mehmood, U., Tariq, S., Haq, Z.U., Agyekum, E.B., Uhunamure, S.E., Shale, K., Nawaz, H., Ali, S., & Hameed, A. (2022). Financial Institutional and Market Deepening, and Environmental Quality Nexus: A Case Study in G-11 Economies Using CS-ARDL. International Journal of Environmental Research and Public Health, 19(19), 11984. https://doi.org/10.3390/ijerph191911984

11. Cui, C., Li, J., Lu, Z., Yan, Z. (2022). Empirical analysis of the role of the environmental accountability system in energy conservation and emission reduction in China. Scientific Reports, 12(1), 15260. https://doi.org/10.1038/s41598-022-19604-8
12. Afjal, M. (2023). The tapestry of green economics: mapping the nexus of CO2 emissions, economic growth, and renewable energy. International Journal of Sustainable Energy, 42(1), 1364-1390. https://doi.org/10.1080/14786451.2023.2268853
13. Espoir, D.K., Sunge, R., & Bannor, F. (2023). Exploring the dynamic effect of economic growth on carbon dioxide emissions in Africa: evidence from panel PMG estimator. Environmental Science and Pollution Research, 30(52), 112959-112976. https://doi.org/10.1007/s11356-023-30108-4
14. Ronaghi, M., Reed, M., & Saghaian, S. (2020). The impact of economic factors and governance on greenhouse gas emission. Environmental Economics and Policy Studies, 22(2), 153-172. https://doi.org/10.1007/s10018-019-00250-w
15. Szetela, B., Majewska, A., Jamroz, P., Djalilov, B., & Salahodjaev, R. (2022). Renewable Energy and CO2 Emissions in Top Natural Resource Rents Depending Countries: The Role of Governance. Frontiers in Energy Research, 10, 872941. https://doi.org/10.3389/fenrg.2022.872941
16. Jain, M., & Kaur, S. (2022). Carbon emissions, inequalities and economic freedom: an empirical investigation in selected South Asian economies. International Journal of Social Economics, 49(6), 882-913. https://doi.org/10.1108/IJSE-02-2021-0108
17. Sadaoui, N., Zabat, L., Sekrafi, H., & Abid, M. (2022). The moderating role of natural resources between governance and CO2 emissions: Evidence from MENA countries. Energy & Environment, 0(0). https://doi.org/10.1177/0958305X221141389
18. Khan, H., Weili, L., & Khan, I. (2022). The role of institutional quality in FDI inflows and carbon emission reduction: evidence from the global developing and belt road initiative countries. Environmental Science and Pollution Research, 29(20), 30594-30621. https://doi.org/10.1007/s11356-021-17958-6
19. Huang, Y., Rahman, S.U., Meo, M.S., Ali, M.S.E., & Khan, S. (2024). Revisiting the environmental Kuznets curve: assessing the impact of climate policy uncertainty in the Belt and Road Initiative. Environmental Science and Pollution Research, 31(7), 10579-10593. https://doi.org/10.1007/s11356-023-31471-y
20. Karimi Alavijeh, N., Ahmadi Shadmehri M.T., Nazeer, N., Zangoei, S., & Dehdar, F. (2023). The role of renewable energy consumption on environmental degradation in EU countries: do institutional quality, technological innovation, and GDP matter? Environmental Science and Pollution Research, 30(15), 44607-44624. https://doi.org/10.1007/s11356-023-25428-4
21. World Development Indicators. DataBank. The World Bank (2023). https://databank.worldbank.org/reports.aspx?source=world-development-indicators
22. Kaufmann, D., Kraay, A. & Mastruzzi, M. (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues. World Bank Policy Research Working Paper No. 5430, Available at SSRN: https://ssrn.com/abstract=1682130
23. Climate Watch Historical GHG Emissions (1990-2020). (2023). Washington, DC: World Resources Institute. Available: https://www.climatewatchdata.org/ghg-emissions
24. Stryzhak, O., Akhmedova, O., Sushchenko, O., & Pokolodna, M. (2020). Industrial Property Management: Sectorial Aspect. E3S Web of Conferences, vol. 168, p. 10. https://doi.org/10.1051/e3sconf/202016800038

25. Hao, Y., Gao, S., Guo, Y., Gai, Z., & Wu, H. (2021). Measuring the nexus between economic development and environmental quality based on environmental Kuznets curve: a comparative study between China and Germany for the period of 2000–2017. Environment, Development and Sustainability, 23(11), 16848-16873. https://doi.org/10.1007/s10668-021-01365-5
26. Todorov, I., & Angelova, G. (2023). Economic growth, income disparity and greenhouse gas emissions: the case of Bulgaria. Ikonomicheski Izsledvania, 32(8), 22-34.
27. Khan, Q.R. (2023). From industrialization to dehumanization: understanding the deriving forces of environment and implications for sustainable development. Environmental science and pollution research international, 30(59), 123396-123411. https://doi.org/10.1007/s11356-023-30983-x